IBM DB2 10.1
for Linux, UNIX, and Windows

DB2 Workload Management Guide and Reference

IBM

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Note

Before using this information and the product it supports, read the general information under Appendix E, "Notices," on page 509.

Contents

About this book

This book provides information on the DB2® workload management features and functionality that can help you obtain a stable, predictable execution environment that meets your business objectives. Using DB2 workload management, both requests and resources are managed. This book also provides information on monitoring and performing troubleshooting for the workload on your data server.

Chapter 1. Introduction to DB2 workload management concepts

A good workload management system helps to efficiently meet goals in the environment where work occurs. You can see examples of the need for a good workload management system all around you.

For example, look at a grocery store. Different activities must be considered: serving customers, stocking shelves, maintaining inventories, and so on. And some simple goals must be set. Store owners want to maximize both the number of customers who move through the store, and the amount that customers purchase, achieving both goals in a way that customers leave both satisfied and wanting to come back. Store owners must also ensure that they have sufficient stock for their customers to buy (but not too much stock, because waste becomes an issue). Store owners also track what their customers purchase, and use this information to create advertisements that are designed to induce their customers to return. Monitoring mechanisms track inventory and send notifications when stocks run low. Security devices are in place to detect shoplifting. Special fast checkout lanes are created so that shoppers who only want to purchase a few items can do so without having to wait behind other customers who are purchasing many items. If all of these goals are met and all of these operational procedures work well, customers are satisfied, and are likely to return rather than to go to another store. These goals and operational procedures are all aspects of workload management.

In a data server environment, you can see even more of a need for effective management of work, especially now that data servers are being stressed like never before. Cash registers generate thousands of data inserts, reports are constantly being generated to determine whether sales targets are being met, batch applications run to load collected data, and administration tasks such as backups and reorganizations run to protect the data and make the server run optimally. All these operations are using the same database system and competing for the same resources.

To ensure the best chance of meeting goals for running a data server, an efficient workload management system is critical.

Domains of workload management

Workload management has three clearly defined domains: identification of the work entering the data server, management of the work when it is running, and monitoring to ensure that the data server is being used efficiently.

A number of aspects must be considered for successful workload management with DB2 workload manager, starting with understanding your goals. In the grocery store example described in Chapter 1, "Introduction to DB2 workload management concepts," goals might include maximizing customer spending, minimizing shoplifting, and ensuring that customers leave the store satisfied so that they will return again.

In a data server environment, you must also define goals. Sometimes the goals are clear, especially when they originate from service level agreement (SLA) objectives. For example, queries from a particular application can consume no more than 10%

of the total processor resource. Goals can also be tied to a particular time of day. For example, an overnight batch utility might have to complete loading data by 8 a.m. so that the daily sales reports are on time. In other situations, the goals can be difficult to quantify. A goal might be to keep the database users satisfied and to prevent aberrant database activity from hampering their day-to-day work. Whether the goals are quantifiable or not, understanding them is critical when considering the following stages of workload management:

Identification

If you want to achieve a goal for some kind of work, you first must be able to identify details about the work. In the grocery store, you can identify shopper information through credit cards and debit cards, or an unpaid-for item through an active security tag on the item. For the data server, you need to decide how you want to identify the work that enters the system. You can use the name of the application that submits the work, the authorization ID that submits the work, or a combination of elements that provide some form of identification.

Management

The management phase includes mechanisms for making steady progress towards your goal, and actions to take if a goal is not being met. An example of a mechanism is managing price checks in fast checkout lanes. Fast checkout lanes should result in faster throughput and satisfied customers, but if a carton of milk has the wrong price and a price check is required, the fast checkout lane could slow down. The problem is managed by performing a fast price check, possibly opening up another checkout lane, and trying to fix the pricing problem so that it does not occur again. On the data server, you might find that overall performance is suffering when a few poorly written SQL statements are running, a surge in volume occurs during peak times, or there is too much competition between different applications for the same resources. The management phase includes mechanisms for assigning resources to achieve your goals and actions to take if a goal is not being met. These workload management mechanisms, which indirectly and directly control CPU resources, include the following:

1. Concurrency thresholds, applied with a work action set defined on the workload, to control the concurrency of incoming work
2. The ability to move work form one service class to another, currently only effective when workload management dispatcher is being used on those service classes
3. Workload management dispatcher to specifically allocate CPU resources for workloads assigned to service classes for more granular control of CPU resources when the first two workload management mechanisms are not adequate

Monitoring

Monitoring is important for a couple of reasons. First, to determine whether you are achieving a goal, you must have a mechanism to track progress toward that goal. Also, monitoring helps to identify the problems that might be preventing you from achieving your goal. In a store, the store manager can watch the flow of customers, automatically be alerted to problems such as shoplifting or dangerously low inventory of a particular sale item, or perform analysis on historical purchase patterns to determine optimal product placement in the store. For a data server, there are often explicit goals for response times of database activities and it is important to have a way to measure this metric, and watch for trends.

The following figure represents the workload management phases:

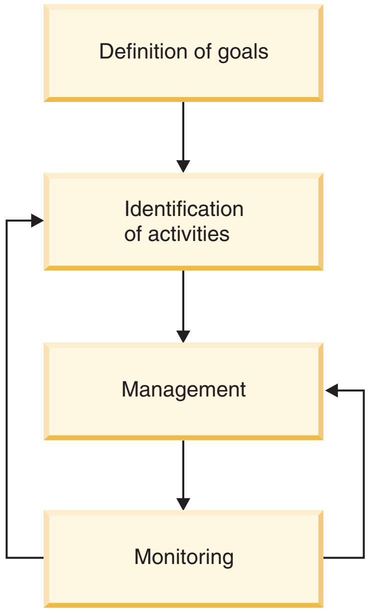


Figure 1. Phases of workload management

Workload management administrator authority (WLMADM)

You need workload management administrator (WLMADM) authority to manage workload objects for a specific database. This authority enables you to create, alter, drop, comment on, grant access to, and revoke access from DB2 workload management objects.

Workload management objects are system objects similar to buffer pools and table spaces. As such, they do not have owners associated with them.

The security administrator, who is someone holding SECADM authority, or a user with ACCESSCTRL authority can grant WLMADM authority to a user, group, or role.

WLMADM authority provides the ability to perform the following tasks:

- Issue CREATE, ALTER, COMMENT ON, and DROP statements for the following DB2 workload management objects:
  - Histogram templates
  - Service classes
  - Thresholds
  - Work action sets
  - Work class sets
  - Workloads
- Issue GRANT and REVOKE statements for workload privileges

If you hold database administrator (DBADM) authority, you hold WLMADM authority implicitly.

Frequently asked questions about DB2 workload management

This FAQ provides you with answers to common questions about DB2 workload management.

General

- On which DB2 platforms can I use DB2 workload management?
- I am not on AIX®. Does this mean I do not have any control over processor resource or I/O activity?
- Now that Query Patroller is discontinued and DB2 Governor are deprecated, how do I migrate to DB2 workload manager?
- Is there a way for WebSphere® Application Server to pass the client information fields used by the DB2 workload?
- Why is my work not assigned to the correct workload?
- Why does DB2 workload manager affect REORGCHK, IMPORT, EXPORT and other CLP commands?
- Is there a way to change the service class to which an activity is assigned while it is executing?
- Much of my batch work is done using CLP scripts under the same ID, how can I go about uniquely identifying these so I can manage them differently from each other?
- When should I use the COLLECT AGGREGATE ACTIVITY DATA clause versus the COLLECT ACTIVITY DATA clause?
- How does DB2 workload management work with the new AIX WPAR feature?
- What is the relationship between the DB2_OPT_MAX_TEMP_SIZE registry variable and a DB2 threshold based on SQLTEMPSPACE?

Licensing

- What are the licensing requirements for DB2 workload manager?

Monitoring

- What information do you get from the different event monitors that are associated with workload management?

OS workload management (AIX WLM and Linux WLM)

- Why would I ever want to use AIX WLM or Linux WLM?
- I am not on AIX. Does this mean I do not have any control over processor resources or I/O activity?
- Can I use AIX WLM to manage I/O activity?
- Can I use AIX WLM to manage memory use?
- How does DB2 WLM work with the new AIX WPAR feature?

Platforms

- On which DB2 platforms can I use DB2 workload manager?
- I am not on AIX. Does this mean I do not have any control over processor resource or I/O activity?
- How does DB2 workload management work with the new AIX WPAR feature?
- Why would I ever want to use AIX WLM or Linux WLM?

Query Patroller and Governor

- How does this new functionality affect Query Patroller and DB2 Governor?
- Now that Query Patroller and DB2 Governor are deprecated, how do I migrate to DB2 workload manager?

Thresholds

- Can I create multiple CONCURRENTDBCOORDACTIVITIES concurrency thresholds for the same set of work?
- How do I determine which activities are queued by a workload management threshold and the order of the activities in the queue?

Workload management dispatcher

- Do I need to use workload management dispatcher?
- What changes in behavior might I see when I turn ON the workload management dispatcher?
- With the introduction of the workload management dispatcher, are concurrency thresholds such as CONCURRENTDBCOORDACTIVITIES no longer needed or useful?

On which DB2 platforms can I use DB2 workload management?

DB2 workload management is available on all platforms supported by DB2 9.5 for Linux, UNIX, and Windows or later. The optional tight integration—offered between DB2 workload management at the service class level and operating system workload management capabilities—is available on AIX platforms and any Linux platform based on the 2.6.26 kernel or higher.

Do I need to use workload management dispatcher?

Most workload management configurations begin with concurrency thresholds, which affect the consumption of all resources by controlling how much work can begin executing at any one time. In some situations, however, a concurrency threshold is not able to effectively limit the total amount of processing resource that is consumed, and high priority work is affected; for example, a scenario in which complex work is restricted to one running query that nevertheless consumes enough resource to disrupt higher priority work. In such cases, the workload management dispatcher is used to explicitly control CPU consumption and protect the higher priority work.

You can use the workload management dispatcher for any or all of the following situations:

- You want to manage the share of CPU resources among multiple users or applications and you are using an operating system that does not have an operating system (OS) workload manager that integrates with DB2 workload management through the `outbound_correlator` field on each service class.
- You want to manage the share of CPU resources among multiple users or applications and you do not have root privilege on the operating system.
- You want to manage the share of CPU resources among multiple users or applications in a multiple member environment across multiple systems and managing this through the OS WLM on each system requires too much administration.

- You want to manage the share of CPU resources among multiple users or applications using hard shares to limit certain service classes, even when the CPU is under-utilized, and this is not available in your OS WLM or does not produce the desired result.

How does this new functionality affect Query Patroller and DB2 Governor?

The DB2 workload manager introduces an independent approach to workload management and does not rely on or interact with Query Patroller or DB2 Governor in any way. Query Patroller has been discontinued starting with the Version 10.1 release. DB2 Governor was deprecated in the DB2 Version 9.7 release and, although still functional, it is no longer central to the DB2 workload management strategy. No further investment is planned for DB2 Governor in future releases.

When DB2 9.5 or later is first installed, the default user service class is automatically defined and all incoming work is sent to it for execution. Although DB2 Governor can watch agents in any service class, it is permitted to adjust the agent priority only for agents in the default user service class.

I am not on AIX. Does this mean I do not have any control over processor resources or I/O activity?

Users on all platforms have the same ability to control processor resources and I/O activity between service classes using SQL, such as the CREATE and ALTER SERVICE CLASS statements, for example.

To control CPU usage when the workload management dispatcher is enabled, use the CPU limit attribute of the DB2 service class to limit the amount of CPU resources a service class can consume. If the workload management dispatcher CPU shares (**wlm_disp_cpu_shares**) database manager configuration parameter is also enabled, you can use the CPU shares attribute of the DB2 service class to specify the share of CPU resources that a service class can consume relative to the CPU consumption of other service classes. On AIX and some Linux platforms, you can supplement (or replace) these approaches by taking advantage of the workload management capabilities that are offered by those operating systems to control CPU consumption.

For I/O activity, users on all platforms can set the buffer pool or prefetcher priority attribute of a DB2 service class to a value of high, medium, or low. All service classes run with a medium priority by default.

Can I use AIX or Linux WLM or the DB2 workload management dispatcher to manage I/O activity?

Currently, neither AIX WLM nor Linux WLM support direct I/O activity controls at the thread level. However, it is possible to indirectly control I/O activity by means of concurrency thresholds, or to use the DB2 workload management dispatcher, AIX WLM, or Linux WLM to manipulate CPU resources. The more CPU resource that is available to an executing thread, the less frequently that thread will request I/O resources.

You can influence buffer pool behavior by using the BUFFERPOOL PRIORITY attribute of any DB2 service class. You can also control DB2 prefetcher I/O activity by using the PREFETCH PRIORITY attribute of any DB2 service class.

Can I use AIX or Linux WLM to manage memory use?

DB2 data server uses primarily shared memory, which is accessed by more than one agent from different service classes. For this reason, it is not possible to divide memory allocation between different service classes using either AIX or Linux WLM.

Memory (such as sortheap) that is consumed during the execution of an SQL statement can be indirectly influenced through the use of concurrency thresholds, because consumption does not begin until the statement is allowed to execute. However, unlike I/O activity, restricting CPU consumption does not affect the amount of memory that is consumed. In fact, restricting CPU consumption can exacerbate the memory situation, because queries will be running more slowly and holding onto their allocated memory longer.

Is there a way for WebSphere Application Server to pass the client information fields used by the DB2 workload?

WebSphere Application Server Version 6.0 and Version 6.1 can set or pass in the CLIENT INFO fields to DB2 data server, either explicitly by your applications (see: Passing client information to a database) or implicitly by having WebSphere Application Server do it for you (see: Implicitly set client information).

Can I create multiple CONCURRENTDBCOORDACTIVITIES concurrency thresholds for the same set of work?

You can create one or more CONCURRENTDBCOORDACTIVITIES concurrency thresholds that apply to the same set of activities by defining them at the level of the database, the service class in which the work executes, or within a work action set applied at the database or workload level. Be aware that each new concurrency threshold that applies to an activity implies additional overhead to enforce that concurrency threshold. Verify that you really need more than one concurrency threshold level.

Why is my work not assigned to the correct workload?

There are a number of reasons why a connection may not be mapped to the desired workload. The most common ones are the failure to grant USAGE privilege on the workload, incorrect spelling of the case sensitive connection attributes, or the existence of a matching workload definition that is positioned earlier in the evaluation order.

Before a connection can be assigned to a workload, the connection attributes must match those of the workload definition, and the session authorization ID must have USAGE privilege on the workload. A common omission is to create the workload but not to grant USAGE privilege on the workload to users (See "GRANT (Workload Privileges) statement" in *SQL Reference*). Only users with ACCESSCTRL, SECADM, or WLMADM authority can grant workload usage privilege to other users. Users with ACCESSCTRL, DATAACCESS, DBADM, SECADM, or WLMADM authority have implicit usage privilege on all workloads.

Connection attributes for workloads are case sensitive. For example: If the system user ID is uppercased, then the SYSTEM_USER connection attribute you specify must be in uppercase as well.

To establish why a connection is not being mapped to the expected workload, you should gather some information. Which workload is the work being mapped to? Is that workload before or after the one that you thought would be used when you look at the workload definitions in the order of evaluation? (Hint: try selecting the workload definitions ordered in ascending order by the value of the EVALUATIONORDER column in SYSCAT.WORKLOADS).

If you do not know what the connection attributes are for the target connection, you can find out the values for the connection in a number of different ways:

- Issue a query against the system using the WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES table function while the connection is active
- Open a cursor on a connection and use the WLM_CAPTURE_ACTIVITY_IN_PROGRESS stored procedure against that cursor to have the activity information captured to the activities event monitor (Hint: do not forget to create and activate the activities information event monitor)
- Turn on the collection of detailed activity information for the workload being used by the connection, issue one statement in order to capture the activity information, and then turn off the collection.

Why does DB2 workload manager affect REORGCHK, IMPORT, EXPORT and other CLP commands?

These CLP commands are affected by DB2 workload management thresholds, because the database engine cannot distinguish system requests originating with these utilities from other requests directly initiated by users within the CLP interactive front-end.

Is there a way to change the service class to which an activity is assigned while it is executing?

Yes, you can change the service subclass an activity is executing in to another service subclass within the same parent service superclass by defining a CPUTIMEINSC, DATATAGINSC, or SQLROWSINSC threshold with the REMAP ACTIVITY action on the original service subclass. Initially, DB2 workload management maps an activity to a service class based on the relevant workload definition for the connection, modifies it as required if a work action set exists on that service class, and then sets up the DB2 agent to execute in the assigned service class. When an activity violates a threshold that has a REMAP ACTIVITY action defined, the agent remaps itself to the specified target service subclass (under the same superclass) once the threshold violation has been detected and the activity continues executing in the new service subclass.

Much of my batch work is done using CLP scripts under the same ID, how can I go about uniquely identifying these so I can manage them differently?

You have a couple of options:

An enhancement has been added to CLP so that the client application name is automatically set to the CLP script filename, with a **`CLP`** prefix preceding it (the value of this field at the server can be seen in the CURRENT CLIENT_APPLNAME special register). For example, if the CLP script filename is **`batch.db2`**, the CURRENT CLIENT_APPLNAME special register value is set to **`CLP`**

batch.db2 by CLP when that script is run. With this feature, it is possible for different CLP scripts to be associated with different workloads based on the client application name.

For example, to create a workload for CLP file `batch1.db2`, you can issue the following DDL statement:

```
CREATE WORKLOAD batch1 CURRENT CLIENT_APPLNAME ('CLP batch1.db2')
SERVICE CLASS class1
```

To create a workload for CLP file **batch2.db2**, you can issue the following DDL statement:

```
CREATE WORKLOAD batch2 CURRENT CLIENT_APPLNAME ('CLP batch2.db2')
SERVICE CLASS class2
```

Since these two batch files are associated with different workloads, they can be assigned to different service classes and managed differently.

Another option is the new stored procedure WLM_SET_CLIENT_INFO, which permits you to set the values of any of the client information fields at the server using a simple CALL SQL statement. By inserting a CALL statement into any of your existing CLP scripts, you can uniquely identify them using these fields and map them to different workload definitions.

For more information, see "WLM_SET_CLIENT_INFO procedure" in *Administrative Routines and Views*.

When should I use the COLLECT AGGREGATE ACTIVITY DATA clause versus the COLLECT ACTIVITY DATA clause?

The answer depends on why the monitoring is desired and what is to be done with the information.

Aggregate activity information spans the entire set of work that has executed within the scope covered by the clause, and it captures summary characteristics of this set; it does not capture specific details about individual activities. The COLLECT AGGREGATE ACTIVITY DATA clause can be specified on DB2 workloads, DB2 service classes, and DB2 work action sets. For normal operational monitoring, use the COLLECT AGGREGATE ACTIVITY DATA clause, because it is very lightweight, it can be gathered automatically by the statistics event monitor for a historical record, and it provides important information on overall response time patterns. If further insight is required on a specific type of work, use the COUNT ACTIVITY or COLLECT AGGREGATE ACTIVITY DATA actions within a DB2 work action set to gather more granular information (with minimal overhead) about different types of work executing in a workload, service class, or database.

In contrast, activity information contains detailed information about each and every activity that executes within the scope covered by the COLLECT ACTIVITY DATA clause. This clause can be specified on DB2 workloads, DB2 service classes, DB2 work action sets, and DB2 thresholds. It permits further in-depth analysis of the individual activities that are captured, in order to understand the flow and type of SQL statements submitted by a new application, for example, or to look into performance tuning opportunities with tools such as the Explain facility or the Design Advisor. Because it captures much more information for each activity affected by it, the impact of using this clause is higher on affected activities than other monitoring methods and it should be carefully controlled.

How does DB2 workload management work with the new AIX WPAR feature?

All aspects of DB2 workload management will work within an AIX WPAR but because AIX WPARs do not support the use of AIX WLM features, the option to tightly integrate DB2 service classes with AIX WLM service classes is of no benefit in this environment.

What is the relationship between the DB2_OPT_MAX_TEMP_SIZE registry variable and DB2 thresholds based on SQLTEMPSPACE?

There is no direct relationship between these two things. The **DB2_OPT_MAX_TEMP_SIZE** registry variable is a directive to the query compiler to limit the amount of temporary table space that a query can use. This can cause the optimizer to choose a plan that is more expensive (potentially less efficient) but which uses less space in the system temporary table spaces. A DB2 threshold based on SQLTEMPSPACE does not affect the type of plan chosen by the optimizer. It simply causes DB2 data server to monitor the usage of system temporary table space by that query at each member and generates a threshold violation if the stated limit is exceeded during normal processing.

Now that Query Patroller is discontinued and DB2 Governor is deprecated, how do I migrate to DB2 workload manager?

Following the introduction of DB2 workload manager as the strategic workload management solution in DB2 Version 9.5, Query Patroller has been discontinued in the Version 10.1 release and the DB2 Governor has been deprecated since the DB2 Version 9.7 release and might be removed in a future release.

Although DB2 Governor is still supported in this release, you should begin adopting the new features and capabilities of DB2 workload manager, including those introduced in this release. Note that with DB2 workload manager, you have many more options, and you should explore them, which might require you to rethink your approach to controlling work on your DB2 data server in current workload management terms. The DB2 best practices article Implementing DB2 workload management in a data warehouse contains a supplement that is specifically designed for those who are migrating from Query Patroller. Pertinent task topics are also available in the Related tasks section.

To facilitate migration from DB2 Query Patroller to DB2 workload manager, a sample script (`qpwlmmig.pl`) has been included starting with DB2 V9.7 Fix Pack 1. For additional information, see one of the following tasks for details on how to migrate from Query Patroller to DB2 workload manager:

- Migrating from Query Patroller to DB2 workload manager using the sample script
- Migrating from Query Patroller to DB2 workload manager

What are the licensing requirements for DB2 workload manager?

A subset of the workload management capabilities in DB2 data server has its use restricted through licensing. This licensed subset is referred to as DB2 workload manager, and it controls the creation of any service class, workload, threshold, or work action set. Access to this subset of workload management capabilities requires one of the following licensed products:

- DB2 Enterprise Server Edition for Linux, UNIX, and Windows
- DB2 Advanced Enterprise Server Edition for Linux, UNIX, and Windows
- Database Enterprise Developer Edition for Linux, UNIX, and Windows
- IBM® InfoSphere® Warehouse, all editions
- IBM Smart Analytics System

The following workload management functions are not restricted by license:
- Using or altering the default service classes and workloads; this includes all monitoring capabilities
- Creating, altering, or dropping histogram templates
- Using the DB2 workload management table functions or stored procedures
- Creating, activating, stopping, or dropping workload management event monitors
- Granting, altering, or revoking workload privileges

What information do you get from the different event monitors that are associated with workload management?

The threshold violations, statistics, and activities event monitors capture information about threshold violations, operational statistics and aggregate activity data, and individual activity data (see: "Historical monitoring with WLM event monitors" on page 233).

Each event monitor collects one or more logical data groups (see: "Event type mappings to logical data groups" in *Database Monitoring Guide and Reference*) and there are one or more monitoring elements in each logical data group (see: "Event monitor logical data groups and monitor elements" in *Database Monitoring Guide and Reference*).

For example, to discover what information is collected by the threshold violations event monitor, start by looking in Table 3 in "Event type mappings to logical data groups" topic. This table shows that the threshold violations event monitor collects information into a single logical data group called `event_thresholdviolations` (note that some event monitors, like the activity event monitor, collect information into multiple logical data groups). Next, find the `event_thresholdviolations` logical data group in "Event monitor logical data groups and monitor elements" topic. This topic shows which monitor elements are reported in the `event_thresholdviolations` logical data group, which includes the following:
- **`activate_timestamp`** - Activate timestamp
- **`activity_collected`** - Activity collected
- **`activity_id`** - Activity ID
- **`agent_id`** - Application Handle (agent ID)
- **`appl_id`** - Application ID
- **`coord_partition_num`** - Coordinator partition number
- **`destination_service_class_id`** – Destination service class ID
- **`source_service_class_id`** - Source service class ID
- **`threshold_action`** - Threshold action
- **`threshold_maxvalue`** - Threshold maximum value
- **`threshold_predicate`** - Threshold predicate
- **`threshold_queuesize`** - Threshold queue size

- **thresholdid** - Threshold ID
- **time_of_violation** - Time of violation
- **uow_id** - Unit of work ID

The approach outlined in this example can be used to discover what data is collected by each event monitor.

How do I determine which activities are queued by a workload management threshold and the order of the activities in the queue?

You can do this by first creating a view using the WLM_GET_SERVICE_CLASS_AGENTS table function and then running statements to list the queued activities in the order of the queue entry time. For examples describing how to do this, see: "Example: Determining which activities are queued by a WLM threshold and their queue order" on page 231.

What changes in behavior might I see when I turn ON the workload management dispatcher?

When you turn ON the workload management dispatcher via the **wlm_dispatcher** database manager configuration parameter and if you had been relying on agent priority to prioritize the work of one service class over another, then this agent priority cannot be used while the workload management dispatcher is enabled. As a result, all service classes are treated as if they have the default agent priority.

If you enable CPU shares via the **wlm_disp_cpu_shares** database manager configuration parameter and do not specify CPU shares or CPU limits for your service classes, all service classes receive an equal soft share of the CPU resources on your system. The effect of all service classes receiving an equal soft share of the CPU resources might result in a different allocation of CPU resources to services classes than in previous DB2 releases. As a result, you should consider setting CPU shares or CPU limit values appropriate for your workload. For more information about how to determine values for CPU shares and CPU limits, see: "Workload management dispatcher" on page 161.

With the introduction of the workload management dispatcher, are concurrency thresholds such as CONCURRENTDBCOORDACTIVITIES no longer needed or useful?

The DB2 workload management dispatcher and concurrency thresholds can be used together. Concurrency thresholds are still very useful for controlling how much work is running. For each activity that starts running, the DB2 database manager provides other resources to that activity, in addition to CPU resources, which the activity usually retains for as long as it is running. Such non-CPU resources include (among others) the DB2 agent, sort memory, temporary table space, locks, and I/O. By preventing an activity from starting to run, those additional non-CPU resources are not consumed and are available for other activities.

In addition, concurrency thresholds can be applied at different points within the DB2 database manager to determine the origin of the work that is running. For example, putting a concurrency threshold on large queries coming from a specific workload limits the consumption or share of the resources available to that particular workload in a service class, as compared to other workloads contributing to the same service class.

In summary, concurrency thresholds can be used to control when activities start to run and consume the CPU and non-CPU resources on the system. The workload management dispatcher can be used to control how much of the CPU resources such activities get to consume once they start running.

Why would I ever want to use AIX WLM or Linux WLM?

Even if you use the DB2 workload management dispatcher for controlling the CPU consumption of your DB2 workloads, the following are reasons to use AIX WLM or Linux WLM as well:

- Operating system (OS) workload managers provide monitoring of resource consumption at the level of the operating system.
- OS workload managers can provide control for all processes or threads on the entire host or LPAR, not just DB2 database manager threads. This can help when there is a need to control processes that compete for resources with DB2 database manager.

Chapter 2. Work identification

A key part of successfully implementing a DB2 workload management solution is identifying the work.

There are three approaches to work identification: workloads, work classes, and data tags.

- Workloads can be used to identify the source of work. You can identify the source at the connection or transaction level by using key session attributes, such as the application name or the system authorization ID that submitted the work, for example.
- A work class enables you to identify work by pinpointing certain characteristics of the work. You can define a work class to identify the work of interest, such as statements that only modify data on the data server, for example (INSERT, UPDATE, or DELETE statements, for example).
- Data tags are available as table space and storage group data tags. They enable you to identify work indirectly by the type of data it accesses during execution. By tagging data of interest, you can identify the work that is accessing that data.

Activities

One way that you can monitor and control workloads is on the basis of individual activities. Each time your DB2 data server executes the access plan for an SQL or XQuery statement or executes the load utility a corresponding activity is created.

For workload monitoring, commonly used monitor elements provide information in terms of activity units. For example, you can obtain information about the workload volume and response time from monitor elements such as the activity execution time monitor element (coord_act_exec_time) and the high watermark for the concurrent activities (concurrent_act_top).

For workload control, most workload controls and thresholds apply to each activity. For example, the ACTIVITYTOTALTIME threshold controls the maximum time that your data server can spend processing an activity.

Statements or commands that trigger activities on your data server

The following statements or commands trigger activities on your data server:

- All DML statements
- All DDL statements
- The CALL statement
- The load utility

The life cycle of activities

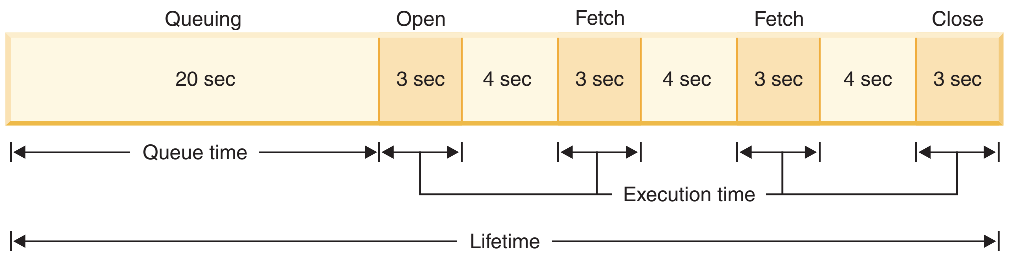
The life cycle of an activity for a DML statement does not include processing that occurs before or outside of access plan execution. This implies that activity-based monitoring does not cover operations such as connecting to the database or compiling SQL into an access plan.

During its life cycle, an activity can spend time in various states, which are reported by the activity_state event monitor element. Some of the states an activity can be in are:

- EXECUTING - This state indicates that the coordinator agent is working on the activity. An activity that encounters a lock wait situation is reported as executing.
- IDLE - This state indicates that the coordinator agent is waiting for the next request from a client.
- QUEUED - Some thresholds include a built-in queue. This state indicates that the activity is waiting in the queue for its turn to begin executing.

Monitoring data for the activity is aggregated at the end of the lifetime of an activity.

The following figure shows how the lifetime of a long running query breaks down into queue time and execution time:



Types of SQL statements and application development

This section describes what activities are created for various SQL statements and identifies the start and end points in the lifetime of these activities. You can use this information to understand how SQL statements are monitored and controlled through activities.

SELECT statements: A SELECT statement is represented by one activity. This includes any cursor requests such as FETCH operations and subselects or subqueries. The activity starts when your DB2 data server starts processing an OPEN cursor statement or request, and ends when your data server has completed processing for a CLOSE cursor statement or request.

SELECT statements using WITH HOLD cursors: When a WITH HOLD cursor is used, an application can open a cursor within one unit of work and close the cursor in a subsequent unit of work. The cursor remains open for multiple units of work. The corresponding activity exists for as long as the cursor is open, because the life cycle of the activity ends only after the cursor is closed.

CALL statement and stored procedures: A CALL statement itself is represented by one activity, but the payload of the stored procedure can spawn nested activities as follows:

Table 1. Contents of stored procedures and activities they create

Contents of stored procedure	**Additional activities created**
A single SQL statement	One
No SQL statements in the stored procedure	0
SQL procedures, multiple SQL statements, and looping logic	Multiple activities, one corresponding to each invocation of each statement

Table 1. Contents of stored procedures and activities they create (continued)

Contents of stored procedure	Additional activities created
A call to another stored procedure	Activities for that stored procedure

The activity associated with the CALL statement starts when your DB2 data server starts processing the statement or request and ends after the stored procedure processing is complete.

Triggers and UDFs: When a SQL statement calls a trigger or UDF, no additional activity is created. The work done by that trigger or UDF is accrued to the activity for the SQL statement that called it. Cases where the trigger or UDF executes additional SQL statements are handled like any statement execution, that is, an activity is created for each statement.

PREPARE statement: No activity is created, because activities are not created until an access plan is executed.

Nested activities

Nested activities do not significantly affect activity-based monitoring and control of workloads, but some additional information applies.

Activities that can have nested activities within them are:

- A stored procedure
- An anonymous block
- An autonomous routine
- A DML activity that executes a UDF
- A load from cursor (a load activity that has the cursor activity nested within it)
- A DML activity that is subject to a trigger that contains any of the activities listed previously as part of the trigger definition

Nested activities are reported in monitoring information as follows:

- A nested activity is indicated by a nonzero parent UOW ID and a nonzero parent activity ID.
- A nested activity is not counted towards histograms or any statistics derived from histograms.
- Data for a nested activity is not also reported as part of the metrics for the parent activity. For example, if a procedure executed by a CALL statement performs an insert which consumes 10 seconds of processor time, that processor time is counted only towards the processor time metric for the insert activity and does not count towards the processor time metric for the parent CALL activity.

Workload control considers nested activities as follows:

- An activity nested inside a UDF or trigger does not contribute to the CONCURRENTDBCOORDACTIVITIES threshold.
- A cursor activity nested within a load activity does not contribute to the CONCURRENTDBCOORDACTIVITIES threshold.

Activities and the load utility

Running the load utility will generate several activities, one of which is a load activity and several others that are of type READ, WRITE, or OTHER. In the case of a load from cursor, an additional activity for the cursor the load activity is loading from is created. This cursor activity is a nested activity of the load activity.

Activities event monitoring

When monitoring activities with an activities event monitor in a multimember database environment, you must be aware of how activity event information is captured. If you are capturing activity events on all members, you might see more than one event for a given activity on members other than the coordinator. Multiple records per activity might be recorded because the activity might come and go on the remote members, depending on the sequencing of events in a section (the executable form of an SQL statement). As a result, multiple records might be captured for the activity on a non-coordinating member. To understand the processing performed by the activity on the remote member, you must consider all the records for the activity. For example, you might want to aggregate metrics from all records for the activity on the remote member.

By contrast, the activity would be recorded only once in the event data collected on the coordinating member.

Workload management DDL statements

Workload management DDL statements consist of the CREATE, ALTER, and DROP statements that you use to work with service classes, workloads, work class sets, work action sets, thresholds, and histograms.

The DB2 workload management DDL statements are as follows:
- CREATE SERVICE CLASS, ALTER SERVICE CLASS, and DROP SERVICE CLASS
- CREATE WORKLOAD, ALTER WORKLOAD, and DROP WORKLOAD
- GRANT USAGE ON WORKLOAD and REVOKE USAGE ON WORKLOAD
- CREATE THRESHOLD, ALTER THRESHOLD, and DROP THRESHOLD
- CREATE WORK CLASS SET, ALTER WORK CLASS SET, and DROP WORK CLASS SET
- CREATE WORK ACTION SET, ALTER WORK ACTION SET, and DROP WORK ACTION SET
- CREATE HISTOGRAM TEMPLATE, ALTER HISTOGRAM TEMPLATE, and DROP HISTOGRAM TEMPLATE

Workload management DDL statements differ from other DB2 DDL statements:
- Only one uncommitted workload management DDL statement is permitted at a time across all database members. If an uncommitted workload management DDL statement exists, subsequent workload management DDL statements wait until the uncommitted workload management DDL statement is either committed or rolled back. Workload management DDL statements are processed in the order in which they are issued.
- Every workload management DDL statement must be followed by a COMMIT or ROLLBACK statement.

- A workload management DDL statement cannot be issued in an XA transaction. After a connection issues a workload management DDL statement, the same connection must issue a COMMIT or ROLLBACK statement immediately after the workload management DDL statement. With XA transactions, it is possible for multiple connections to join a transaction, and any of the connections can commit or roll back the transaction. In this situation, it is impossible to ensure that the workload management environment would be correctly implemented.
- DB2 for z/OS® does not recognize DB2 Database for Linux, UNIX, and Windows workload management DDL statements.

Work identification by origin with workloads

Workloads identify incoming work based on its source so that it can later be monitored or managed by DB2 workload management independently of all other work. The source is determined using the attributes of the database connection under which the work is submitted.

The attributes of a connection are first evaluated when the connection is established and the connection is matched to a workload definition. This relationship between a connection and a specific workload definition is called a *workload occurrence*. If any of the attributes change during the life of that connection, the workload assignment is reevaluated at the start of the next unit of work following the change. If a new workload definition is found to be a better match for the connection at this time, the old workload occurrence (for the previously assigned workload) ends and a new occurrence starts for the newly assigned workload definition. Although each connection is assigned to one and only one workload at a time, there can be multiple connections (workload occurrences) assigned to the same workload definition simultaneously. For more information, see "Workload assignment" on page 23.

For example, to assign all connections created by the application `Accounts` to a workload REPORTING, which maps the activities under those connections to run in the `Marketing` service class, issue a CREATE WORKLOAD statement such as the following:

```
CREATE WORKLOAD REPORTING APPLNAME('Accounts') SERVICE CLASS Marketing
```

This creates the following workload:

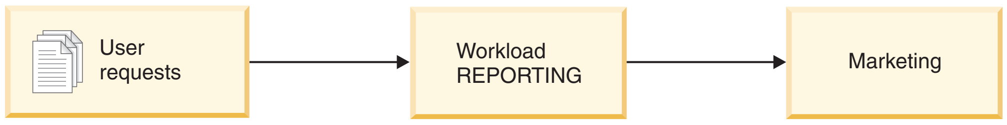


Figure 2. The REPORTING workload

Then grant the USAGE privilege on the REPORTING workload to PUBLIC:

```
GRANT USAGE ON WORKLOAD REPORTING TO PUBLIC
```

To assign all activities created by the application `Accounts` under the connections that belong to the session user group `Deptmgr` to the SUMMARY workload, which maps the activities to the `HumanResources` service class, issue a statement such as the following:

```
CREATE WORKLOAD SUMMARY SESSION_USER_GROUP('Deptmgr') APPLNAME('Accounts')
SERVICE CLASS HumanResources
```

This creates the following workload:

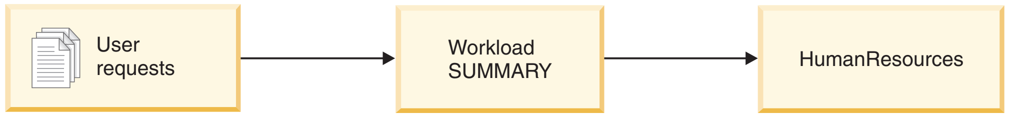


Figure 3. The SUMMARY workload

Then grant the USAGE privilege on the SUMMARY workload to PUBLIC:

```
GRANT USAGE ON WORKLOAD SUMMARY TO PUBLIC
```

You can view your workload definitions by querying the SYSCAT.WORKLOADS view, and you can view the connection attributes that you specified for each workload by querying the SYSCAT.WORKLOADCONNATTR view. You can view who is authorized to use a workload by querying the SYSCAT.WORKLOADAUTH view. To see what workload occurrences exist on the system at any point in time, use the WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES or MON_GET_WORKLOAD table function.

SYSDEFAULTUSERWORKLOAD is the default workload. Any connection that is not assigned to a custom-defined workload during workload evaluation is assigned to this default workload, which ensures that all database connections are associated with a workload. Work assigned to the default workload SYSDEFAULTUSERWORKLOAD is executed in the SYSDEFAULTUSERCLASS service class by default.

Supported database connection attributes

You must specify at least one database connection attribute in the workload definition, and each connection attribute can have one or more values. If you do not specify a value for a specific connection attribute in the workload definition, the data server does not examine that attribute during workload evaluation.

Table 2. Connection attributes in a workload definition

Connection attribute	**Description**
Address	The actual communication address used by the client to communicate with the database server. The only protocol supported is TCP/IP. The address must be an IPv4 address, an IPv6 address, or a secure domain name.
Application name	The name of the application running at the client, as known to the data server. The application name is equivalent to the value shown in the `Application name` field in the system monitor output. See the **`appl_name`** monitor element for more information.
System authorization ID	The authorization ID of the user who connected to the database, as set in the SYSTEM_USER special register. You can change the value of SYSTEM_USER by connecting as a user with a different authorization ID.

Table 2. Connection attributes in a workload definition (continued)

Connection attribute	**Description**
Session authorization ID	The authorization ID that is used for the current session of the application, as set in the SESSION_USER special register. You can change the value of SESSION_USER by using a trusted context or the SET SESSION AUTHORIZATION statement.
Group of session authorization ID	The groups to which the current session user belongs.
Role of session authorization ID	The roles granted to the current session user.
Client user ID	The client user ID from the client information as set in the CURRENT CLIENT_USERID (or CLIENT USERID) special register. You can change the value of the client user ID by using one of the defined mechanisms provided by specific DB2 clients, the sqleseti (set client information) API, or the WLM_SET_CLIENT_INFO procedure.
Client application name	The application name from the client information as set in the CURRENT CLIENT_APPLNAME (or CLIENT APPLNAME) special register. You can change the value of the client application name by using one of the defined mechanisms provided by specific DB2 clients, the sqleseti API, or the WLM_SET_CLIENT_INFO procedure.
Client workstation name	The workstation name from the client information as set in the CURRENT CLIENT_WRKSTNNAME (or CLIENT WRKSTNNAME) special register. You can change the value of the client workstation name by using one of the defined mechanisms provided by specific DB2 clients, the sqleseti API, or the WLM_SET_CLIENT_INFO procedure.
Client accounting string	The accounting string from the client information as set in the CURRENT CLIENT_ACCTNG (or CLIENT ACCTNG) special register. You can change the value of the client accounting string by using the sqleseti API or the WLM_SET_CLIENT_INFO procedure.

Use of wild cards in connection attributes

Some connection attributes support the specification of an asterisk (*) as a wild card in the CREATE WORKLOAD and ALTER WORKLOAD statements. You can use wild cards in situations where a connection attribute can take on several similar values, which can be matched by a regular expression using wild cards, without defining connection attributes for each of the possible values.

The wild card asterisk (*) matches zero or more characters. If you need to match an asterisk, use a double asterisk (**) to specify the asterisk as a literal character.

For example: If you have several accounts receivable applications (*accrec01, accrec02 ... accrec15*) that you all want to belong to the same workload for equal treatment by DB2 workload manager, define the *CURRENT CLIENT_APPLNAME('accrec*')* connection attribute to match all of these applications when you create or alter your workload. Similarly, an *acc*rec* accounts receivable application (a name that includes an asterisk character) is matched by the *CURRENT CLIENT_APPLNAME('acc**rec')* connection attribute.

The following workload connection attributes support the use of wild cards:
- APPLNAME
- CURRENT CLIENT_ACCTNG
- CURRENT CLIENT_APPLNAME
- CURRENT CLIENT_USERID
- CURRENT CLIENT_WRKSTNNAME

Set client information to identify requests

By default, many application servers set up connections with the same information and pass the same client information, if any, for all client requests that they handle. Some products, such as WebSphere and Cognos®, provide a facility to push down unique information about each request through the client information fields. This information uniquely identifies the end-user request within DB2. Most other products provide a way for the application server to be customized so that unique client information can be sent to DB2 prior to the start of processing an end-user request.

Specifying unique client attributes from the application server enables the specialized treatment of requests within DB2 and the assignment of requests from different clients to different workloads (and to different service classes).

Connection attribute evaluation order

As you analyze the usage characteristics of your environment, you can use the CREATE WORKLOAD statement to create your own workloads and map them to specific service classes. When you create the workload, you define both the values that are used to evaluate the connection attributes during workload assignment and the order in which the workload is evaluated relative to other workloads. Because more than one workload can match incoming connection attributes, being able to change the evaluation order enables you to determine which matching workload is chosen. Whether or not the session user has the USAGE privilege on the workload also determines which matching workload is chosen. For more information, see “Workload assignment” on page 23.

The following figure shows multiple requests being evaluated against workloads in the order A, B, C, and D, then assigned to specific workloads and executed in the applicable service class. Requests that cannot be matched to an existing workload are matched to the SYSDEFAULTUSERWORKLOAD workload. For information about the types of activities that run in the default maintenance class and default system class, see “Default service superclasses and subclasses” on page 70.

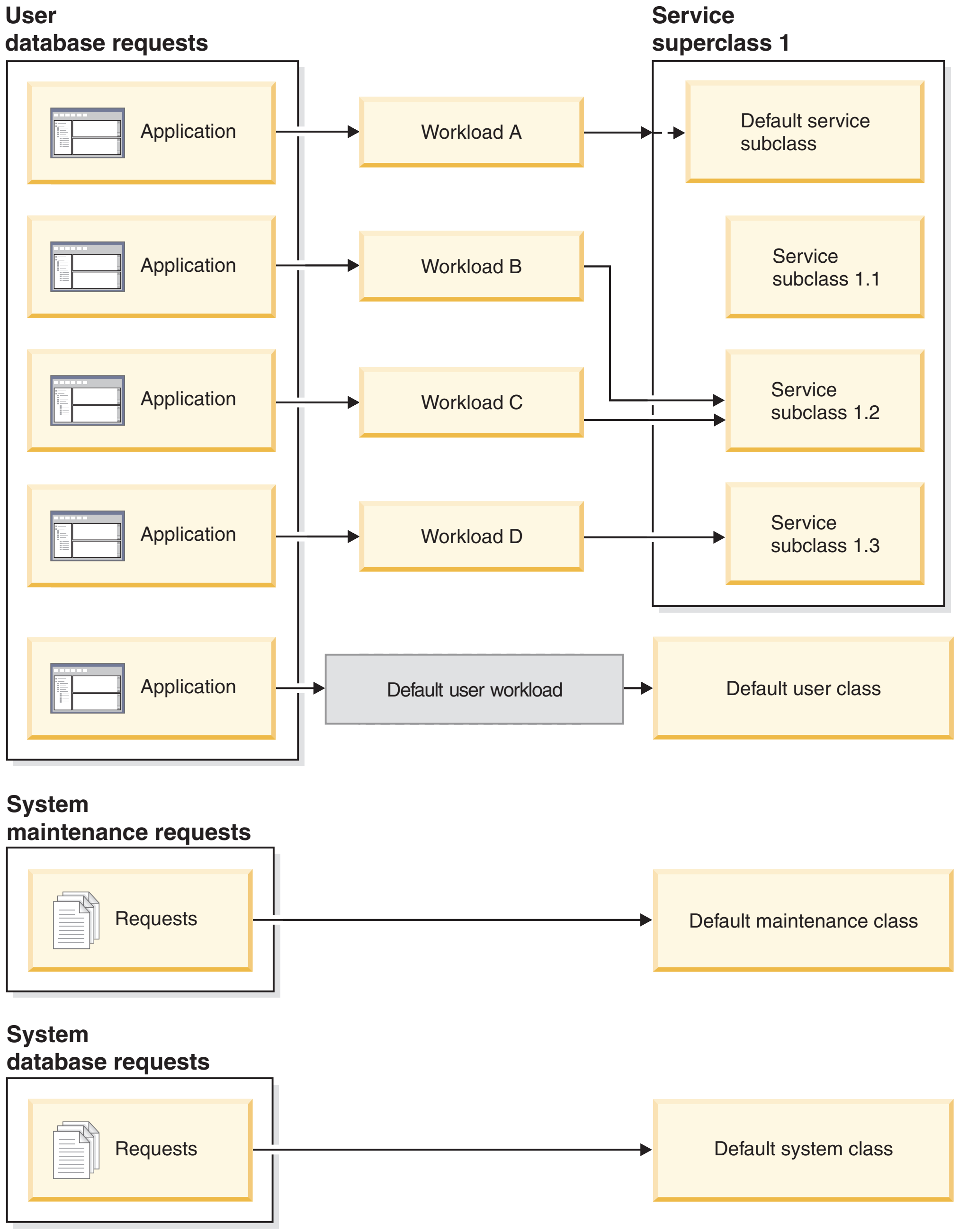


Figure 4. Service classes and workloads

Workload assignment

At the beginning of the first unit of work after a database connection is established, the data server assigns the connection to a workload by evaluating the connection attributes of each workload that is enabled.

The order in which the workloads are evaluated is determined by the EVALUATIONORDER column value of each workload in the SYSCAT.WORKLOADS table. If a workload with matching connection attributes is found, the data server checks whether the current session user has the USAGE privilege on the workload. If the user has the USAGE privilege on the matching workload, the workload assignment is complete, and the connection is assigned to that workload. If the user does not have the USAGE privilege on the matching workload, the data server continues to evaluate workloads until it finds a matching workload on which the session user has the USAGE privilege. If no matching workload is found, the data server attempts to use the SYSDEFAULTUSERWORKLOAD workload. If the current session user does not have the USAGE privilege on that workload, SQL4707N is returned, and the unit of work is rejected. Otherwise, the connection is assigned to the SYSDEFAULTUSERWORKLOAD workload.

You can set the evaluation order by using the POSITION keyword of the CREATE WORKLOAD or ALTER WORKLOAD statement, as follows:

- By specifying the absolute position of the workload in the evaluation order, as shown in the following example:

  ```
  CREATE WORKLOAD...POSITION AT 2
  ```

  POSITION AT 2 means that the workload is to be positioned second in the evaluation order. A matching workload that is positioned higher in the evaluation order is evaluated first. That is, if the workloads at both position 2 and position 3 match, the workload at position 2 is evaluated before the workload at position 3.

  If the position that you specify on the CREATE WORKLOAD or ALTER WORKLOAD statement is greater than the total number of existing workloads, the workload is positioned next to last in the evaluation order, before the SYSDEFAULTUSERWORKLOAD workload. The effect is the same as specifying POSITION LAST on the CREATE WORKLOAD or ALTER WORKLOAD statement.
- By using the POSITION BEFORE *workload-name* or POSITION AFTER *workload-name* keyword, where *workload-name* is an existing workload. This keyword specifies the position of a new or altered workload relative to another workload in the evaluation order, as shown in the following example:

  ```
  ALTER WORKLOAD...POSITION BEFORE workload2
  ```

If you do not specify the POSITION keyword, by default, the new workload is positioned after the other defined workloads in the evaluation order but before the SYSDEFAULTUSERWORKLOAD workload, which is always considered last.

Workload reassignment

A connection can potentially change its assigned workload at each unit of work boundary if one of its connection attributes or the set of workload definitions changes. A unit of work boundary is the point when a connection disassociates with its current transaction. The following events cause a unit of work boundary: Commit, rollback, XA end (success), XA commit, and XA rollback.

The workload assignment is reevaluated at the beginning of a new unit of work if the data server detects that one of the following events occurred:

- A relevant connection attribute changed. See the table in “Work identification by origin with workloads” on page 19 for a list of connection attributes that you can specify in a workload definition. Workload reevaluation also occurs if the current session authorization ID changes because the database connection switches because of a trusted context. For more information, see Trusted contexts and trusted connections.
- You created or altered a workload.

- You granted the USAGE privilege on a workload to a user, a group, or a role or revoked the USAGE privilege on a workload from a user, group, or role.

A connection cannot be reassigned to a different workload while an activity that spans a unit of work boundary is still active. An activity can be an operation that maintains resources across multiple UOWs, such as a load operation, a stored procedure or table function, or a WITH HOLD cursor. The current workload occurrence runs until all activities complete. The workload reassignment then occurs at the beginning of the next unit of work.

An attempted workload assignment or reassignment results in an SQL4707N error if either of the following cases exists:
- The data server attempts to assign the connection to a workload that is dispermitted access to the database. For more information, see "Preventing occurrences of a workload from accessing the database" on page 36.
- The data server attempts to assign the connection to the SYSDEFAULTUSERWORKLOAD workload, but the current session user does not have the USAGE privilege on this workload.

If you have ACCESSCTRL, DATAACCESS, DBADM, SECADM, or WLMADM authority, you can assign your database connection to the SYSDEFAULTADMWORKLOAD workload, the default administrator workload. See "Taking corrective action using the default administration workload" on page 28 for more information.

XA transactions and workload reassignment

XA calls such as XA_END (success), XA commit, and XA rollback issue a DB2 COMMIT or ROLLBACK, which indicates the end of a unit of work. Because workload reevaluation can occur at the beginning of a unit of work, these XA calls can initiate workload reevaluation, although the reason for workload reevaluation is not directly related to the XA transaction itself.

Default workloads

The default user workload SYSDEFAULTUSERWORKLOAD provides a workload for your data server to which all connections are assigned initially. The default administration workload SYSDEFAULTADMWORKLOAD permits you to take corrective administrative action that cannot otherwise be performed. Both workloads are created at database creation time and you cannot drop them.

The default user workload (SYSDEFAULTUSERWORKLOAD)

Connections that are assigned to the default user workload are mapped to the default user service superclass SYSDEFAULTUSERCLASS, which provides the default execution environment. You can map connections to user-defined service classes by creating user defined workloads. In addition, you can alter SYSDEFAULTUSERWORKLOAD so that it maps connections to a different service class than SYSDEFAULTUSERCLASS.

You can view the SYSDEFAULTUSERWORKLOAD workload by querying the SYSCAT.WORKLOADS table.

The following table shows shows the columns returned for the SYSDEFAULTUSERWORKLOAD workload in the SYSCAT.WORKLOADS view, along with values and whether you can modify these values. See "Workload assignment” on page 23 for information on how to assign a connection to the SYSDEFAULTUSERWORKLOAD workload.

Table 3. SYSDEFAULTUSERWORKLOAD entry in SYSCAT.WORKLOADS

Column	**Value**	**Modifiable using the ALTER WORKLOAD statement if you have DBADM or WLMADM authority (and SQLADM for COLLECT clauses)**
WORKLOADID	1	No
WORKLOADNAME	SYSDEFAULTUSERWORKLOAD	No
EVALUATIONORDER	Second last one	No
CREATE_TIME	Timestamp of database creation	No
ALTER_TIME	Timestamp of the last update of the workload definition	No (but the data server modifies this column when you update the workload definition)
ENABLED	Y	No
ALLOWACCESS	Y	Yes
SERVICECLASSNAME	SYSDEFAULTSUBCLASS	Yes
PARENTSERVICECLASSNAME	SYSDEFAULTUSERCLASS	Yes
COLLECTAGGACTDATA	N	Yes
COLLECTACTDATA	N	Yes
COLLECTACTPARTITION	C	Yes
COLLECTDEADLOCK	W	Yes
COLLECTLOCKTIMEOUT	W	Yes
COLLECTLOCKWAIT	N	Yes
LOCKWAITVALUE	0	Yes
COLLECTACTMETRICS	N	Yes
COLLECTUOWDATA	N	Yes
EXTERNALNAME	NULL	No
REMARKS	BLANK	Yes

For more information, see SYSCAT.WORKLOADS.

The default administration workload (SYSDEFAULTADMWORKLOAD)

This workload permits ACCESSCTRL, DATAACCESS, DBADM, SECADM, or WLMADM users to query the database and perform administrative or monitoring tasks at any time, but is typically used in cases when:

- The workload to which the administrator is assigned is not permitted to access the database (that is, the DISALLOW DB ACCESS keyword of the CREATE WORKLOAD or ALTER WORKLOAD statement was specified for the workload).
- A threshold was violated, preventing the administrator from performing work on the database.

The SYSDEFAULTADMWORKLOAD workload differs from other workloads in the following ways:

- You cannot drop or disable it.
- You cannot specify DISALLOW DB ACCESS for it.
- None of the thresholds apply to occurrences of this workload and the activities in it.
- You can run this workload only in the SYSDEFAULTUSERCLASS service superclass. See “Default service superclasses and subclasses” on page 70 for more information.
- You can assign a connection to this workload by using the **`SET WORKLOAD`** command from the CLP interface, or by invoking the WLM_SET_CLIENT_INFO stored procedure (and specifying `SYSDEFAULTADMWORKLOAD` for the **`client_workload`** parameter). For more information, see “Taking corrective action using the default administration workload” on page 28.

You can view the SYSDEFAULTADMWORKLOAD workload by querying the SYSCAT.WORKLOADS table. The following table shows the columns returned for the SYSDEFAULTADMWORKLOAD workload in the SYSCAT.WORKLOADS catalog view, along with values and whether you can modify these values:

Table 4. SYSDEFAULTADMWORKLOAD entry in SYSCAT.WORKLOADS

Column	Value	Modifiable using the ALTER WORKLOAD statement if you have DBADM or WLMADM authority (and SQLADM for COLLECT clauses)
WORKLOADID	2	No
WORKLOADNAME	SYSDEFAULTADMWORKLOAD	No
EVALUATIONORDER	Last one	No
CREATE_TIME	Timestamp of database creation	No
ALTER_TIME	Timestamp of the last update of the workload definition	No (but the data server modifies this column when you update the workload definition)
ENABLED	Y	No
ALLOWACCESS	Y	No
SERVICECLASSNAME	SYSDEFAULTSUBCLASS	No
PARENTSERVICECLASSNAME	SYSDEFAULTUSERCLASS	No
COLLECTAGGACTDATA	N	Yes
COLLECTACTDATA	N	Yes
COLLECTACTPARTITION	C	Yes
COLLECTDEADLOCK	W	Yes
COLLECTLOCKTIMEOUT	W	Yes
COLLECTLOCKWAIT	N	Yes
LOCKWAITVALUE	0	Yes
COLLECTACTMETRICS	N	Yes
COLLECTUOWDATA	N	Yes
EXTERNALNAME	NULL	No
REMARKS	BLANK	Yes

For more information, see SYSCAT.WORKLOADS.

Taking corrective action using the default administration workload

The default administration workload SYSDEFAULTADMWORKLOAD is a special DB2-supplied workload definition that is not subject to any DB2 thresholds. Use this workload to take corrective action that cannot otherwise be performed, such as altering prohibitive threshold definitions that prevent all activities from running in a workload.

Before you begin

Use the SET WORKLOAD command (or the WLM_SET_CLIENT_INFO procedure) to assign a connection to the default administration workload SYSDEFAULTADMWORKLOAD.

Although you require no special authority to use the **SET WORKLOAD** command, you require ACCESSCTRL, DATAACCESS, DBADM, SECADM, or WLMADM authority to assign a connection to the default administration workload. Otherwise, SQL0552N is returned during workload assignment.

About this task

Because this workload is not affected by thresholds, it has limited workload management control and is not recommended for use in submitting regular day-to-day work.

Procedure

To assign a connection to the default administration workload, issue the **SET WORKLOAD** command as follows:

```
SET WORKLOAD TO SYSDEFAULTADMWORKLOAD
```

When the command takes effect depends on when you issue it:

- If you issue the SET WORKLOAD TO SYSDEFAULTADMWORKLOAD command before the connection to the database, after the connection is established, it is assigned to SYSDEFAULTADMWORKLOAD at the beginning of the first unit of work.
- If you issue the SET WORKLOAD TO SYSDEFAULTADMWORKLOAD command at the beginning of a unit of work, after a connection to the database is established, the connection is assigned to SYSDEFAULTADMWORKLOAD when the first request that is not an sqleseti (Set Client Information) request is submitted.
- If you issue the SET WORKLOAD TO SYSDEFAULTADMWORKLOAD command at the middle of a unit of work, after a connection is established, the connection is assigned to SYSDEFAULTADMWORKLOAD at the beginning of the next unit of work.

When a connection is assigned to SYSDEFAULTADMWORKLOAD, workload reassignment is performed at the beginning of the next unit of work if either of the following situations occurs:

- You revoke SYSADM or DBADM authority from the session user. In this situation, SQL0552N is returned.
- You issue a SET WORKLOAD TO AUTOMATIC command. This command indicates that the next unit of work should not be assigned to the

SYSDEFAULTADMWORKLOAD workload and that a normal workload evaluation is to be performed at the beginning of the next unit of work. For more information, see “Workload assignment” on page 23.

Example

The following example shows how you can use the SYSDEFAULTADMWORKLOAD workload to take corrective action when no other corrective action is possible.

If you create a severely prohibitive concurrency threshold so that no activities can execute, because the threshold is always being exceeded, the same threshold can prevent you from correcting the problem. To be able to alter the prohibitive threshold, you must first set the workload so that the work runs in the default administration workload. Because activities running in this workload are not subject to thresholds, you can correct the problem and set the workload (for your ID) back to the default behavior.

The threshold that is the cause of the problem is created accidentally with the following statement. Concurrency should have been set to 100 but was set to 0. This threshold effectively prevents any activity from executing:

```
CREATE THRESHOLD PROHIBITIVE FOR DATABASE ACTIVITIES
   ENFORCEMENT DATABASE WHEN CONCURRENTDBCOORDACTIVITIES > 0
   STOP EXECUTION
```

Note: This statement is intended only to show you how a severely prohibitive threshold might be created. You should not issue this statement.

If you attempt to execute even just a simple SELECT statement, an error is returned, because concurrency is set to 0:

```
SELECT * FROM SYSCAT.TABLES

SQL4712N  The threshold "PROHIBITIVE" has been exceeded.  Reason code = "6".
SQLSTATE=5U026
```

Before you can take corrective action, you must set the workload to the default administration workload:

```
SET WORKLOAD TO SYSDEFAULTADMWORKLOAD
```

This statement can be issued only by someone with ACCESSCTRL, DATAACCESS, DBADM, SECADM, or WLMADM authority and causes any connection to be assigned to the SYSDEFAULTADMWORKLOAD workload, where activities are not subject to the prohibitive threshold.

The problem can now be corrected by altering the threshold so that activities can run:

```
ALTER THRESHOLD PROHIBITIVE WHEN CONCURRENTDBCOORDACTIVITIES > 100 STOP EXECUTION
```

Once corrected, change the workload back so that the connection will no longer be assigned to SYSDEFAULTADMWORKLOAD but to whatever workload it was assigned to before:

```
SET WORKLOAD TO AUTOMATIC
```

The same SELECT statement used before should now complete successfully:

```
SELECT * FROM SYSCAT.TABLES

...

DB20000I  The SQL command completed successfully.
```

Creating a workload

Use a CREATE WORKLOAD statement to add a workload to the catalogs.

Before you begin

To create a workload, you require WLMADM or DBADM authority.

See the following topics for more information about prerequisites:
- "Workload management DDL statements" on page 18
- Appendix A, "General naming rules," on page 491

Procedure

To create a workload:
1. Specify one or more of the following properties for the workload using the CREATE WORKLOAD statement:
   - The name of the workload.
   - The connection attributes. The incoming connection must supply matching connection attributes to those that you specified for the workload for a match to occur. For more information, see "Work identification by origin with workloads" on page 19. When specifying the connection attributes, note that values are ORed and attributes are ANDed: for example, UserID (bob OR sue OR frank) AND Application (SAS).
   - A value that indicates whether occurrences of this workload are permitted to access the database. By default, occurrences of this workload are permitted to access the database.
   - A value that indicates whether the workload is enabled or disabled. By default, the workload is enabled.
   - The service class where work submitted by occurrences of this workload is to be executed. The SYSDEFAULTUSERCLASS service superclass is the default. If you specify a user-defined service superclass, the work submitted by the workload occurrences runs in the SYSDEFAULTSUBCLASS service subclass of the service superclass.

     Note: You cannot specify the SYSDEFAULTSUBCLASS service subclass under any service superclass, including the SYSDEFAULTUSERCLASS service superclass.
     If you have defined a workload to point to a service superclass but do not want work submitted by it to run in the default SYSDEFAULTSUBCLASS service subclass, you can either change the workload definition to point directly to a user-defined service subclass or you can use a work action set defined on the service superclass to map individual pieces of work to a different service subclass. For more information, see "Work actions and work action sets" on page 96.
   - The position of the workload relative to other workloads when cached in the memory. The position of the new workload determines the order in which it is evaluated during workload assignment. By default, the new workload is

positioned last, which means that it is evaluated last, immediately before the default user workload is considered. For more information, see “Workload assignment” on page 23.

- The monitoring activity metrics collection level for activities submitted by connections associated with this workload. The default activity metrics collection setting for a workload is NONE. Note that the effective activity collection setting for activities is the combination of both the workload activity metrics collection level and the **`mon_act_metrics`** database configuration parameter.
- The type of activity information to collect. By default, no information for activities associated with the workload is sent to an activities event monitor.
- The aggregate activity information to collect. The aggregate activity information used for the workload only changes after the CREATE WORKLOAD operation is committed.
- The lock timeout events information to collect. By default, data about a lock event is sent to the locking event monitor, if one is active, when the lock event occurs, but previous lock timeout events are not sent (WITHOUT HISTORY).
- The deadlock information to collect. By default, data about a deadlock event is sent to the locking event monitor, if one is active, when the deadlock event occurs, but previous deadlock events are not sent (WITHOUT HISTORY).
- The lock wait information to collect. By default, no lock wait information is collected if a lock is not acquired within the set wait time.
- The unit of work information for each transaction associated with this workload to send to the unit of work event monitor, if one is active, when a unit of work ends. By default, no unit of work information is sent.
- The histogram templates that the workload should use as templates for its histograms. The histogram templates specified are reflected in the SYSCAT.HISTOGRAMTEMPLATEUSE view. For more information about histograms and histogram templates, see “Histograms in workload management” on page 253.

2. Commit your changes. When you commit your changes the workload is added to the SYSCAT.WORKLOADS view. Committing the change causes a workload re-evaluation to take place at the beginning of the next unit of work of each application. Depending on which workload is chosen, the application might be reassigned to a different workload.

What to do next

After you create a workload, you might need to grant the USAGE privilege on it to one or more session users. (Session users with WLMADM or DBADM authority have an implicit privilege to use any workload.) Even if a connection provides an exact match to the connection attributes of the workload, if the session user does not have the USAGE privilege on the workload, the data server does not consider the workload when performing workload evaluation. For more information, see “Granting the USAGE privilege on a workload” on page 36.

Altering a workload

An ALTER WORKLOAD statement changes a workload in the catalogs.

Before you begin

To alter a workload, you require SQLADM, WLMADM, or DBADM authority. To specify any clause other than a COLLECT clause, the authorization id must include WLMADM or DBADM authority.

See "Workload management DDL statements" on page 18 for more information about prerequisites.

Procedure

To alter a workload:

1. Specify one or more of the following properties for the workload using the ALTER WORKLOAD statement:
   - The connection attributes. You can add connection attributes to and drop connection attributes from the workload definition unless it is the SYSDEFAULTUSERWORKLOAD or SYSDEFAULTADMWORKLOAD workload. The incoming connection must supply matching connection attributes to those that you specified for the workload for a match to occur. For more information, see "Work identification by origin with workloads" on page 19. To see the connection attributes for a workload, query the SYSCAT.WORKLOADCONNATTR view.
   - A value that indicates whether an occurrence of this workload is permitted to access the database. By default, an occurrence of this workload is permitted to access the database. You cannot remove database access from the SYSDEFAULTADMWORKLOAD workload.
   - A value that indicates whether the workload is enabled or disabled. By default, the workload is enabled. You cannot disable the SYSDEFAULTUSERWORKLOAD or the SYSDEFAULTADMWORKLOAD workload.
   - The service class under which occurrences of this workload are to be executed. The SYSDEFAULTUSERCLASS service superclass is the default. If you specify a user-defined service superclass, you can specify a service subclass under the service superclass. You cannot specify the SYSDEFAULTSUBCLASS subclass under any service superclass, including the SYSDEFAULTUSERCLASS service superclass. In addition, you cannot specify the SYSDEFAULTSYSTEMCLASS or SYSDEFAULTMAINTENANCECLASS service superclass.
   - The position of the workload relative to other workloads, which determines the order in which the workload is evaluated during workload assignment. You cannot specify the position of the SYSDEFAULTUSERWORKLOAD or the SYSDEFAULTADMWORKLOAD workload. For more information, see "Workload assignment" on page 23.
   - The type of activity information to collect. By default, no information for activities associated with the workload is sent to an activities event monitor.
   - The monitoring activity metrics collection level for activities submitted by connections associated with this workload. Note that the effective activity collection setting for activities is the combination of both the workload activity metrics collection level and the **`mon_act_metrics`** database configuration parameter.
   - The aggregate activity information to collect. The aggregate activity information used for the workload only changes after the ALTER WORKLOAD operation is committed.

- The lock timeout event information to send to the locking event monitor, if one is active, when a lock event occurs.
- The deadlock information to send to the locking event monitor, if one is active, when a deadlock event occurs.
- The lock wait information to collect.
- The unit of work information for each transaction associated with this workload to send to the unit of work event monitor, if one is active, when a unit of work ends.
- The histogram templates that the workload should use as templates for its histograms. The histogram templates specified are reflected in the SYSCAT.HISTOGRAMTEMPLATEUSE view. For more information about histograms and histogram templates, see "Histograms in workload management" on page 253.

2. Commit your changes. When you commit your changes the workload is updated in the SYSCAT.WORKLOADS view. The committed change causes a workload re-evaluation to take place at the beginning of the next unit of work of each application. Depending on which workload is chosen, the application might be reassigned to a different workload.

What to do next

You might need to grant the USAGE privilege on it to one or more session users. (Session users with DBADM authority have an implicit privilege to use any workload.) Even if a connection provides an exact match to the connection attributes of the workload, if the session user does not have the USAGE privilege on the workload, the data server does not associate the connection with the workload to create an occurrence of the workload. For more information, see "Granting the USAGE privilege on a workload" on page 36.

Enabling a workload

The DB2 data server checks the connection attributes specified for a workload against the connection attributes of the current session. The data server does not consider a disabled workload when it looks for a matching workload.

Before you begin

To alter a workload, you require WLMADM or DBADM authority.

See "Workload management DDL statements" on page 18 for more information about prerequisites.

About this task

By default, a workload is enabled when you create it. If you create a workload as disabled, you must enable it for the data server to consider the workload when it performs workload evaluation.

Procedure

To enable a workload:

1. Identify the workload that you want to enable. You can display the set of disabled workloads by querying the SYSCAT.WORKLOADS view, as shown in the following example:

   ```
   SELECT * FROM SYSCAT.WORKLOADS WHERE ENABLED='N'
   ```

2. Use the ALTER WORKLOAD statement to enable the disabled workload:
   ```
   ALTER WORKLOAD...ENABLE
   ```
   If the ALTER WORKLOAD statement is successful, the definition for the workload is written to the database catalog.
3. Commit your changes. When you commit your changes the workload is updated in the SYSCAT.WORKLOADS view.

Results

Enabling a workload takes effect at the beginning of the next unit of work. At that point, a workload reevaluation occurs, and the data server considers the newly enabled workload when it performs workload reevaluation.

Disabling a workload

Use this task to prevent specific workloads from being considered during workload assignment. If you disable a workload, the data server does not consider it when it looks for a matching workload. Instead, the data server assigns the unit of work to the next matching workload. If no custom-defined workload matches, the work is assigned to the default workload.

Before you begin

To create or alter a workload, you require WLMADM or DBADM authority.

See “Workload management DDL statements” on page 18 for more information about prerequisites.

Procedure

To disable a workload:

1. Use the DISABLE option of the ALTER WORKLOAD statement to disable the workload:
   ```
   ALTER WORKLOAD...DISABLE
   ```
2. Commit your changes. When you commit your changes, the workload is updated in the SYSCAT.WORKLOADS view.

Results

Disabling a workload takes effect at the beginning of the next unit of work. At that point, a workload reevaluation occurs, and the connection is assigned to the next enabled workload that matches the connection attributes and for which there is authorization.

Dropping a workload

Dropping a workload removes it from the database catalog.

Before you begin

To drop a workload, you require WLMADM or DBADM authority.

See “Workload management DDL statements” on page 18 for more information about prerequisites.

Procedure

To drop a workload:

1. Disable the workload by specifying the ALTER WORKLOAD statement. See "Disabling a workload" on page 34 for more information. Disabling the workload prevents new occurrences of the workload from being able to run against the database.
2. Ensure that no occurrences of this workload are running by using the WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES table function. For more information, see WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES table function.

   The WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES table function returns the application handles corresponding to the active workload occurrences. You can use the **FORCE APPLICATION** command to terminate the applications using the application handles.
3. Drop the workload by specifying the DROP WORKLOAD statement. For example, to drop the ACCTNG workload, specify the following statement:
   ```
   DROP WORKLOAD ACCTNG
   ```
4. Commit your changes. When you commit your changes, the workload is removed from the SYSCAT.WORKLOADS view. In addition, authorization information for the workload is removed from the SYSCAT.WORKLOADAUTH view.

Permitting occurrences of a workload to access the database

If you have a workload that is not permitted to access the database but now want to permit occurrences of that workload to run, alter the workload so that it is permitted to access the database. By default, when a workload is created, it is permitted to access the database.

Before you begin

To alter a workload so that it can access a database, you require WLMADM or DBADM authority.

See "Workload management DDL statements" on page 18 for more information about prerequisites.

About this task

When you prevent a workload from accessing the database, the data server still examines that workload when performing workload assignment. However, all occurrences of that workload are rejected with an error.

Procedure

To permit a workload to access the database:

1. Use the ALLOW DB ACCESS option of the ALTER WORKLOAD statement to permit the workload to access the database. For example, to permit a workload called WL1 to access the database, specify the following statement:
   ```
   ALTER WORKLOAD WL1 ALLOW DB ACCESS
   ```
2. Commit your changes. When you commit your changes workload is updated in the SYSCAT.WORKLOADS view.

Results

Altering a workload to permit its occurrences to access the database takes effect when the data server analyzes the next unit of work for that workload. For example, if you specified DISALLOW DB ACCESS for workload A and alter the workload by specifying ALLOW DB ACCESS, new occurrences of workload A are permitted to execute. Previously, any occurrence of workload A would have been rejected with an error.

Preventing occurrences of a workload from accessing the database

Use this task to control which workloads can access the database. Before a workload occurrence begins to run, the data server checks whether the workload is permitted to access the database. If you dispermit the workload occurrence from accessing the database, an error is returned indicating that the workload occurrence is rejected.

Before you begin

To prevent a workload from accessing the database, you require WLMADM or DBADM authority.

See “Workload management DDL statements” on page 18 for more information about prerequisites.

About this task

Preventing a workload occurrence differs from disabling a workload. When you disable a workload, the workload definition is not cached in memory and is therefore not considered for workload assignment.

Procedure

To prevent a workload from accessing a database:

1. Use the DISALLOW DB ACCESS option of the ALTER WORKLOAD statement, as shown in the following example:
   ```
   ALTER WORKLOAD workload-name DISALLOW DB ACCESS ...
   ```
2. Commit your changes. When you commit your changes, the workload is updated in the SYSCAT.WORKLOADS view.

Results

Altering a workload to prevent its occurrences from accessing a database takes effect at the beginning of the next unit of work for workload occurrences that are already running. For example, if you specify ALLOW DB ACCESS for workload A and alter the workload by specifying DISALLOW DB ACCESS, occurrences of workload A that are already running receive an SQL error at the beginning of the next unit of work. New occurrences of workload A are rejected.

Granting the USAGE privilege on a workload

For a workload to be associated with a connection, the session user must have the USAGE privilege on that workload. Users with the ACCESSCTRL, DATAACCESS, DBADM, SECADM, or WLMADM authority implicitly have the USAGE privilege on all workloads.

Before you begin

To use the GRANT USAGE ON WORKLOAD statement, you require ACCESSCTRL, SECADM, or WLMADM authority

See “Workload management DDL statements” on page 18 for more information about prerequisites.

About this task

When the data server finds a workload that matches the attributes of an incoming connection, the data server checks whether the session user has the USAGE privilege on that workload. If the session user does not have the USAGE privilege on that workload, the data server looks for the next matching workload. (In other words, the workloads for which the session user does not have the USAGE privilege are treated as if they do not exist.) Therefore, the workload USAGE privilege gives you the ability to further control which workload among the matching workloads a user, group, or role should be assigned to. For example, you can define more than one workload with the same connection attributes and grant the USAGE privilege on each of these workloads to only certain users, groups, or roles. For more information, see “Workload assignment” on page 23.

The client can set the client user ID, client application name, client workstation name, and client accounting string (which are some of the connection attributes that are used to assign a connection to a workload) without authorization. Therefore, the workload USAGE privilege also permits you to control which session user has the authority to use a workload.

You can view the USAGE privilege information by querying the SYSCAT.WORKLOADAUTH view.

If you create a database with the RESTRICTIVE option, the USAGE privilege on the SYSDEFAULTUSERWORKLOAD workload is not granted to PUBLIC at database creation time. You must explicitly grant the USAGE privilege on this workload to non-WLMADM and non-DBADM users. If the session user does not have the USAGE privilege on any of the workloads, including SYSDEFAULTUSERWORKLOAD, SQL4707N is returned when the data server attempts to associate a workload with the database connection.

Procedure

To grant the USAGE privilege on a workload:

1. Use the GRANT USAGE ON WORKLOAD statement. You can grant the USAGE privilege to specific users, groups, roles, or PUBLIC. For example, to grant the USAGE privilege on the ACCOUNTS workload to the CPA group, you would issue the following statement:

   ```
   GRANT USAGE ON WORKLOAD ACCOUNTS TO GROUP CPA
   ```

   You cannot grant the USAGE privilege on the SYSDEFAULTADMWORKLOAD workload. The SYSDEFAULTADMWORKLOAD workload can only be used by ACCESSCTRL, DATAACCESS, DBADM, SECADM, or WLMADM users who issue the SET WORKLOAD TO SYSDEFAULTADMWORKLOAD command.
2. Commit your changes. When you commit your changes, the SYSCAT.WORKLOADAUTH view is updated. Until the GRANT statement is committed, the data server cannot consider the workload when performing workload assignment for the newly authorized users, groups, or roles.

Revoking the USAGE privilege on a workload

Use the REVOKE USAGE ON WORKLOAD statement to revoke the USAGE privilege on a workload.

Before you begin

To use the REVOKE USAGE ON WORKLOAD statement, you require ACCESSCTRL, SECADM, or WLMADM authority.

See "Workload management DDL statements" on page 18 for more information about prerequisites.

About this task

You cannot explicitly revoke the USAGE privilege on the SYSDEFAULTADMWORKLOAD workload. Only ACCESSCTRL, DATAACCESS, DBADM, SECADM, or WLMADM users who issue the SET WORKLOAD TO SYSDEFAULTADMWORKLOAD command can use this workload. Therefore, REVOKE USAGE ON WORKLOAD statements do not work for SYSDEFAULTADMWORKLOAD.

Procedure

To revoke the USAGE privilege on a workload:

1. Use the REVOKE USAGE ON WORKLOAD statement. You can revoke the USAGE privilege from specific users, groups, roles, or PUBLIC. For example, to revoke the USAGE privilege on the ACCOUNTS workload from PUBLIC, you would specify the following statement:
   ```
   REVOKE USAGE ON WORKLOAD ACCOUNTS FROM PUBLIC
   ```
2. Commit your changes. When you commit your changes, the SYSCAT.WORKLOADAUTH view is updated. Until the REVOKE statement is committed, the data server considers the workload when performing workload assignment.

Example: Workload assignment

At the beginning of the first unit of work after a database connection is established, the data server assigns the connection to a workload by evaluating the connection attributes of each workload that is enabled.

Workload reevaluation occurs at the beginning of each unit of work if the value of a connection attribute or the workload definition itself changes during the unit of work.

The following figure shows a workload assignment. Users in the `Marketing` group who submit queries through `AppA` are assigned to the APPAQUERIES workload. They are not assigned to the PAYROLL workload, even though PAYROLL is positioned before APPAQUERIES, because the definition of workload PAYROLL specifies the SESSION_USER GROUP keyword as `Finance`. Users in the `Finance` group who submit queries through `AppA` are assigned to the FINANCE workload. They are not assigned to the PAYROLL workload, even though it is more specific and specifies both `AppA` and `Finance` in its definition, because the FINANCE workload is positioned before the PAYROLL workload. Users in the `Marketing` group who submit queries through `AppB` are assigned to the SYSDEFAULTUSERWORKLOAD workload, because none of the connection attributes specified in the FINANCE, PAYROLL, or APPAQUERIES workload definitions match the `AppB` application or `Marketing` group.

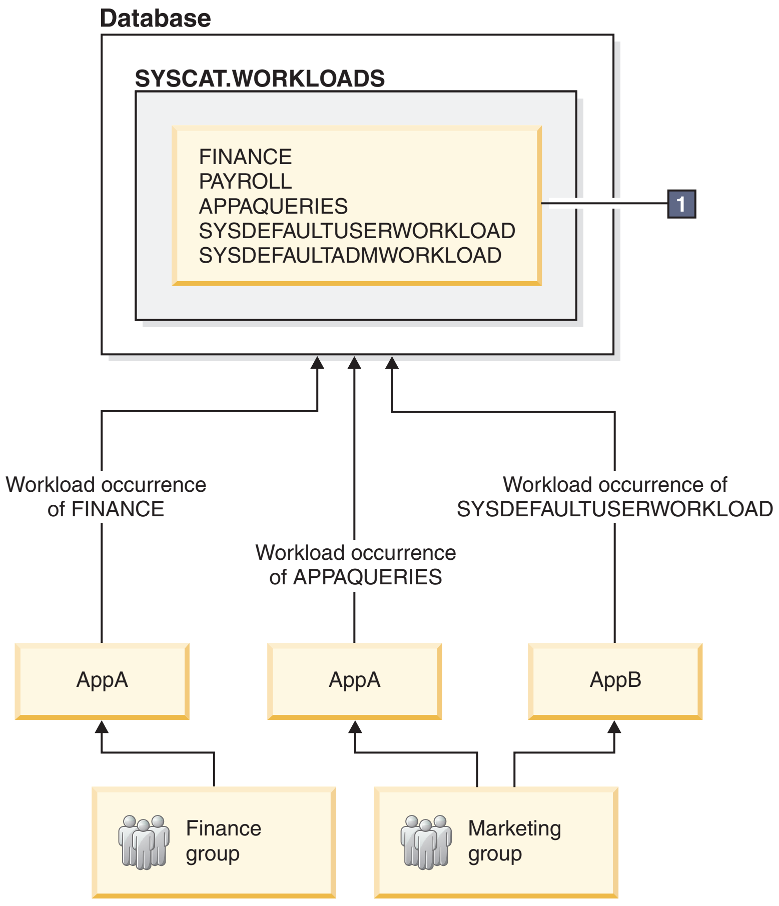


Figure 5. Example of workload assignment

1 In the preceding figure, the CREATE WORKLOAD statements are as follows:

```
CREATE WORKLOAD PAYROLL APPLNAME ('AppA') SESSION_USER GROUP ('FINANCE')
SERVICE CLASS SC1

CREATE WORKLOAD APPAQUERIES APPLNAME('AppA') POSITION LAST
SERVICE CLASS SC2

CREATE WORKLOAD FINANCE SESSION_USER GROUP ('FINANCE') SERVICE CLASS SC1
POSITION BEFORE PAYROLL
```

By default, many application servers set up connections with the same information and pass the same client information, if any, for all client requests that they handle. Some products, such as WebSphere and Cognos, provide a facility to push down unique information about each request through the client information fields. This information uniquely identifies the end-user request within DB2. Most other products provide a way for the application server to be customized so that unique client information can be sent to DB2 prior to the start of processing an end-user request.

Specifying unique client attributes from the application server enables the specialized treatment of requests within DB2 and the assignment of requests from different clients to different workloads (and to different service classes).

The following figure shows an example of a three-tier environment where queries are submitted by different user applications, (`marketing.exe`, `auditing.exe`, and `reporting.exe`), through an application server that establishes a connection to the database using the session user APPUSER. Three workloads are defined: one for queries submitted by `marketing.exe`, one for queries submitted by `reporting.exe`, and one for the rest of the queries. As shown in the figure, to assign queries submitted by `marketing.exe` to the MARKETING workload, the application server calls the sqleseti API to set the value of the CURRENT CLIENT_APPLNAME special register to `marketing.exe`. Similarly, to assign queries submitted by `reporting.exe` to the REPORTING workload, the server calls sqleseti to set the value of the CURRENT CLIENT_APPLNAME special register to `reporting.exe`. Note that in the figure, when the server calls sqleseti to set the CURRENT CLIENT_USERID special register to `Lidia` (with nothing else changing; that is, the client application name is still set to `reporting.exe`), no workload reassignment occurs because there is no workload defined specifically with the CURRENT CLIENT_USERID set to `Lidia`.

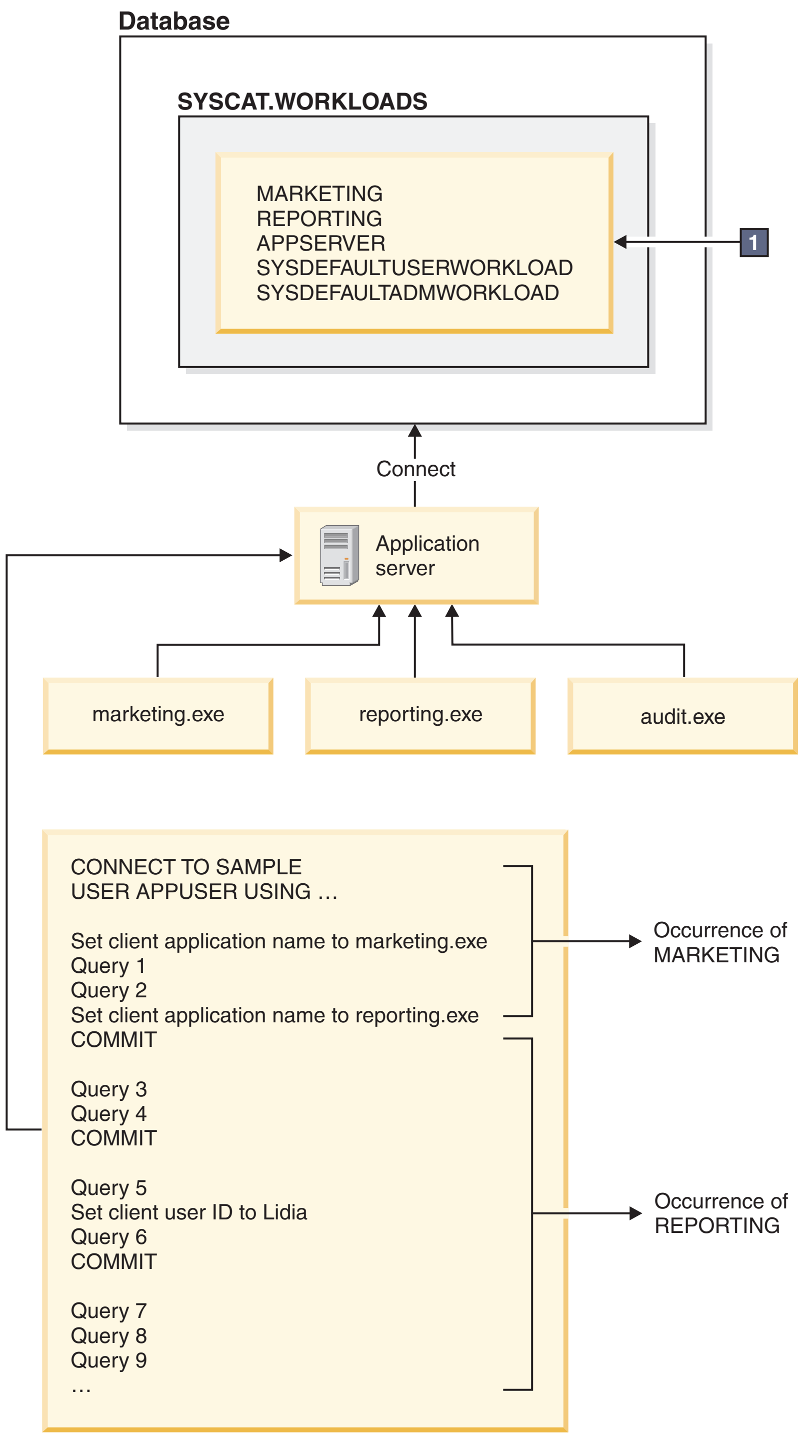


Figure 6. Example of workload assignment in a three-tier environment

The following statements are used to define the workloads specified in box **1** in the previous figure:

```
CREATE WORKLOAD MARKETING SESSION_USER ('APPUSER')
CURRENT CLIENT_APPLNAME ('marketing.exe') SERVICE CLASS SC2
POSITION AT 1

CREATE WORKLOAD REPORTING SESSION_USER ('APPUSER')
CURRENT CLIENT_APPLNAME ('reporting.exe') SERVICE CLASS SC4
```

```
POSITION AFTER MARKETING

CREATE WORKLOAD APPSERV SESSION_USER ('APPUSER')
SERVICE CLASS SC1
```

Example: Workload assignment when workload attributes have single values

The example in this topic shows how the data server performs workload assignment. In this example, only one value is specified for each workload connection attribute.

Assume that the following workloads exist in the catalog:

Table 5. Workloads in the catalog

Evaluation order	Workload name	ADDRESS	APPLNAME	SYSTEM _USER	SESSION _USER	SESSION _USER GROUP	SESSION _USER ROLE	CURRENT CLIENT _USERID	CURRENT CLIENT _APPLNAME	CURRENT CLIENT _WRKSTNNAME	CURRENT CLIENT _ACCTNG
1	REPORTS		AppA								
2	INVENTORY REPORT		AppB	LYNN		ACCOUNTING	TELEMKTR				
3	SALES REPORT		AppC	KATE	KATE		SALESREP				
4	AUDIT REPORT		AppB			ACCOUNTING	FINANALYST				
5	EXPENSE REPORT		AppA	TIM			EXPENSE APPROVER				
6	AUDIT RESULT				LYNN			LYNN			Audit Group

Assume that a database connection with the following attributes is established:

Table 6. Database connection attributes

ADDRESS	APPLNAME	SYSTEM _USER	SESSION _USER	SESSION _USER GROUP	SESSION _USER ROLE	CURRENT CLIENT _USERID	CURRENT CLIENT _APPLNAME	CURRENT CLIENT _WRKSTNNAME	CURRENT CLIENT _ACCTNG
9.26.53.111	AppA	TIM	TIM	FINANCE	FINANALYST, EXPENSE APPROVER	NULL	NULL	NULL	Business account

When the first unit of work is submitted, the data server checks each workload in the catalog, starting with the first workload in the list, and processes the workloads in ascending order until it finds a workload with matching attributes. When a matching workload is found, the unit of work runs under an occurrence of that workload. When determining which workload to assign the connection to, the data server compares the connection attributes in deterministic order.

The data server first checks the REPORTS workload for a match. The REPORTS workload is first in the list.

Table 7. REPORTS workload in the catalog

Evaluation order	Workload name	ADDRESS	APPLNAME	SYSTEM _USER	SESSION _USER	SESSION _USER GROUP	SESSION _USER ROLE	CURRENT CLIENT _USERID	CURRENT CLIENT _APPLNAME	CURRENT CLIENT _WRKSTNNAME	CURRENT CLIENT _ACCTNG
1	REPORTS		AppA								

The data server checks the connection attributes in the following deterministic order:

1. APPLNAME. The value of APPLNAME, `AppA`, for the database connection matches the value of APPLNAME for the REPORTS workload.
2. SYSTEM_USER, which is not set in the workload definition. Any value (including a null value) is considered a match.
3. SESSION_USER, which is not set in the workload definition. Any value is considered a match.

4. SESSION_USER GROUP, which is not set in the workload definition. Any value is considered a match.
5. SESSION_USER ROLE, which is not set in the workload definition. Any value is considered a match.
6. CURRENT CLIENT_USERID, which is not set in the workload definition. Any value is considered a match.
7. CURRENT CLIENT_APPLNAME, which is not set in the workload definition. Any value is considered a match.
8. CURRENT CLIENT_WRKSTNNAME, which is not set in the workload definition. Any value is considered a match.
9. CURRENT CLIENT_ACCTNG, which is not set in the workload definition. Any value is considered a match.

In this situation, because of the explicit and implicit matches between the connection attributes of the REPORTS workload and the information passed on the connection, the data server selects the REPORTS workload as a potential match. After selecting a workload, the data server then checks whether the session user has the USAGE privilege on the workload. Assuming that the session user TIM has the USAGE privilege on the REPORTS workload, that workload is used for the connection. If, however, TIM does not possess the USAGE privilege on the REPORTS workload, the data server continues by checking the INVENTORYREPORT workload for a match.

Assume that you want TIM to be assigned to the EXPENSEREPORT workload because that workload has additional connection attributes specified. In this situation, you would alter the evaluation order of the workloads to position EXPENSEREPORT before REPORTS in the workload list:

```
ALTER WORKLOAD EXPENSEREPORT POSITION AT 1
```

You could also use the following SQL statement to achieve the same result:

```
ALTER WORKLOAD EXPENSEREPORT BEFORE REPORTS
```

To ensure that the ALTER WORKLOAD statement takes effect, you must immediately issue a COMMIT statement after the ALTER WORKLOAD statement. The effect of the ALTER WORKLOAD statement on the catalog is as follows:

Table 8. Workloads in the catalog after repositioning the EXPENSEREPORT workload

Evaluation order	Workload name	APPLNAME	SYSTEM _USER	SESSION _USER	SESSION _USER GROUP	SESSION _USER ROLE	CURRENT CLIENT _USERID	CURRENT CLIENT _APPLNAME	CURRENT CLIENT _WRKSTNNAME	CURRENT CLIENT _ACCTNG
1	EXPENSE REPORT	AppA	TIM			EXPENSE APPROVER				
2	REPORTS	AppA								
3	INVENTORY REPORT	AppB	LYNN		ACCOUNTING	TELEMKTR				
4	SALES REPORT	AppC	KATE	KATE		SALESREP				
5	AUDIT REPORT	AppB			ACCOUNTING	FINANALYST				
6	AUDIT RESULT			LYNN			LYNN			Audit Group

If TIM does not already have the USAGE privilege on the EXPENSEREPORT workload, you must issue the following statements (the COMMIT statement ensures that the GRANT statement takes effect):

```
GRANT USAGE ON WORKLOAD EXPENSEREPORT TO USER TIM
COMMIT
```

At the beginning of the next unit of work, workload reassignment occurs, and the data server assigns the connection from TIM to the EXPENSEREPORT workload.

In addition, new units of work submitted by other connections that have the same attributes are also associated with the EXPENSEREPORT workload.

Example: Workload assignment for a unit of work when multiple workloads exist

The example in this topic shows how the data server performs workload evaluation to assign the connection to an existing workload.

Assume that the following workloads are defined in the catalog:

Table 9. Workloads in the catalog

Evaluation order	Workload name	APPLNAME	SYSTEM _USER	SESSION _USER	SESSION _USER GROUP	SESSION _USER ROLE	CURRENT CLIENT _USERID	CURRENT CLIENT _APPLNAME	CURRENT CLIENT _WRKSTNNAME	CURRENT CLIENT _ACCTNG
1	EXPENSE REPORT	AppB	TIM			EXPENSE APPROVER				
2	REPORTS	AppB								
3	INVENTORYREPORT	AppA	LYNN		ACCOUNTING	TELEMKTR				
4	SALES REPORT	AppC	KATE	KATE		SALESREP				
5	AUDIT REPORT	AppA			ACCOUNTING	FINANALYST				
6	AUDIT RESULT			LYNN			LYNN			Audit Group

Suppose that a database connection with the following attributes is established:

Table 10. Database connection attributes

APPLNAME	SYSTEM _USER	SESSION _USER	SESSION _USER GROUP	SESSION _USER ROLE	CURRENT CLIENT _USERID	CURRENT CLIENT _APPLNAME	CURRENT CLIENT _WRKSTNNAME	CURRENT CLIENT _ACCTNG
AppA	LYNN	LYNN	ACCOUNTING	FINANALYST, SALESREP	LYNN	NULL	wrkstn2	Audit group

When the first unit of work is submitted, the data server checks each workload in the catalog in ascending evaluation order and stops when it finds a workload whose connection attributes match those supplied by the connection. When it checks the workloads, the data server compares the connection attributes in deterministic order.

First, the data server checks the EXPENSEREPORT workload:

Table 11. EXPENSEREPORT workload in the catalog

Evaluation order	Workload name	APPLNAME	SYSTEM _USER	SESSION _USER	SESSION _USER GROUP	SESSION _USER ROLE	CURRENT CLIENT _USERID	CURRENT CLIENT _APPLNAME	CURRENT CLIENT _WRKSTNNAME	CURRENT CLIENT _ACCTNG
1	EXPENSEREPORT	AppB	TIM			EXPENSE APPROVER				

Because the APPLNAME attribute in the workload definition is `AppB` but the APPLNAME attribute passed by the connection is `AppA`, no match is possible. The data server proceeds to the REPORTS workload, which is second in the list:

Table 12. REPORTS workload in the catalog

Evaluation order	Workload name	APPLNAME	SYSTEM _USER	SESSION _USER	SESSION _USER GROUP	SESSION _USER ROLE	CURRENT CLIENT _USERID	CURRENT CLIENT _APPLNAME	CURRENT CLIENT _WRKSTNNAME	CURRENT CLIENT _ACCTNG
2	REPORTS	AppB								

Again, the APPLNAME attribute in the workload definition is `AppB`, which does not match `AppA`. The data server proceeds to the third workload in the list, INVENTORYREPORT:

Table 13. INVENTORYREPORT workload in the catalog

Evaluation order	Workload name	APPLNAME	SYSTEM _USER	SESSION _USER	SESSION _USER GROUP	SESSION _USER ROLE	CURRENT CLIENT _USERID	CURRENT CLIENT _APPLNAME	CURRENT CLIENT _WRKSTNNAME	CURRENT CLIENT _ACCTNG
3	INVENTORYREPORT	AppA	LYNN		ACCOUNTING	TELEMKTR				

The data server checks for a match between the submitted connection attributes and the INVENTORYREPORT workload. The attributes are checked in the following order:

1. APPLNAME. Both the workload definition and the connection have a value of `AppA`, so a match occurs.
2. SYSTEM_USER. Both the workload definition and the connection have a value of `LYNN`, so a match occurs.
3. SESSION_USER. The connection passed a value of `LYNN`. Because the SESSION_USER attribute is not set for the workload, any value, including a null value, that is passed by the connection matches.
4. SESSION_USER GROUP. Both the workload definition and the connection have a value of `ACCOUNTING`, so a match occurs.
5. SESSION_USER ROLE. The workload definition specifies the value `TELEMKTR`, but the connection supplied the values of `FINANALYST` and `SALESREP`. No match occurs for this attribute.

The data server stops trying to match the INVENTORYREPORT workload and the connection attributes and proceeds to the fourth workload in the list, SALESREPORT:

Table 14. SALESREPORT workload in the catalog

Evaluation order	Workload name	APPLNAME	SYSTEM _USER	SESSION _USER	SESSION _USER GROUP	SESSION _USER ROLE	CURRENT CLIENT _USERID	CURRENT CLIENT _APPLNAME	CURRENT CLIENT _WRKSTNNAME	CURRENT CLIENT _ACCTNG
4	SALESREPORT	AppC	KATE	KATE		SALESREP				

Because the APPLNAME of the SALESREPORT workload definition is `AppC`, no match occurs with the connection (which passed a value of `AppA` for APPLNAME). The data server then proceeds to the fifth workload in the list, AUDITREPORT:

Table 15. AUDITREPORT workload in the catalog

Evaluation order	Workload name	APPLNAME	SYSTEM _USER	SESSION _USER	SESSION _USER GROUP	SESSION _USER ROLE	CURRENT CLIENT _USERID	CURRENT CLIENT _APPLNAME	CURRENT CLIENT _WRKSTNNAME	CURRENT CLIENT _ACCTNG
5	AUDITREPORT	AppA			ACCOUNTING	FINANALYST				

The data server compares the attributes of the AUDITREPORT workload and the connection in the deterministic order:

1. APPLNAME. Both the workload definition and the connection have a value of `AppA`, so a match occurs.
2. SYSTEM_USER. The connection passed a value of `LYNN`. Because the SYSTEM_USER attribute is not set for the workload, any value passed by the connection matches.
3. SESSION_USER. The connection passed a value of `LYNN`. Because the SESSION_USER attribute is not set for the workload, any value passed by the connection matches.
4. SESSION_USER GROUP. Both the workload and the connection have a value of `ACCOUNTING` for this attribute, so a match occurs.
5. SESSION_USER ROLE. Both the workload and the connection have a value of `FINANALYST` for this attribute, so a match occurs.

6. CURRENT CLIENT_USERID. Because the CURRENT CLIENT_USERID attribute is not set for the workload, any value passed by the connection matches.
7. CURRENT CLIENT_APPLNAME. Because the CURRENT CLIENT_APPLNAME attribute is not set for the workload, any value passed by the connection matches.
8. CURRENT CLIENT_WRKSTNNAME. Because the CURRENT CLIENT_WRKSTNNAME attribute is not set for the workload, any value passed by the connection matches.
9. CURRENT CLIENT_ACCTNG. Because the CURRENT CLIENT_ACCTNG attribute is not set for the workload, any value passed by the connection matches.

After processing all the connection attributes and finding a matching workload, the data server checks whether the session user has the USAGE privilege on the workload. Assume that LYNN does not have the USAGE privilege on the AUDITREPORT workload. In this situation, although all of the connection attributes match, this workload is not associated with the connection. The data server proceeds to the sixth workload in the evaluation list, AUDITRESULT:

Table 16. AUDITRESULT workload in the catalog

Evaluation order	Workload name	APPLNAME	SYSTEM _USER	SESSION _USER	SESSION _USER GROUP	SESSION _USER ROLE	CURRENT CLIENT _USERID	CURRENT CLIENT _APPLNAME	CURRENT CLIENT _WRKSTNNAME	CURRENT CLIENT _ACCTNG
6	AUDITRESULT			LYNN			LYNN			Audit Group

The data server compares the attributes of the AUDITRESULT workload and the connection in the deterministic order:

1. APPLNAME. Because the APPLNAME attribute is not set for the workload, any value passed by the connection matches.
2. SYSTEM_USER. Because the SYSTEM_USER attribute is not set for the workload, any value passed by the connection matches.
3. SESSION_USER. Both the workload and the connection have a value of LYNN for this attribute, so a match occurs.
4. SESSION_USER GROUP. Because the SESSION_USER GROUP attribute is not set for the workload, any value passed by the connection matches.
5. SESSION_USER ROLE. Because the SESSION_USER ROLE attribute is not set for the workload, any value passed by the connection matches.
6. CURRENT CLIENT_USERID. Both the workload and the connection have a value of LYNN for this attribute, so a match occurs.
7. CURRENT CLIENT_APPLNAME. Because the CURRENT CLIENT_APPLNAME attribute is not set for the workload, any value passed by the connection matches.
8. CURRENT CLIENT_WRKSTNNAME. Because the CURRENT CLIENT_WRKSTNNAME attribute is not set for the workload, any value passed by the connection matches.
9. CURRENT CLIENT_ACCTNG. Both the workload and the connection have a value of Audit Group for this attribute, so a match occurs.

After processing all of the connection attributes and finding a matching workload, the data server checks whether the session user has the USAGE privilege on the workload. In this situation, assume that the session user LYNN has the USAGE privilege on the AUDITRESULT workload. Because all of the connection attributes match and the session user has the USAGE privilege, the connection is assigned to the AUDITRESULT workload.

Example: Workload assignment when workload attributes have multiple values

The example in this topic shows how the data server performs workload assignment. In this example, some of the workload definitions permit more than one value for a connection attribute.

Assume that the following workloads are defined in the catalog:

Table 17. Workloads in the catalog

Evaluation order	Workload name	APPLNAME	SYSTEM _USER	SESSION _USER	SESSION _USER GROUP	SESSION _USER ROLE	CURRENT CLIENT _USERID	CURRENT CLIENT _APPLNAME	CURREN CLIENT _WRKSTNNAME	CURRENT CLIENT _ACCTNG
1	ITEMINQ		KYLE, GEORGE		RETAIL, SALES					
2	DAILY TRANS REPORT	AppC		KYLE, CAROL	SALES, ACCOUNTING					
3	SALES SUMMARY	AppA, AppB				ACCOUNTANT, FINANALYST				

Assume that a database connection with the following attributes is established:

Table 18. Database connection attributes

APPLNAME	SYSTEM _USER	SESSION _USER	SESSION _USER GROUP	SESSION _USER ROLE	CURRENT CLIENT _USERID	CURRENT CLIENT _APPLNAME	CURREN CLIENT _WRKSTNNAME	CURRENT CLIENT _ACCTNG
AppC	LINDA	KYLE	SALES	ACCOUNTANT	LINDA	NULL	NULL	Business Account

When the first unit of work is submitted, the data server checks each workload in the catalog in ascending evaluation order and stops when it finds a workload whose connection attributes match those supplied by the connection. When it checks the workloads, the data server compares the connection attributes in deterministic order.

First, the data server checks the ITEMINQ workload:

Table 19. ITEMINQ workload in the catalog

Evaluation order	Workload name	APPLNAME	SYSTEM _USER	SESSION _USER	SESSION _USER GROUP	SESSION _USER ROLE	CURRENT CLIENT _USERID	CURRENT CLIENT _APPLNAME	CURREN CLIENT _WRKSTNNAME	CURRENT CLIENT _ACCTNG
1	ITEMINQ		KYLE, GEORGE		RETAIL, SALES					

The data server checks for a match between the submitted connection attributes and the ITEMINQ workload. The attributes are checked in the following order:

1. APPLNAME. Because the APPLNAME attribute is not set for the workload, any value, including a null value, that is passed by the connection matches.
2. SYSTEM_USER. The connection passed a value of `LINDA`. However, the ITEMNO workload values are `KYLE` and `GEORGE`. No match occurs for this attribute.

The data server stops trying to match the ITEMNO workload and the connection and proceeds to the second workload in the list, DAILYTRANSREPORT:

Table 20. DAILYTRANSREPORT workload in the catalog

Evaluation order	Workload name	APPLNAME	SYSTEM _USER	SESSION _USER	SESSION _USER GROUP	SESSION _USER ROLE	CURRENT CLIENT _USERID	CURRENT CLIENT _APPLNAME	CURREN CLIENT _WRKSTNNAME	CURRENT CLIENT _ACCTNG
2	DAILYTRANSREPORT	AppC		KYLE, CAROL	SALES, ACCOUNTING					

The data server compares the attributes of the DAILYTRANSREPORT workload and the connection in deterministic order:

1. APPLNAME. Both the workload definition and the connection have a value of `AppC`, so a match occurs.
2. SYSTEM_USER. Because the SYSTEM_USER attribute is not set for the workload, any value, including a null value, that is passed by the connection matches.
3. SESSION_USER. The SESSION_USER value passed on the connection is `KYLE`, which is a match with one of the workload SESSION_USER values. If the connection had passed `CAROL`, this would also be a match because both `KYLE` and `CAROL` are specified as part of the DAILYTRANSREPORT workload definition.
4. SESSION_USER GROUP. The SESSION_USER GROUP value passed on the connection is `SALES`, which matches the `SALES` value specified for the workload SESSION_USER GROUP attribute. If the connection had passed `ACCOUNTING`, this would also be a match because both `SALES` and `ACCOUNTING` are specified in the workload definition.
5. SESSION_USER ROLE. Because the SESSION_USER ROLE attribute is not set for the workload, any value passed by the connection matches.
6. CURRENT CLIENT_USERID. Because the CURRENT CLIENT_USERID attribute is not set for the workload, any value passed by the connection matches.
7. CURRENT CLIENT_APPLNAME. Because the CURRENT CLIENT_APPLNAME attribute is not set for the workload, any value passed by the connection matches.
8. CURRENT CLIENT_WRKSTNNAME. Because the CURRENT CLIENT_WRKSTNNAME attribute is not set for the workload, any value passed by the connection matches.
9. CURRENT CLIENT_ACCTNG. Because the CURRENT CLIENT_WRKSTNNAME attribute is not set for the workload, any value passed by the connection matches.

After processing all of the connection attributes and finding a matching workload for the connection, the data server checks whether the session user has the USAGE privilege on the workload. In this situation, assume that the session user `KYLE` has the USAGE privilege on the DAILYTRANSREPORT workload. Because all connection attributes match and the session user has the USAGE privilege, the connection is assigned to the DAILYTRANSREPORT workload.

Work identification by type, cost, or data accessed with work classes

In addition to using connection attributes that focus on the origin of activities with workloads, you can identify activities based on the type, cost or data that may be accessed through the creation of a work class set containing a work class.

A work class is a method of categorizing individual database activities based on attributes of the activities. If a work class has a work action defined for it, the work action will be applied to the work class and determines how the activities in the work class are managed. For more information, see “Apply controls to types of activities with work action sets” on page 93.

The following table shows the type keywords available for work classes and the SQL statements that correspond to the different keywords. Except for the load utility, all the statements in the following table are intercepted immediately before execution in the processing of an EXECUTE, EXECUTE IMMEDIATE, or OPEN request. The load utility, when issued from a client, might issue requests before starting the actual load operation on the data server.

Table 21. Work types

Work type keyword	**Applicable SQL statements**
READ, including SET statements with embedded READ SQL	• All SELECT statements (select into, values into, full select) **Exception:** SELECT statements containing a DELETE, INSERT, or UPDATE are not included. • All XQuery statements
WRITE, including SET statements with embedded WRITE SQL	• All UPDATE statements (searched, positioned) • All DELETE statements (searched, positioned) • All INSERT statements (values, subselect) • All MERGE statements • All SELECT statements containing a DELETE, INSERT, or UPDATE statement
CALL	CALL statement The CALL statement is only classified under the CALL and ALL work class types. **Note:** Both anonymous blocks and autonomous routines are classified as CALL statements.
DML, including SET statements with embedded READ or WRITE SQL	All statements that are classified under the READ and WRITE work class types.
DDL	• All ALTER statements • All CREATE statements • COMMENT statement • DECLARE GLOBAL TEMPORARY TABLE statement • DROP statement • FLUSH PACKAGE CACHE statement • All GRANT statements • REFRESH TABLE • All RENAME statements • All REVOKE statements • SET INTEGRITY statement
LOAD	Load utility The load utility is only classified under the LOAD and ALL work class types.

Table 21. Work types (continued)

Work type keyword	**Applicable SQL statements**
ALL	Work types that are represented by all of the preceding keywords. **Note:** If the action is a threshold, the database activity that the threshold is applied to depends on the type of threshold. For example, if the threshold type is ESTIMATEDSQLCOST, only DML activity with an estimated cost (in timerons) is affected by the threshold. For more information, see "Example: Working with a work class defined with the ALL keyword" on page 63.

The following figure shows a hierarchical view of the work type keywords:

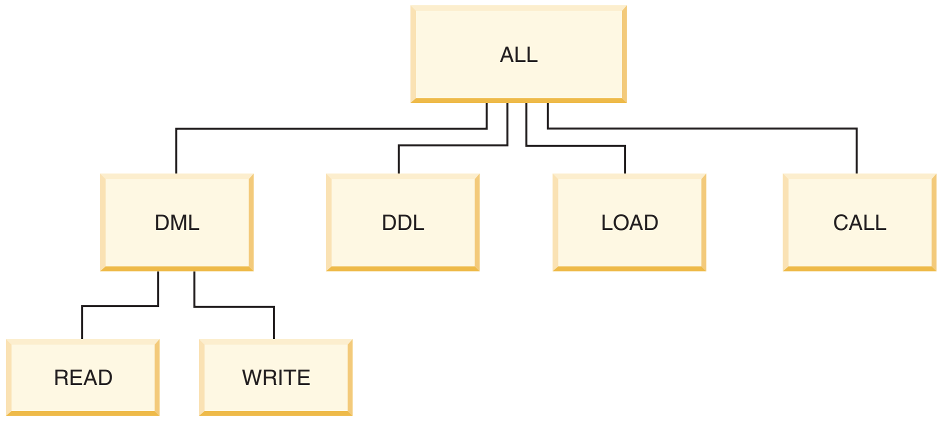


Figure 7. Work type keywords

SQL statements that do not fall under any of the available keywords are not classified, and behave as though no work class and work class set exists. For example, if the statement is SET SCHEMA and the only work class in the work class set has a work type of DML, that statement is not classified and no work action can be applied to it. So, if the action is MAP, the SET SCHEMA activity runs in the default service subclass (SYSDEFAULTSUBCLASS). If the action is a threshold, no threshold is applied to the activity.

Additional identification

Work classes also permit you to use predictive elements in the identification for DML work (or READ and WRITE statements). Predictive elements are useful because they provide information about database activities that can be used to take action before these activities start consuming resources on the data server. The following table provides information about predictive elements supported by work classes:

Table 22. Characteristics for predictive identification

Predictive element	**Description**
Estimated cost	Uses the estimated cost available from the DB2 compiler to include DML within a given timeron range (for example, create a work class for all large queries with an estimated cost over 1 000 000 timerons)
Estimated cardinality	Uses the estimated rows returned (cardinality) from the DB2 compiler to include DML within a given range of rows returned (for example, create a work class for large queries that are estimated to return more than 500 000 rows)
Estimated data accessed	Uses the estimated data accessed from the DB2 compiler to include DML that accesses data assigned a specific data tag (for example, create a work class for queries that are estimated to access data in table spaces tagged with a data tag value of 3) **Note:** The set of table spaces that the DB2 compiler predicts will be accessed is based on the optimized SQL statement, which might differ from the user-specified SQL statement. In some cases, for example, when inserting into range partitioned tables, the number of table spaces that are predicted to be accessed is more than the expected table spaces.

You can also identify activities by using the schema name of the procedure that a CALL statement calls.

Based on workload attributes and work class types, you can identify work and prepare it for the next stage, the management of the work.

For more information on working with work classes and work class sets, refer the following topics:

Work classes and work class sets

A work class is a method of categorizing individual database activities based on attributes of the activities. Work classes are grouped into work class sets, which can be shared by different work action sets.

Examples of database activity attributes which can determine which work class an activity is associated with includes: activity type (DDL, DML, LOAD), the estimated cost (where available), the estimated cardinality (where available), the estimated data tag, and the schema (where available).

Work classes

A work class has the following attributes:

- The work class name, which must be unique in the work class set.
- The database activity attributes, which consist of the following information:
  - The type of database activity that falls into this work class. Using predefined keywords (for example, CALL, READ, WRITE, DML, DDL, LOAD, or ALL), you can classify database requests into different categories. Different types of database activities can be associated with a work class depending on its work type. For example, the WRITE keyword includes updates, deletes, inserts,

merges, and selects that contain a delete, insert, or update. For more information, see "Work identification by type, cost, or data accessed with work classes" on page 48.

  – The range information that further categorizes DML or XQuery types of database activity:
    - The type of range to specify (either timeron cost or cardinality). Specifying a range of values is optional. For example, when you specify a range for a work class, you can specify that all queries with an estimated cost of less than 100 timerons be processed differently than other queries.
    - The bottom of the range.
    - The top of the range.
  – The schema of the routine to be called. Specifying the schema is optional. When defining a work class, you can use the schema attribute to further classify CALL statements according to the schema of the procedure being called. For example, if you specify SCHEMA1 for the schema of a work class and the work type is CALL, all CALL statements calling a SCHEMA1 procedure are classified in that work class. If you specify the schema for a work class type other than CALL or ALL, the error SQL0628N is returned.
  – The identification tag given to the data the activity might touch. For example, when you specify a data tag of 3 for a work class, activities that touch data in a table space or storage group with a data tag of 3 can be isolated and treated differently.
- The evaluation order of the work class (or position of the work class in the work class set). For more information, see "Evaluation order of work classes in a work class set" on page 58.
- An automatically generated class identifier that uniquely identifies the work class.

You can create work classes in two ways:
- Create a new work class set to contain the new work class using the WORK CLASS keyword of the CREATE WORK CLASS SET statement.
- Add the new work class to an existing work class set using the ADD keyword of the ALTER WORK CLASS SET statement

You can alter work classes by using the ALTER WORK CLASS keyword of the ALTER WORK CLASS SET statement.

You can drop work classes from a work class set using the DROP WORK CLASS keyword of the ALTER WORK CLASS SET statement, or by using the DROP WORK CLASS SET statement to drop the work class set.

You can view your work classes by querying the SYSCAT.WORKCLASSES view.

Work class sets

You use work class sets to group one or more work classes. A work class set consists of the following attributes:
- A unique descriptive name for the work class set
- Any comments that you want to supply for the work class set
- Zero or more work classes (although a work class can only exist in a work class set, a work class set does not have to contain any work classes)
- An automatically generated ID that uniquely identifies the work class set

You create a new work class set using the CREATE WORK CLASS SET statement. You can create an empty work class set and add work classes later, or you can create a work class set that contains one or more work classes.

You change an existing work class set in the following ways using the ALTER WORK CLASS SET statement:
- Add work classes to the work class set.
- Change work class attributes for work classes in the work class set.
- Drop work classes from the work class set.

You cannot change any work class set attributes.

Drop a work class set using the DROP WORK CLASS SET statement.

You can view your work class sets by querying the SYSCAT.WORKCLASSSETS catalog view.

The following figure shows an example of work classes in a work class set.

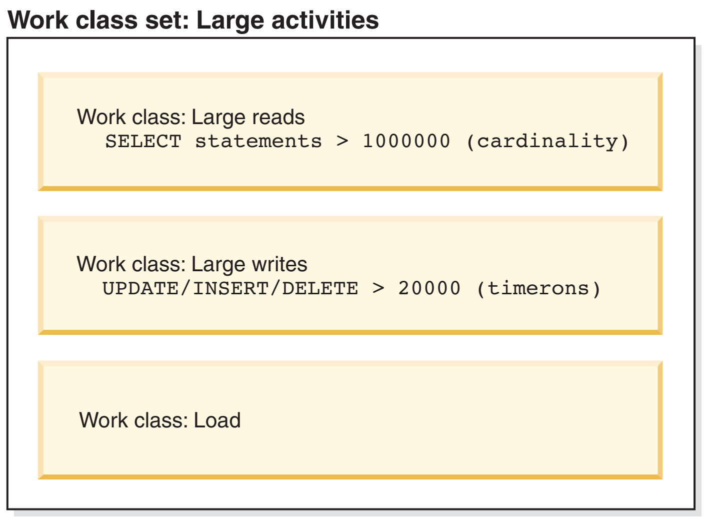

Work class set: Large activities
Work class: Large reads
SELECT statements > 1000000 (cardinality)
Work class: Large writes
UPDATE/INSERT/DELETE > 20000 (timerons)
Work class: Load

Figure 8. Example of work classes and a work class set

For a work class set to be effective on the system, you must define a work action set and associate it with the work class set. By using a work action set, you can associate a work class set to a service superclass, a workload, or a database, to indicate what action should be applied to the database activities that fall within the classification. If you do not create a work action set for the work class set, the data server ignores the work class set.

Creating a work class

To create a work class, use the CREATE WORK CLASS SET statement or the ALTER WORK CLASS SET statement.

Before you begin

To create a work class, you require WLMADM or DBADM authority.

For additional prerequisites, see the following topics:
- “Workload management DDL statements” on page 18

- Naming rules

Procedure

To create a work class:

1. Create a work class at the same time you create a new work class set or add the new work class to an existing work class set:
   - To create a new work class that is added to a new work class set, use the WORK CLASS keyword of the CREATE WORK CLASS SET statement.
   - To create a new work class that is added to an existing work class set, use the ADD WORK CLASS keyword of the ALTER WORK CLASS SET statement.

   Specify one or more of the following properties for the new work class:
   - A name for the work class. This name must be unique in the work class set.
   - Attributes for the work class. These attributes are used to associate an activity with the work class:
     - The type of work that the work class is to be used for. Use the WORK TYPE parameter to specify this characteristic.
       - READ, which represents non-updating SELECT activities, and all XQuery activities. When you specify the READ keyword, you can also specify an optional for-from-to-clause or data-tag-clause argument.
         - Use the optional for-from-to-clause argument to specify a range for either the cost of the statement in timerons, or its cardinality (that is, the number of rows returned). You must specify a numeric value for the first value. For the second value, you can specify either a numeric value, or the value UNBOUNDED to indicate that you do not want to impose an upper limit on either the cost or cardinality of the activity. You can also specify this argument for the WRITE keyword, the DML keyword, and the ALL keyword.

           For example, to associate SELECT activities that have a cost of 5000 timerons or more with this work class, you would specify:
           ```
           WORK TYPE READ FOR TIMERONCOST FROM 5000 TO UNBOUNDED
           ```
         - Use the optional data-tag-clause argument to specify a data tag identifying data that the activity is estimated to access. You can specify a value between 1 and 9. If the data-tag-clause is not specified no restriction is imposed on the type of data that a query accesses. You can also specify this argument for the WRITE keyword, the DML keyword, and the ALL keyword.

           For example, to associate SELECT activities with this work class, that are estimated to access data in table spaces that have been assigned a data tag value of 1, you would specify:
           ```
           WORK TYPE READ DATA TAG LIST CONTAINS 1
           ```
       - WRITE, which represents SQL activities that update data in the database. When you specify the WRITE keyword, you can also specify an optional for-from-to-clause or data-tag-clause argument.

         For example, to associate all data writing activities with this work class that, at compile time, are estimated to touch data tagged with a value of 5, you would specify:
         ```
         WORK TYPE WRITE FOR CARDINALITY FROM 50 TO 100
         ```
       - CALL, which represents CALL activities.

When you specify the CALL keyword, you can also specify the ROUTINES IN SCHEMA keyword to indicate that only CALL activities to routines in a specific schema should be associated with this work class. For example, if you only want to associate calls to routines in the ACCOUNTS schema to this work class, you would specify:

```
WORK TYPE CALL ROUTINES IN SCHEMA ACCOUNTS
```

- DML, which represents SQL activities covered by both the READ and WRITE keywords.

  For example, to associate all DML activities that have an estimated cost in timerons from 500 to 1000 and, at compile time, are estimated to touch data tagged with a value of 8, you would specify:

  ```
  WORK TYPE DML FOR TIMERONCOST FROM 500 TO 1000 DATA TAG LIST CONTAINS 8
  ```

- DDL, which represents the following activities:
  - ALTER
  - CREATE
  - COMMENT
  - DECLARE GLOBAL TEMPORARY TABLE
  - DROP
  - FLUSH PACKAGE CACHE
  - GRANT
  - REFRESH TABLE
  - RENAME
  - REVOKE
  - SET INTEGRITY

  For example, to associate all DDL activities with this work class, you would specify:

  ```
  WORK TYPE DDL
  ```

- LOAD, which represents a LOAD activity.

  For example, to associate LOAD activities to this work class, you would specify:

  ```
  WORK TYPE LOAD
  ```

- ALL, which represents all the work types indicated by all the preceding keywords.

  When you specify ALL for a work class type, you can also specify the ROUTINES IN SCHEMA keyword to indicate that only CALL activities to routines in a specific schema should be associated with this work class. You can also specify the for-from-to-clause argument to indicate that all DML activities that have an estimated timeron cost or cardinality specified fall into this class. For example, to associate both DML activities that have a cardinality of 300 to 1500 rows and routines that are called from the NEWHIRES schema to this work class, you would specify the following statement.You can also specify the data-tag-clause argument to indicate all DML activities that access data in table spaces that are tagged with a data tag value. Because this work class has a type of ALL, it would also apply to other activities that do not have a schema or cardinality, such as LOAD activities and DDL activities.

  ```
  WORK TYPE ALL FOR CARDINALITY FROM 300 TO 1500 ROUTINES
  IN SCHEMA NEWHIRES
  ```

   – Optional. The position of the work class in the work class set. The position of the work class in the work class set determines the order in which the work class is evaluated when classifying an activity to a work class. When work class assignment occurs, the data server first determines the work class set associated with the object (either a service superclass or the database), then selects the first matching work class in the work class set that has a work action associated with it. Use the POSITION keyword to specify one of the following:
     - LAST. The work class is placed at the end of the list of work classes in the work class set. For example:
       ```
       WORK TYPE ... POSITION LAST
       ```
     - BEFORE *work-class-name*. The work class is to be created in the work class set and positioned before the specified work class. For example:
       ```
       WORK TYPE ... POSITION BEFORE LARGEDDL
       ```
     - AFTER *work-class-name*. The work class is to be created in the work class set and positioned after the specified work class. For example:
       ```
       WORK TYPE ... POSITION AFTER LARGEDDL
       ```
     - AT *integer*. The work class is to be created in the work class set in the position specified by the integer value. For example:
       ```
       WORK TYPE ... POSITION AT 3
       ```
2. Commit your changes. When you commit your changes, the work class is added to the SYSCAT.WORKCLASSES view.

Altering a work class

If you need to alter a work class, use the ALTER WORK CLASS SET statement.

Before you begin

To alter a work class, you require WLMADM or DBADM authority.

See "Workload management DDL statements" on page 18 for additional prerequisites.

Procedure

To alter a work class:

1. Use the ALTER keyword of the ALTER WORK CLASS SET statement to change one or more of the following properties. See "Creating a work class" on page 53 for an explanation of the supported values for these properties.
   - The FOR keyword. For example, you can change the value specified for the FOR keyword from CARDINALITY to TIMERONCOST.
   - The FROM *from-value* TO *to-value* argument. For example, you can change the argument from `FROM 50 TO 100` to `FROM 500 TO 1500`.
   - The ROUTINES IN SCHEMA or the ROUTINES IN ALL keywords, for CALL activities. For example, if the work class currently does not specify a schema, you can add one. You can also specify the keyword ALL, so that the work class applies to all CALL statements, regardless of the schema of the routine. ALL is the default.
   - The DATA TAG LIST CONTAINS keyword. For example, you can change the value specified for this keyword from ANY to 8.
   - The POSITION keyword, followed by the keywords LAST, BEFORE, AFTER, or AT. If you specify POSITION BEFORE or POSITION AFTER, you must also specify the work class that you want to use to position your altered

work class. If you specify POSITION AT, you must include the position number. For example, you can move a work class from the last position to any position by using the AT keyword, or from any position to the last position by using the LAST keyword.

2. Commit your changes. When you commit your changes, the work class is updated in the SYSCAT.WORKCLASSES view.

Dropping a work class

If you no longer require a work class, you can drop it from the work class set.

Before you begin

To drop a work class, you require WLMADM or DBADM authority.

See "Workload management DDL statements" on page 18 for additional prerequisites.

Procedure

To drop a work class:

1. Use the DROP keyword of the ALTER WORK CLASS SET statement. You cannot drop a work class if any work action in any work action set associated with this work class set has a dependency on the work class you want to drop. In this situation, you must first drop all dependent work actions before dropping the work class.
2. Commit your changes. When you commit your changes, the work class is removed from the SYSCAT.WORKCLASSES view.

Creating a work class set

To create a work class set, use the CREATE WORK CLASS SET statement.

Before you begin

To create a work class set, you require WLMADM or DBADM authority.

For additional prerequisites, see the following topics:

- "Workload management DDL statements" on page 18

Procedure

To create a work class set:

1. Specify the following properties for the work class set using the CREATE WORK CLASS SET statement:
   - A name for the work class set. The name you specify must be unique in the database.
   - Optional: One or more work classes for the work class set. For more information, see "Creating a work class" on page 53.
2. Commit your changes. When you commit your changes, the work class set is added to the SYSCAT.WORKCLASSSETS view.

Altering a work class set

You cannot change the work class set attributes after you create a work class set. However, you can add, alter, and drop work classes in the work class set using the ALTER WORK CLASS SET statement.

Before you begin

To alter a work class set, you require WLMADM or DBADM authority.

For additional prerequisites, see the following topics:
- "Workload management DDL statements" on page 18
- Naming rules

Procedure

1. If you want to add work class to the work class set, use the ADD keyword. For information about the keywords that you can specify when adding a work class, see "Creating a work class" on page 53.
2. If you want to alter a work class, use the ALTER keyword. For information about altering a work class, see "Altering a work class" on page 56.
3. If you want to drop a work class, use the DROP keyword. For information about dropping a work class from a work class set, see "Dropping a work class" on page 57. If you want to drop all the work classes from the work class set, you can drop the work class set itself. For more information, see "Dropping a work class set."
4. Commit your changes. When you commit your changes, the SYSCAT.WORKCLASSES view is updated to show any added, altered, or dropped work class.

Dropping a work class set

Use the DROP WORK CLASS SET statement to drop a work class set.

Before you begin

To drop a work class set, you require WLMADM or DBADM authority.

About this task

You can drop a work class set only if no work action sets are associated with it. If you want to drop the work class set, you must first drop its dependent work action sets.

Procedure

To drop a work class set:
1. Use the DROP WORK CLASS SET statement.
2. Commit your changes. When you commit your changes the work class set is removed from the SYSCAT.WORKCLASSSETS view. In addition, all work classes that were part of the work class set are removed from the SYSCAT.WORKCLASSES view.

Evaluation order of work classes in a work class set

A work class set can have multiple work classes that match with a database activity. To select which work class from a work class set an activity should fall under, the data server goes through the work classes according to the evaluation order, stopping at the first work class that matches the activity.

If no matching work class exists, the database activity does not belong to any work class, and no work action is applied to that activity.

You can affect the evaluation order of work classes in a work class set when you create or alter a work class set. When you create or alter a work class set, you determine the position at which a work class is placed in the work class set using one of the following three methods:

- Specify the absolute position of the work class in the list.

  For example, POSITION AT 2. In this situation, the work class is placed in the second position in the work class set, and the work class that was at the second position is now the third, the third work class is now the fourth, and so on. If the position specified for the work class by the CREATE WORK CLASS SET or ALTER WORK CLASS SET statement is greater than the total number of work classes in the work class set, the work class is positioned last in the list.
- Use the POSITION BEFORE or POSITION AFTER keyword to specify the position of the work class relative to work classes already in the work class set.
- Omit the position when creating a work class.

  In this situation, the new work class is positioned at the end of the list. The position you specify for the work class in the work class set list is not necessarily the actual value of the EVALUATIONORDER column in the SYSCAT.WORKCLASSES view. The data server automatically assigns the order value to prevent gaps.

Work classes are processed in the order they are received, which can affect the evaluation order. For example, assume that you issue the following statement:

```
ALTER WORK CLASS SET WCS ALTER WORK CLASS C1 POSITION AT 1
   ALTER WORK CLASS C2 POSITION AT 1
```

As a result, the C1 work class has a evaluation order of 2 and the C2 work class has an evaluation order of 1 because C2 was the last work class processed.

Assignment of activities to work classes

If a work class set, through a work action set, is associated with a database, a workload, or a service superclass, then, just prior to execution in processing of an execute, execute immediate, or open request, or just before the execution of the load utility, the database activity is checked to determine if it matches any of the criteria specified in the work classes within the work class set.

The work classes are sorted within the work class set, by their evaluation order. Based on this evaluation order, the database activity is checked against each work class based on the attributes of the database activity (such as the activity type and cardinality) until there is a match or the list of work classes in the work class set has been exhausted.

Assume that the following work classes are in a work class set:

- Evaluation order: 1; work class name: `MyLoad`; work class type: LOAD
- Evaluation order: 2; work class name: `SmallRead`; work class type: READ; other attributes: estimated cost < 300 timerons
- Evaluation order: 3; work class name: `AllDML`; work class type: DML
- Evaluation order: 4; work class name: `LargeRead`; work class type: READ; other attributes: estimated cost > 301 timerons
- Evaluation order: 5; work class name: `MyDDL`; work class type: DDL

If a SELECT statement with an estimated cost of 200 timerons is received, it is assigned to the `SmallRead` work class. If a DDL activity (such as CREATE TABLE) arrives, it is assigned the `MyDDL` work class. If a SELECT statement with an estimated cost of 500 timerons arrives, it is assigned to the `AllDML` work class because `AllDML` is positioned before the `LargeRead` work class. For more information, see "Example: Working with a work class defined with the ALL keyword" on page 63.

Work classifications supported by thresholds

Although any of the threshold types that can be used in work actions can be associated with any work class, not all types of database activities are supported for all of those threshold types.

For example, if you create a work class for DDL, then associate that work class with an ESTIMATEDSQLCOST threshold work action, that threshold will not apply to any of the requests that are classified under DDL because DDL statements do not have an estimated cost. If you create a work class for ALL, then associate that work class with an ESTIMATEDSQLCOST threshold work action, although all database activities belong to the ALL work class, the threshold will only apply to the database activities that have an estimated cost.

The following tables show which work class categories are supported by which threshold types:

Table 23. Work classification supported by thresholds

	"ACTIVITYTOTALTIME threshold" on page 131	"ESTIMATEDSQLCOST threshold" on page 135	"CONCURRENTDBCOORDACTIVITIES threshold" on page 141	"CPUTIME threshold" on page 132
READ, including SET statements with embedded READ SQL	Yes	Yes	Yes[1]	Yes
WRITE, including SET statements with embedded WRITE SQL	Yes	Yes	Yes[1]	Yes
CALL	Yes	No	No	Yes
DML, including SET statements with embedded READ or WRITE SQL	Yes	Yes	Yes[1]	Yes
DDL	Yes	No	Yes[1]	No
LOAD	Yes	No	Yes[1]	No
ALL	Yes	Some	Yes[1]	Some

Note:

1. Activities that run within user-defined functions (UDFs) and that contain these work classifications are not affected by the CONCURRENTDBCOORDACTIVITIES threshold.

Table 24. Work classification supported by thresholds (continued)

	"SQLROWSREAD threshold" on page 136	"SQLROWSRETURNED threshold" on page 138	"SQLTEMPSPACE threshold" on page 139
READ, including SET statements with embedded READ SQL	Yes	Yes	Yes
WRITE, including SET statements with embedded WRITE SQL	Yes	Yes	Yes
CALL	No	No (see note)	No

Table 24. Work classification supported by thresholds (continued) (continued)

	"SQLROWSREAD threshold" on page 136	"SQLROWSRETURNED threshold" on page 138	"SQLTEMPSPACE threshold" on page 139
DML, including SET statements with embedded READ or WRITE SQL	Yes	Yes	Yes
DDL	No	No	No
LOAD	No	No	No
ALL	Some	Some	Some

Note:

- Although the statements in the procedure called may return rows, because the rows are not returned as a result of the CALL statement they are not controlled by the SQLROWSRETURNED threshold.

Example: Analyzing workloads by activity type

You can use DB2 workload management table functions to examine the workloads in your environment according to the types of activities being run.

In some situations, you might be interested in the behavior of a certain type of activities, such as LOAD activities. For example, you can observe how many LOAD activities are currently in the system as follows:

```
SELECT COUNT(*)
FROM TABLE(WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES(CAST(NULL AS BIGINT), -2))
AS ACTS
WHERE ACTIVITY_TYPE = 'LOAD'
```

You can obtain a count of how many activities of a specific type have been submitted since the last reset of the DB2 workload management statistics by using the WLM_GET_WORK_ACTION_SET_STATS table function, as shown in the following example. Assume that the READCLASS and LOADCLASS work classes exist for activities of type READ and activities of type LOAD. The * represents all activities that do not fall into the READCLASS or LOADCLASS work class.

```
SELECT SUBSTR(WORK_ACTION_SET_NAME,1,18) AS WORK_ACTION_SET_NAME,
       SUBSTR(CHAR(DBPARTITIONNUM),1,4) AS PART,
       SUBSTR(WORK_CLASS_NAME,1,15) AS WORK_CLASS_NAME,
       LAST_RESET,
       SUBSTR(CHAR(ACT_TOTAL),1,14) AS TOTAL_ACTS
FROM TABLE(WLM_GET_WORK_ACTION_SET_STATS('', -2)) AS WASSTATS
ORDER BY WORK_ACTION_SET_NAME, WORK_CLASS_NAME, PART

WORK_ACTION_SET_NAME PART WORK_CLASS_NAME LAST_RESET                 TOTAL_ACTS
-------------------- ---- --------------- -------------------------- ----------
AdminActionSet       0    ReadClass       2005-11-25-18.52.49.343000 8
AdminActionSet       1    ReadClass       2005-11-25-18.52.50.478000 0
AdminActionSet       0    LoadClass       2005-11-25-18.52.49.343000 2
AdminActionSet       1    LoadClass       2005-11-25-18.52.50.478000 0
AdminActionSet       0    *               2005-11-25-18.52.50.478000 0
AdminActionSet       1    *               2005-11-25-18.52.50.478000 0
```

You can view the average lifetime of LOAD activities by creating a work action set to map LOAD activities to a specific service subclass. For example, suppose you map LOAD activities to the service subclass LOADSERVICECLASS under the service superclass MYSUPERCLASS. Then, you can query the WLM_GET_SERVICE_SUBCLASS_STATS table function:

```
SELECT SUBSTR(SERVICE_SUPERCLASS_NAME,1,19) AS SUPERCLASS_NAME,
       SUBSTR(SERVICE_SUBCLASS_NAME,1,18) AS SUBCLASS_NAME,
       SUBSTR(CHAR(DBPARTITIONNUM),1,4) AS PART,
       CAST(COORD_ACT_LIFETIME_AVG / 1000 AS DECIMAL(9,3)) AS AVGLIFETIME
```

```
FROM TABLE
   (WLM_GET_SERVICE_SUBCLASS_STATS('MYSUPERCLASS', 'LOADSERVICECLASS', -2))
AS SCSTATS
ORDER BY SUPERCLASS_NAME, SUBCLASS_NAME, PART

SUPERCLASS_NAME     SUBCLASS_NAME      PART AVGLIFETIME
------------------- ------------------ ---- ----------------------
SYSDEFAULTUSERCLASS LOADSERVICECLASS   0                  4691.242
SYSDEFAULTUSERCLASS LOADSERVICECLASS   1                  4644.740
SYSDEFAULTUSERCLASS LOADSERVICECLASS   2                  4612.431
SYSDEFAULTUSERCLASS LOADSERVICECLASS   3                  4593.451
```

Example: Using a work class set to manage specific types of activities

The following example shows how to use a work class set to manage DML activities.

Assume that you have a large number of applications running on your NONAME database each day and lately a few performance issues have been occurring. To deal with some of these issues, you decide that you need to be able to control the number of large queries (that is, any query that has an estimated cost of greater than 9999 timerons or an estimated cardinality of greater than 9999 rows) that can run simultaneously on the database.

To control the number of large queries that can run on the database, you would do the following:

1. Create a MYWORKCLASSSET work class set that contains two work classes: one for queries with a large estimated cost and one for queries with a large estimated cardinality. For example:
   ```
   CREATE WORK CLASS SET MYWORKCLASSSET
    (WORK CLASS LARGEESTIMATEDCOST WORK TYPE DML
   FOR TIMERONCOST FROM 10000 TO UNBOUNDED,
   WORK CLASS LARGECARDINALITY WORK TYPE DML
   FOR CARDINALITY FROM 10000 TO UNBOUNDED)
   ```
2. Create a DATABASEACTIONS work action set that contains two work actions that are to be applied to the work classes in the MYWORKCLASSSET work class set at the database level
   ```
   CREATE WORK ACTION SET DATABASEACTIONS FOR DATABASE
   USING WORK CLASS SET LARGEQUERIES
   (WORK ACTION ONECONCURRENTQUERY ON WORK CLASS LARGEESTIMATEDCOST
   WHEN CONCURRENTDBCOORDACTIVITIES > 1 AND QUEUEDACTIVITIES > 1 STOP EXECUTION,
   WORK ACTION TWOCONCURRENTQUERIES ON WORK CLASS LARGECARDINALITY
   WHEN CONCURRENTDBCOORDACTIVITIES > 2 AND QUEUEDACTIVITIES > 3 STOP EXECUTION)
   ```

In addition, several large administrative applications run daily against the database, and you want these applications to run in one resource pool. To accomplish this goal, you would create a service superclass called ADMINAPPS for these applications. For each application, you would create a workload to map it to the ADMINAPPS service superclass.

Because it is important that the queries (SELECT statements) run quickly, you decide to create a service subclass called SELECTS in the ADMINAPPS service superclass for these queries.

To map the SELECT statements to the SELECTS service subclass:

1. Create a SELECTDML work class set that contains a work class for all SELECT statements that do not update the database:

```
CREATE WORK CLASS SET SELECTDML (WORK CLASS SELECTCLASS WORK TYPE READ)
```

2. Create an ADMINAPPSACTIONS work action set. This work action set contains a work action that is to be applied to the work class in work class set SELECTDML at the service superclass level

```
CREATE WORK ACTION SET ADMINAPPSACTIONS FOR SERVICE CLASS ADMINAPPS
USING WORK CLASS SET SELECTDML
(WORK ACTION MAPSELECTS ON WORK CLASS SELECTCLASS MAP ACTIVITY TO SELECTS)
```

Example: Working with a work class defined with the ALL keyword

This example shows how to work with a work class defined as ALL, which potentially covers all recognized activities in the database.

The DB2 workload management infrastructure recognizes the following specific subset from the domain of all possible database activities: load operations, the CALL statement, all DDL statements, and all DML statements. Full support for monitoring and controlling these *recognized activities* is provided by DB2 workload management.

When a work class with the type of ALL is used with a mapping work action, all recognized database activity is mapped to the service subclass specified in the work action. If a work class with the work type of ALL is used with a threshold work action, the threshold type determines which database activities the threshold applies to. Consider the following example.

Assume that you create a work class set called `Example` with the following work classes. The evaluation order of the work class is as follows:

1. SMALLDML, which is for all DML-type SQL that has an estimated cost of less than 1000 timerons.
2. LOADUTIL, which is for the load utility.
3. ALLACTIVITY, which is for all database activity

ALLACTIVITY is the last work class evaluated, and covers database activities that do not correspond to the first three work classes.

The DDL for creating this work class set is:

```
CREATE WORK CLASS SET EXAMPLE
(WORK CLASS SMALLDML WORK TYPE DML FOR TIMERONCOST FROM 0 TO 999,
WORK CLASS LOADUTIL WORK TYPE LOAD,
WORK CLASS ALLACTIVITY WORK TYPE ALL)
```

Assume that you have a service superclass called EXAMPLESERVICECLASS, and it has two service subclasses called SMALLACTIVITY and OTHERACTIVITY. You want to set up the system so that all small database activities run in the SMALLACTIVITY service subclass, and all other recognized database activities, except for the load utility, run in the OTHERACTIVITY service subclass. You do not want to remap the load utility to any other service subclass, but instead want it to run in the default service subclass.

To accomplish these goals, you would set up a work action set, SERVICECLASSACTIONS for the EXAMPLESERVICECLASS service superclass. The SERVICECLASSACTIONS work action set would contain the following work actions.

Table 25. SERVICECLASSACTIONS work action set

Work action	Work class applied to	Action
MAPDML	SMALLDML	Maps to the SMALLACTIVITY service subclass
COUNTLOAD	LOADUTIL	Counts the number of LOAD activities
MAPOTHER	ALLACTIVITY	Maps to the OTHERACTIVITY service subclass

The DDL to create this work action set is:

```
CREATE WORK ACTION SET SERVICECLASSACTIONS FOR SERVICE CLASS EXAMPLESERVICECLASS
USING WORK CLASS SET EXAMPLE
(WORK ACTION MAPDML ON WORK CLASS SMALLDML MAP ACTIVITY TO SMALLACTIVITY,
WORK ACTION COUNTLOAD ON WORK CLASS LOADUTIL COUNT ACTIVITY,
WORK ACTION MAPOTHER ON WORK CLASS ALLACTIVITY MAP ACTIVITY TO OTHERACTIVITY)
```

Using this configuration, all small DML runs under the SMALLACTIVITY service subclass. The COUNTLOAD work action is applied to the LOADUTIL work class, which runs under the default service subclass. All other recognized database activities run under the OTHERACTIVITY service subclass.

Note: If the ALLACTIVITY work class were at the top of the evaluation order, all recognized activities would be mapped to the OTHERACTIVITY service subclass.

Now assume that you want to define a work action set for the database and apply thresholds that control what is permitted to run concurrently on the system. You could create a work action set called DATABASEACTIONS that contains the following work actions. The DML for creating this work action set is:

```
CREATE WORK ACTION SET DATABASEACTIONS FOR DATABASE USING WORK CLASS SET EXAMPLE
(WORK ACTION CONCURRENTSMALLDML ON WORK CLASS SMALLDML
WHEN CONCURRENTDBCOORDACTIVITIES > 1000 AND QUEUEDACTIVITIES > 10000
COLLECT ACTIVITY DATA STOP EXECUTION,
WORK ACTION CONCURRENTLOAD ON WORK CLASS LOADUTIL
WHEN CONCURRENTDBCOORDACTIVITIES > 2 AND QUEUEDACTIVITIES > 10
COLLECT ACTIVITY DATA STOP EXECUTION,
WORK ACTION CONCURRENTOTHER ON WORK CLASS ALLACTIVITY
WHEN CONCURRENTDBCOORDACTIVITIES > 100 AND QUEUEDACTIVITIES > 100
COLLECT ACTIVITY DATA STOP EXECUTION,
WORK ACTION MAXCOSTALLOWED ON WORK CLASS ALLACTIVITY
WHEN ESTIMATEDSQLCOST > 1000000 COLLECT ACTIVITY DATA STOP EXECUTION)
```

Table 26. DATABASEACTIONS work action set

Work action	Work class applied to	Threshold type and value	Action
CONCURRENTSMALLDML	SMALLDML	Concurrency up to 1000 statements; queue up to 10 000 statements	• Stop execution • Collect activity data
CONCURRENTLOAD	LOADUTIL	Concurrency up to 2 occurrences; queue up to 10 occurrences	• Stop execution • Collect activity data
CONCURRENTOTHER	ALLACTIVITY	Concurrency up to 100 activities; queue up to 100 activities	• Stop execution • Collect activity data

Table 26. DATABASEACTIONS work action set (continued)

Work action	Work class applied to	Threshold type and value	Action
MAXCOSTALLOWED	ALLACTIVITY	Estimated SQL cost up to 1 000 000 timerons	• Stop execution • Collect activity data

When these work actions are applied, up to 1000 small DML-type SQL statements (because of the SMALLDML work class) can run at a time, and up to 10 000 of these statements can be queued. Only two occurrences of the load utility can run at a time, and up to 10 occurrences can be queued. Only 100 activities that are not LOAD and are not small DML are permitted to run at a time, and only 100 of these activities can be queued at a time. In all situations, if the queued threshold is violated, the database activity is not permitted to run and an error message is returned.

In addition, the MAXCOSTALLOWED work action is applied to the ALLACTIVITY work class. This means that a database activity with an estimated cost (that is, DML and XQueries statements) of more than 1 000 000 timerons is not permitted to run. Although the MAXCOSTALLOWED work action is applied to the ALLACTIVITY work class, this work action only affects database activities that have an estimated cost greater than 1 000 000 timerons. This work action does not affect activities that do not have an estimated cost, such as DDL.

Chapter 3. Activities management

Once you have identified the work running on your data server, you are ready to actively manage this work by assigning resources and imposing controls.

Resource assignment with service classes

A service class defines an execution environment in which work can run. This execution environment allocates available resources and can include thresholds that determine how work is permitted to run.

All work runs in a service class and you use workloads to assign work to service superclasses, or you assign work to service subclasses in a service superclass by using workloads, the REMAP ACTIVITY threshold action, or the MAP ACTIVITY work action. When you define a workload, you indicate the service class where work associated with that workload runs. By default, a default user workload also exists (SYSDEFAULTUSERWORKLOAD) that maps work to the default user service class (SYSDEFAULTUSERCLASS), so that any work not explicitly mapped to a user defined service class using a user defined workload will run in the default user service class.

Without service classes, requests cannot be organized into recognizable, logical groupings, as is shown in the following figure.

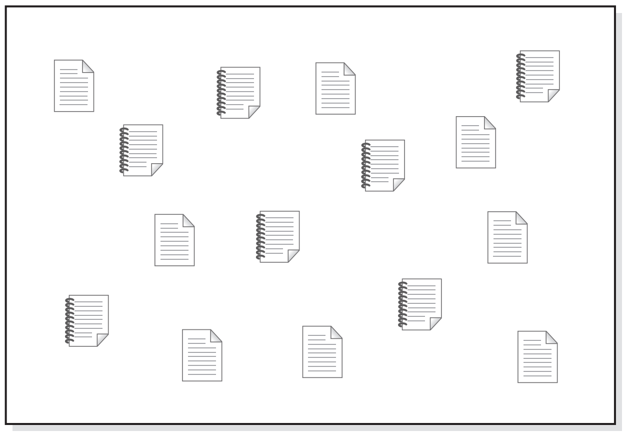


Figure 9. Unorganized work

You can create different service superclasses to provide the execution environment for different types of work, then assign the applicable requests to the service superclasses. Assume that you have applications from two separate lines of business, finance and inventory. Each line of business would have its own applications to fulfill its responsibilities to the organization. You can organize the requests into categories that make sense for your workload management objectives. In the following figure, different service superclasses are assigned to different lines of business.

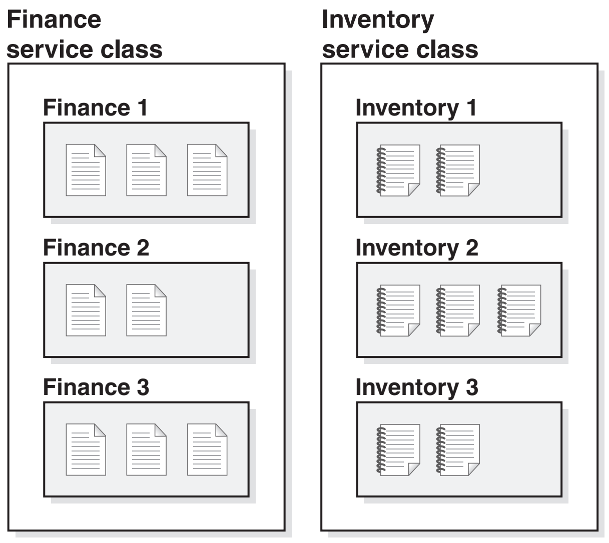


Figure 10. Work organized by service classes

In the previous figure, the activities in both service superclasses are further subdivided. The service class provides a two-tier hierarchy: a service superclass and service subclasses underneath. This hierarchy permits for a more complex division of execution environment and better emulates a real-world model. Unless specified otherwise, service subclasses inherit characteristics from the service superclass. Use the service subclasses to further subdivide work in the service superclass.

Prioritization and resource control

When you create or alter a service class object, you can define a number of resource controls:

Table 27. Resource control afforded by service classes

Control	Description
Agent priority	This control sets a processor priority level for the agent threads running in a service class. This priority flows through to the operating system as a relative (delta) priority to other threads and processes running in the data server. **Note:** This control cannot be set when outbound correlator is in use.
Prefetch priority	This control assigns a priority to the prefetch requests, which affects the order in which they are addressed by the data server.
Buffer pool priority	This control assigns a buffer pool priority to service classes which affects how likely pages fetched by activities in a service class are to be swapped out.

Table 27. Resource control afforded by service classes (continued)

Control	Description
Outbound correlator	This control permits a workload to have some of its resources controlled by a operating system workload manager like AIX Workload Manager or Linux workload management. The tag flows through the agent to the external workload manager and maps to a resource group defined with the manager. When DB2 workload management is used in conjunction with an operating system workload manager, additional controls are available. With AIX Workload Manager, you can control the amount of processor resource allocated to each service class by setting a minimum, maximum, or relative share of processor resource for each service class. With Linux workload management, you can control the amount of CPU resource by setting shares for each service class relative to the Linux default class. **Note:** This control cannot be set when agent priority is in use.

Service subclasses

Although the service superclass is the highest tier for work, activities run only in service subclasses. Each service superclass has a default service subclass defined to run activities that you do not assign to an explicitly defined subclass. This default subclass is created when the service superclass is created. You can create additional subclasses in a service class as you require them to further isolate work. Except for histograms and the COLLECT ACTIVITY DATA, COLLECT AGGREGATE ACTIVITY DATA and COLLECT AGGREGATE REQUEST DATA options, a service subclass inherits the attributes of its service superclass, unless otherwise specified. The resources of the superclass are shared by all subclasses in it.

You can define only a single level of subclasses (that is, you cannot define a subclass under another subclass, only under a service superclass).

The following figure is an example of a custom DB2 workload management configuration using workloads and service classes:

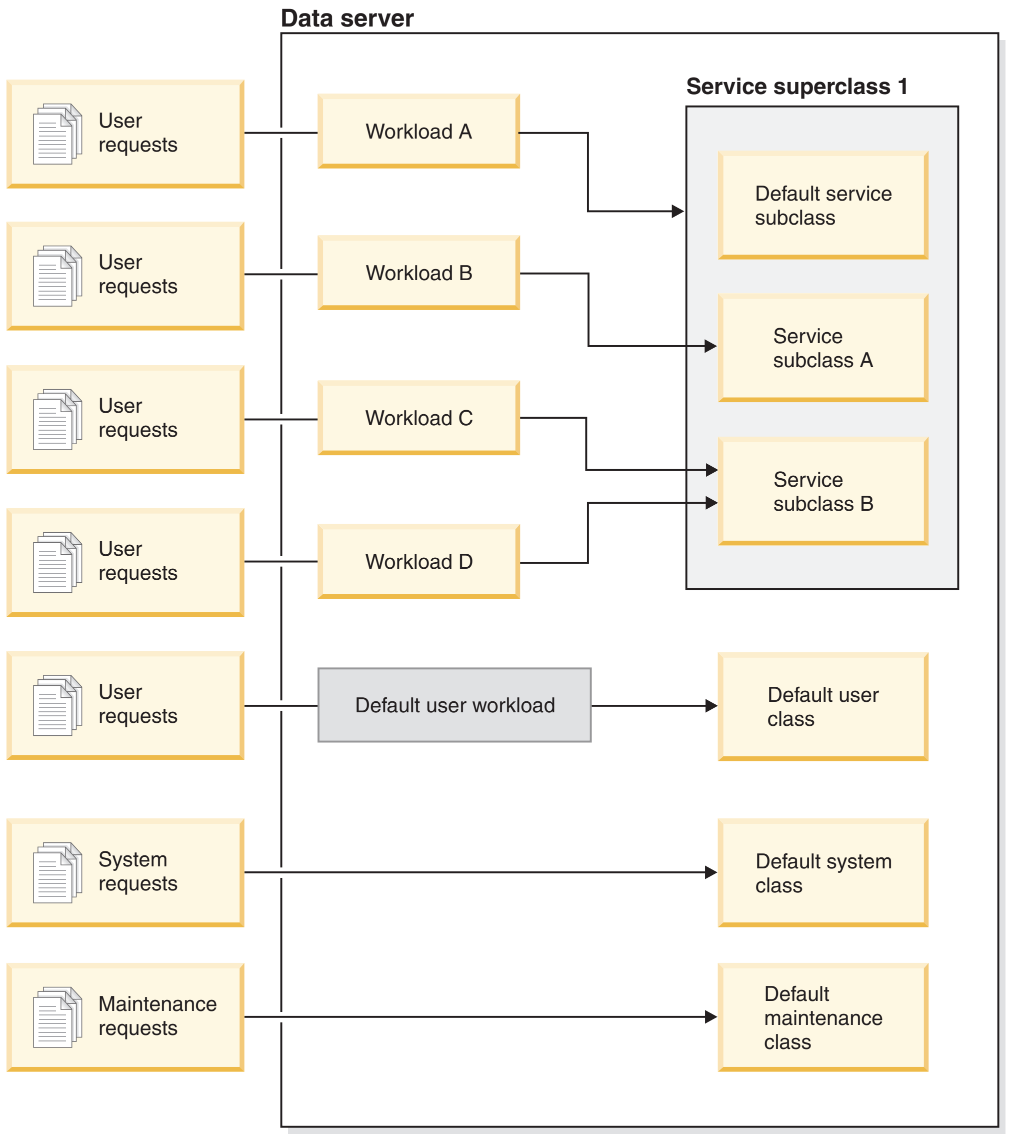


Figure 11. A custom DB2 workload management configuration using workloads and service classes

As user requests enter the data server, they are identified as belonging to a given workload and assigned to a service superclass or subclass. There are also system requests (for example, prefetches) that run under a special default system service class (SYSDEFAULTSYSTEMCLASS) and DB2-driven maintenance requests (such as an automatic RUNSTATS from the health monitor) that run under a default maintenance service class (SYSDEFAULTMAINTENANCECLASS).

You can view your service classes by querying the SYSCAT.SERVICECLASSES catalog view.

Default service superclasses and subclasses

Each new database or upgraded database has three predefined default service superclasses: the default user class, the default maintenance class, and the default system class.

You cannot disable or drop any of the default service superclasses.

All of the default service superclasses are created with one default service subclass. You cannot create additional service subclasses for the default service superclasses. The default service subclass is always created with the name SYSDEFAULTSUBCLASS, as follows:

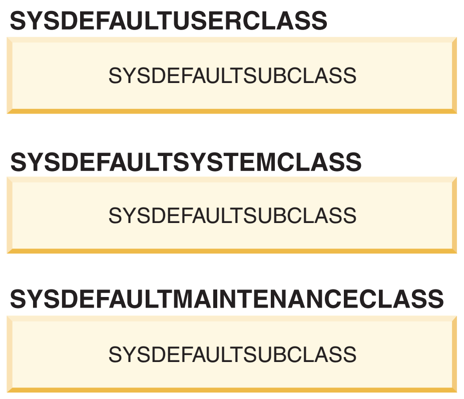


Figure 12. Two-tier service class hierarchy

All work issued by connections to a default service superclass are processed in the default service subclass of that service superclass.

Default service superclasses and their default service subclasses are dropped only when the database is dropped. They cannot be dropped using the DROP SERVICE CLASS statement.

Default user service superclass (SYSDEFAULTUSERCLASS)
By default, all user activities run in the SYSDEFAULTUSERCLASS.

Default maintenance service superclass (SYSDEFAULTMAINTENANCECLASS)
The default maintenance service superclass tracks the internal DB2 connections that perform database maintenance and administration tasks. Connections from the DB2 asynchronous background processing (ABP) agents are mapped to this service superclass. ABP agents are internal agents that perform database maintenance tasks. Asynchronous index cleanup (AIC) is an example of an ABP-driven task. ABP agents automatically reduce their resource consumption and number of subagents when the number of user connections increases on the data server. Utilities that are issued by user connections are mapped using regular service classes. You cannot implement service class thresholds on SYSDEFAULTMAINTENANCECLASS.

The internal connections tracked by the default maintenance service superclass include:

- ABP connections (including AIC)
- Health monitor initiated backup
- Health monitor initiated RUNSTATS
- Health monitor initiated REORG

Default system service superclass (SYSDEFAULTSYSTEMCLASS)
The default system service superclass tracks internal DB2 connections and threads that perform system-level tasks. You cannot define service subclasses for this service superclass, nor can you associate any workloads or work actions with it. In addition, you cannot implement service class

thresholds on SYSDEFAULTSYSTEMCLASS. The DB2 threads and connections tracked by the default system service superclass include:

- ABP daemon
- Self Tuning Memory Manager (STMM)
- Prefetcher engine dispatchable units (EDUs) (db2pfchr)
- Page cleaner EDUs (db2pclnr)
- Log reader EDUs (db2loggr)
- Log writer EDUs (db2loggw)
- Log file reader EDUs (db2lfr)
- Deadlock detector EDUs (db2dlock)
- Event monitors (db2evm)
- Event monitor fast writers (db2fw)
- Connections performing system level tasks

Activity-to-service class mapping

All database connections are assigned to a workload at the beginning of the first unit of work. When a workload occurrence is started, all activities running under that workload occurrence are mapped to service classes based on the service class name specified in the workload definition.

The data server assigns a connection to a workload definition if the connection meets the criteria defined for that workload definition. For example, you can set up a workload management configuration so that all connections from application A belong to the workload definition Alpha, while all connections from application B belong to the workload definition Beta.

If the workload occurrence is assigned to a service superclass, activities submitted for that workload occurrence can be reassigned to a user-defined service subclass in that service superclass using a work action set.

You can use the workload to map activities from a connection to a service superclass by specifying the SERVICE CLASS keyword of the CREATE WORKLOAD statement. Assuming that no work class or work action applies to the activity, the activity is run in the default service subclass of the service superclass. You can also use a workload to map activities from a connection to a service subclass in the service superclass by specifying the UNDER keyword for the SERVICE CLASS keyword of the CREATE WORKLOAD statement. In this situation, the connection still belongs to the service superclass, but all activities issued from that connection are automatically mapped to the service subclass specified in the workload definition.

After an activity has been mapped to a service subclass and has begun executing, it stays in that service subclass, unless you remap it to another service subclass (with a threshold). Remapping is the process by which you can change the resource assignments for an activity through a different activity-to-service subclass mapping. Both the source and the target service subclasses must exist under the same superclass. After the activity is remapped, it continues to execute in the new service subclass.

The following figure shows the relationship between connections, workloads, and service superclasses. Connections that meet the definition of workload A are mapped to service superclass 1; connections that meet the definition of workloads B or C are mapped to service superclass 2; connections that meet the definition of workload D are mapped to the SYSDEFAULTUSERCLASS service superclass.

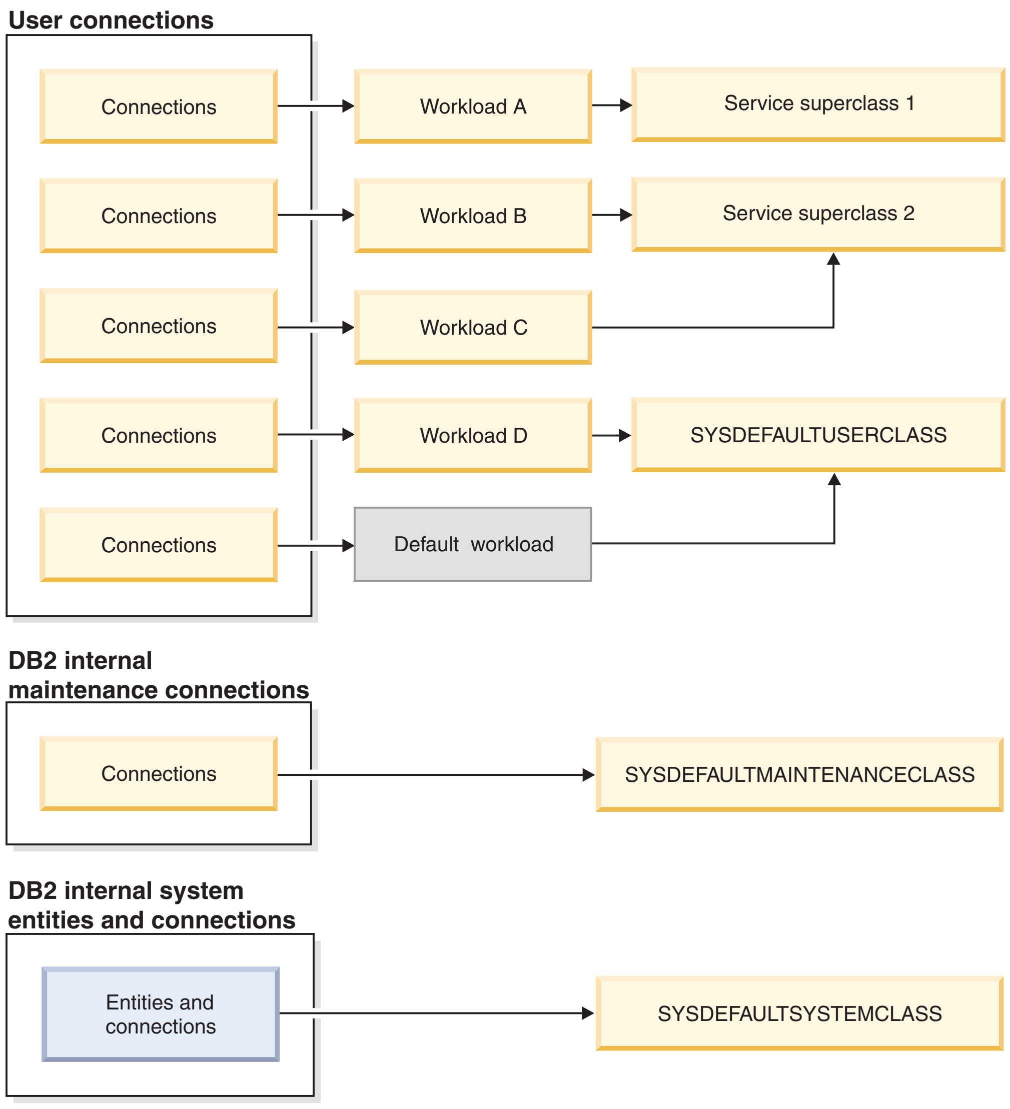


Figure 13. Mapping of database connections to a service superclass

Further differentiating between activities

If you have a more complex DB2 workload manager configuration, you might want to handle activities differently based on either the activity type or some other activity attribute. For example, you might want to do one of the following actions:

- Put DML in a different service subclass than DDL.
- Put all read-type queries with an estimated cost of less than 100 timerons in a different service subclass than all the other read-type queries.

In a more complex configuration you can set up the workload to map activities from the connection to the service superclass. Then, using work actions (contained in a work action set that is applied to the service superclass), you can remap activities, based on their type or attribute, to specific service subclasses in a service superclass.

Specifically, you could apply a work action set that contains a MAP ACTIVITY work action to the service superclass. All activities that are both mapped to the service superclass and match a work class to which a MAP ACTIVITY work action is associated are mapped to the service subclass specified by the work action.

If a workload definition associates itself with a service subclass, any activities that are submitted through that workload are not affected by a work action set that is assigned to the parent service superclass.

- An activity can be mapped to one service subclass in a service superclass by a workload.
- A work action that maps the activity to a different service subclass in the same service superclass also applies to the activity.

If an activity is not mapped to a service subclass through a workload or a work action, the activity is mapped to the default subclass (SYSDEFAULTSUBCLASS) of the service superclass for that activity.

When database activities have been mapped to their respective service superclasses and service subclasses, you can implement controls on all the activities in a particular service class. Statistics are available at the service-class level that you can use to monitor database activities in that service class.

The following figure shows requests to the database being mapped to a service superclass or service subclass through workloads. For information on how work actions are used to map activities to a service subclass, see "Work actions and work action sets" on page 96

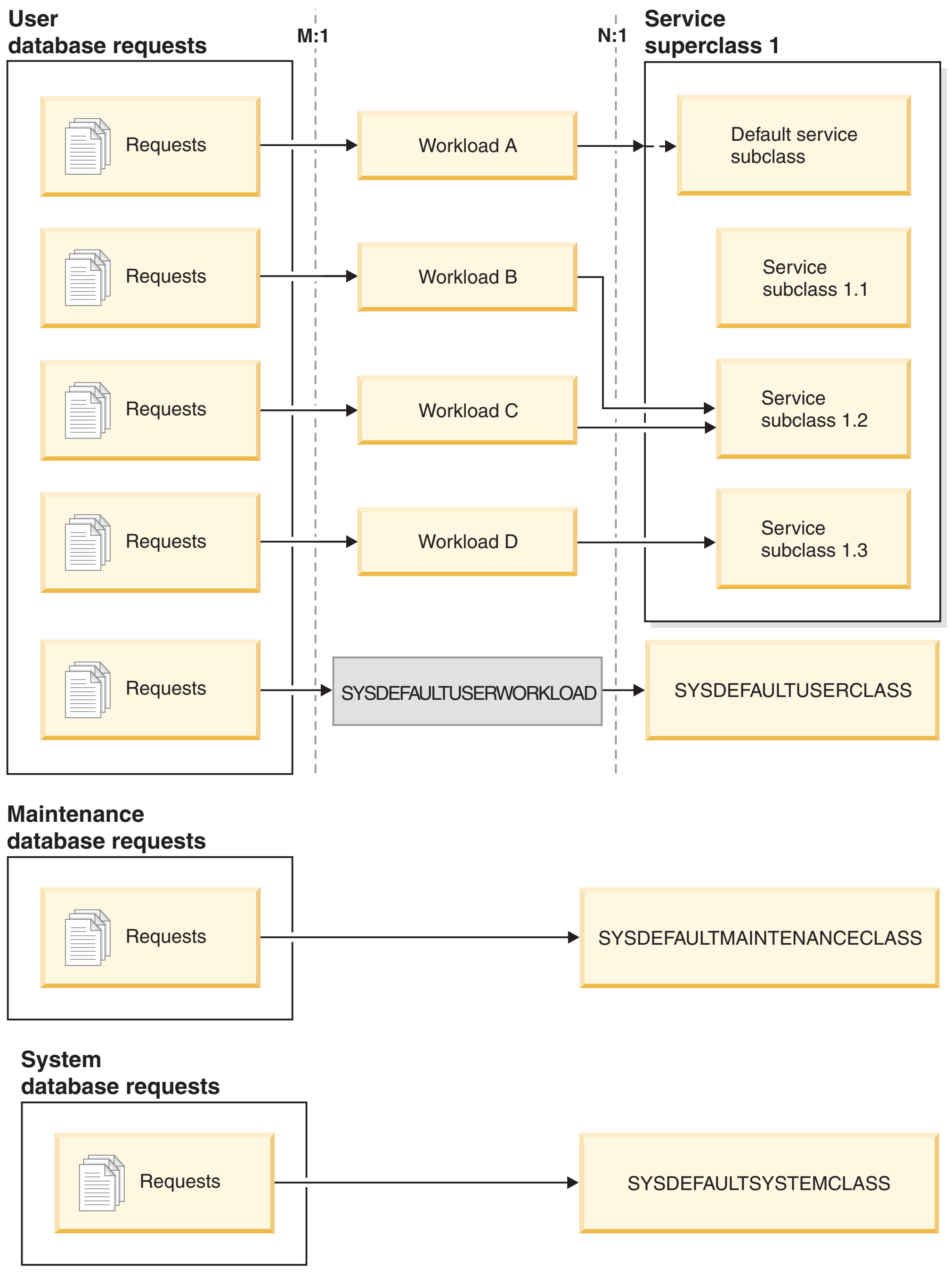


Figure 14. Database connections being mapped to a service superclass

Connections that do not map to a user-defined workload definition are mapped to the default user workload definition, SYSDEFAULTUSERWORKLOAD. By default, connections from the default workload definition (SYSDEFAULTUSERWORKLOAD) are mapped to the SYSDEFAULTUSERCLASS service superclass, which is the default service superclass for user requests. You can alter the SYSDEFAULTUSERWORKLOAD workload so that it maps to a different service class. Internal DB2 maintenance connections are mapped to the SYSDEFAULTMAINTENANCECLASS, which is the default service superclass for maintenance requests. Internal system entities and connections are mapped to SYSDEFAULTSYSTEMCLASS, which is the default service superclass for internal DB2 connections and threads that perform system-level tasks.

Agent priority of service classes

You can associate each DB2 service class with a relative agent priority, which controls processor priority on your data server. This priority is set for all agents that work in a service class and is relative to the agent priority of all other DB2 agents.

If you do not specify the agent priority value for a service class, all agents in that service class have the same priority as all other DB2 agents.

Setting the agent priority for a DB2 service class adjusts the priority of agents only for new work that enters the service class. Non-agent threads running in the service class do not use the agent priority value that you specify. DB2 workload management does not assign service class agent priority to work being done within a fenced mode process (FMP). Fenced procedures do not run their logic within a service class. These fenced procedures run within the DB2 FMP and this work is not done by DB2 agents. As a reminder, DB2 WLM controls DB2 agents.

If you are integrating DB2 service classes with an operating system workload manager such as AIX Workload Manager or Linux workload management, you can use the operating system workload manager to specify the processor priority to be used for the operating system class (as processor shares), then have the DB2 service class inherit this value through the OUTBOUND CORRELATOR value of the DB2 service class. The processor priority that you specify using the operating system workload manager controls the priority for agents that run in the DB2 service class, and any service class agent priority setting is ignored.

Note: You cannot use agent priority to cap the amount of CPU used by a subset of work on the system. Agent priority does bias CPU processing between competing workloads when they need CPU resources, but, agent priority does not explicitly allocate or manage CPU resources between competing workloads. Therefore, under circumstances in which competing workloads are not equally demanding CPU resources, agent priority appears to be ineffective in those cases where the lower priority work makes more requests to consume CPU resources than the higher priority work. However, agent priority is effective if you have competing workloads that are equally demanding CPU resources and you just want to bias CPU consumption rather than explicitly throttle or control CPU consumption. To apply more explicit control on CPU consumption, then Linux WLM integration or concurrency controls are more effective options.

Important: Do not use the deprecated **agentpri** database manager configuration parameter with DB2 workload management. You can use this configuration parameter to set the absolute processor priority of all agents in a DB2 instance to a fixed value. However, if you set the absolute priority for an agent by using **agentpri**, you cannot alter the relative priority of the agent by setting the DB2 service class agent priority or by using an operating system workload manager. If you set **agentpri**, the service class agent priority and operating system workload manager have no effect on the priority of agents.

On UNIX operating systems and Linux, valid values are DEFAULT and -20 to 20 (SQLSTATE 42615). Negative values denote a higher relative priority. Positive values denote a lower relative priority.

On Windows operating systems, valid values are DEFAULT and -6 to 6 (SQLSTATE 42615). Negative values denote a lower relative priority. Positive values denote a higher relative priority.

On AIX operating systems, the instance owner must have CAP_NUMA_ATTACH and CAP_PROPAGATE capabilities to set a higher relative priority for agents in a service class using AGENT PRIORITY. To grant these capabilities, logon as root and run the following command:

```
chuser capabilities=CAP_NUMA_ATTACH,CAP_PROPAGATE
```

On Solaris 10 or higher, the instance owner must have the proc_priocntl privilege to set a higher relative priority for agents in a service class using AGENT PRIORITY. To grant this privilege, logon as `root` and run the following command:

```
usermod -K defaultpriv=basic,proc_priocntl db2user
```

In this example, proc_priocntl is added to the default privilege set of user db2user.

Moreover, when DB2 is running in a non-global zone of Solaris, the proc_priocntl privilege must be added to the limit privilege set of the zone. To grant this privilege to the zone, logon as `root` and run the following command:

```
global# zonecfg -z db2zone
zonecfg:db2zone> set limitpriv="default,proc_priocntl"
```

In this example, proc_priocntl is added to the limit privilege set of zone db2zone.

On Solaris 9, there is no facility for DB2 to raise the relative priority of agents. Upgrade to Solaris 10 or higher to use the service class agent priority.

Prefetch priority of service classes

Prefetchers retrieve data from disk and store this data in buffer pools so that it can be quickly accessed by agents. Each service superclass and subclass can be assigned to have a different prefetch priority.

Agents send read-ahead requests to the database prefetch queue. The prefetchers take these read-ahead requests from the queue, then retrieve the data into the buffer pools. When an agent requires specific data, it first checks the buffer pools to see if the data is available. If not, the agent retrieves the data from disk. Prefetchers perform expensive disk I/O operations, which frees agents to perform computational work in parallel.

Any connection routed to a service class has its prefetch requests processed according to the prefetch priority assigned for the service class. Each service class can be associated with one of the three prefetch priorities: high, medium, or low. You specify the prefetch priority of a service class with the PREFETCH PRIORITY keyword on either the CREATE or ALTER SERVICE CLASS statement.

Specifying DEFAULT for a service superclass sets a medium prefetch priority for the service superclass. You can specify a different prefetch priority for any service subclass in the service superclass, but if you use the default prefetch priority for the service subclass, the service subclass inherits its prefetch priority setting from its service superclass.

High-priority prefetch requests are processed before medium-priority prefetch requests, which, in turn, are processed before low-priority prefetch requests. Prefetch priority affects the order in which prefetch requests are processed, but it does not affect the speed at which they are processed.

Buffer pool priority of service classes

Setting the buffer pool priority of service classes allows you to influence the proportion of pages in the buffer pool that may be occupied by activities in a given service class, which can improve the throughput and performance of activities in that service class.

You can associate each DB2 service class with a relative buffer pool priority, which controls how likely pages fetched into the buffer pool by activities in the service class are to be swapped out. Increasing the buffer pool priority potentially increases the proportion of pages in use by agents of a particular service class.

If you do not specify a buffer pool priority, or if you specify BUFFERPOOL PRIORITY DEFAULT, the buffer pool priority assigned to the service class is DEFAULT. For service superclasses, DEFAULT maps to a value of LOW; for service subclasses, DEFAULT maps to the value of the buffer pool priority of the parent service superclass. All default subclasses have a buffer pool priority of DEFAULT, which cannot be changed.

When upgrading from an earlier DB2 version, the buffer pool priority of existing service classes is set to DEFAULT.

Realizing the benefits of setting buffer pool priority

You are more likely to realize a performance advantage with setting the buffer pool priority for a service class if there is a reasonable amount of contention on the buffer pool. Buffer pool contention demonstrated by an overall hit ratio of 85% or less is likely to see the most benefit. If the overall hit ratio exceeds 90%, there is likely not substantial buffer pool contention to begin with, and setting buffer pool priority will yield less or little benefit in most cases. What benefits you realize are dependent on the type of workload your data server runs.

For some workloads, setting buffer pool priority is more effective if you also turn on proactive page cleaning. This is because buffer pool priority settings are effective only for non-dirty pages and proactive page cleaning is more aggressive about writing out dirty pages to disk. Note that you should turn on proactive page cleaning only if it yields a performance benefit.

If you use asynchronous page cleaning (also known as classic page cleaning), setting the **chngpgs_thresh** database configuration parameter to a lower value will likely yield the same effect of making your buffer pool priority settings more effective, because a low value for this parameter also ensures that there are enough clean pages in the buffer pool.

It is possible that the positive effects of setting buffer pool priority can be surpassed by the effects of prefetching, with or without setting prefetch priority, if there is a reasonable amount of prefetching taking place. For example, if you define a service class with high buffer pool priority where there is only little prefetching, the effective advantage of this buffer pool priority setting might be small when compared to a service class with low buffer pool priority but where activities perform a significant amount of prefetching. Due to the benefits of prefetching, the activities in the service class with low buffer pool priority might even outperform the activities in the high buffer pool priority service class. However, setting buffer pool priority can still supplement your workload management strategy under these circumstances, and you should use it.

States of connections and activities in a service class

Service classes collect connection statistics for each service class. You can see which connections and activities are in a service class, and the state of either the connection or activity.

States of a connection

Following are the possible states of a connection in a service class:

CONNECTED
: The connection successfully connected to the database but is not yet associated with its workload and service superclass.

DECOUPLED
: The connection does not have a coordinator agent assigned (concentrator case).

DISCONNECTPEND
: The connection is disconnecting from the database.

FORCED
: The connection has been forced.

INTERRUPTED
: The connection has been interrupted.

MAPPED
: The connection is mapped to a workload and has joined a service superclass. The connection can now submit activities for execution.

QUEUED
: The connection coordinator agent is queued by a DB2 connection or activity threshold that offers queuing, such as the CONCURRENTDBCOORDACTIVITIES threshold. In a multimember database environment, this state might indicate that the coordinator agent has made an RPC to another member to obtain threshold tickets and has not yet received a response.

TRANSIENT
: The connection is attempting to join a service class that has reached its connections threshold. The connection is queued to join the service class. When the service class is not violating its connections threshold, the connection will join the service class. A connection in the transient state cannot submit activities for execution.

TERMINATING
: The connection received a connect reset from the client or is being terminated because of a force or an error condition.

UOWEXEC
: The connection is processing a request.

UOWWAIT
: The connection is waiting for a request from the client.

States of an activity

Following are the possible states of an activity in a service class:

CANCEL_PENDING
: If you cancel an activity that has no agent actively working on a request

for the activity, the activity is placed in the CANCEL_PENDING state and is cancelled on the next request that is received.

EXECUTING
The activity is executing.

IDLE There is no agent actively processing a request for the activity.

INITIALIZING
The activity was created and is being prepared for execution.

QUEUED
The activity cannot be executed because of a concurrency threshold at the database or service class level. The activity is queued until it is permitted to execute.

TERMINATING
The activity is being terminated.

UNKNOWN
The state of the activity is unknown.

System-level entities not managed by service classes

Service classes are used for monitoring and controlling objects at the database level. However, not all DB2 entities work directly in a database.

Because service classes work in a database and are stored in the catalog tables of the database, entities that do not work in a database cannot be managed by service classes. Instance-level entities, such as the system controller and the health monitor daemons, work at the instance level and are not directly associated with any database. Agents that perform instance attachments and gateway connections are not managed by service classes either. Because instance attachment agents and gateway agents do not work in a database, they are not managed by service classes.

The following list is a partial list of entities that do not work within a database and are not managed by service classes:
- DB2 system controllers (db2sysc)
- IPC listeners (db2ipccm)
- TCP listeners (db2tcpcm)
- FCM daemons (db2fcms, db2fcmr)
- DB2 resynchronization agents (db2resync)
- Idle agents (agents with no database association)
- Instance attachment agents
- Gateway agents
- All other instance-level EDUs

Creating a service class

You create service superclasses and service subclasses under them using the DDL statement CREATE SERVICE CLASS.

Before you begin

To create a service class, you require WLMADM or DBADM authority.

Also see the following topics for other prerequisites:

- "Workload management DDL statements" on page 18
- Appendix A, "General naming rules," on page 491

Procedure

To create a service class:

1. Specify one or more of the following properties for the service class on the CREATE SERVICE CLASS statement:
   - Specify the name of the service class:

     Note: Once set, the name of a service class cannot be changed.
     - If you are creating a service superclass, the name must be unique among all service superclasses in the database.

       When a service superclass is created, its associated default service subclass is automatically created. Only after you have created a service superclass can you create other service subclasses under it.
     - If you are creating a service subclass, the name must be unique among all service subclasses in the service superclass. A service subclass cannot have the same name as its service superclass.
   - If you are creating a service subclass, specify the name of the parent service superclass. After a service subclass is created under a service superclass, it cannot be associated with a different service superclass.
   - Specify the buffer pool priority for the service class which affects how likely pages fetched by activities in the service class are to be swapped out. For service superclasses, the DEFAULT value internally maps to LOW. Service subclasses set to DEFAULT inherit the buffer pool priority from their parent superclasses.
   - Specify the prefetch priority. You can specify the priority with which agents in the service class can submit their prefetch requests. Depending on the value specified, the prefetch requests are routed to the high, medium, or low priority prefetch queues. The default prefetch priority is medium.
   - Specify the outbound correlator string if you want to associate the DB2 service class with an AIX class or a Linux class. A null value indicates no operating system workload manager association.

     If the outbound correlator is set, all threads in the DB2 service class are associated with the operating system workload manager by using the outbound correlator when the next activity begins.

     If the outbound correlator is set to NONE for a service subclass and the outbound correlator is specified for the associated service superclass, the service subclass inherits the outbound correlator specified for its service superclass.
   - Specify the activity data to collect. When activity data collection is enabled, information about an activity is sent from the coordinator member to the applicable event monitor at the end of the activity. You can write data to the event monitor that includes information about the statement that was run, its compilation environment, and any applicable input data values. You can also specify that no activity data is collected. By default, no activity data is collected.
   - Collected aggregate activity information. The aggregate activity information used for the service class only changes after the CREATE SERVICE CLASS operation is committed.

- The type of request metrics to collect for requests submitted by a connection that is associated with the service superclass you specify. By default, basic metrics are always collected for activities associated with the workload.
- The histogram templates that the service subclass should use as templates for its histograms. The histogram templates specified are reflected in the SYSCAT.HISTOGRAMTEMPLATEUSE view. For more information about histograms and histogram templates, see “Histograms in workload management” on page 253.
- Specify whether the service class is enabled or disabled.
  - If a service class is created as enabled (the default), connections and activities can be mapped to the service class. If a service class is created as disabled, new connections and activities mapped to it are rejected.
  - If you create a service superclass as disabled, all service subclasses that you associate with this service superclass behave as though they are disabled, even though they might be displayed as being enabled when you query the SYSCAT.SERVICECLASSES view.

2. Commit your changes. When you commit your changes the service class is added to the SYSCAT.SERVICECLASSES view.

Altering a service class

If you want to change a service class definition, use the ALTER SERVICE CLASS statement.

Before you begin

To alter a service class, you require SQLADM, WLMADM, or DBADM authority. To specify any clause other than a COLLECT clause, the authorization ID must include WLMADM or DBADM authority.

See “Workload management DDL statements” on page 18 for more information about prerequisites.

About this task

Activities that have already acquired resources and are running are usually not affected by the ALTER statement. These activities will hold their resources and run until completion. (Note that changes to the CPU shares or CPU limits of a service class that are made through the ALTER SERVICE CLASS statement take effect immediately, even in the case of activities that are already running.) However, if a subagent request is sent to a remote member during the ALTER SERVICE CLASS operation, the service class definition seen by the coordinator agent and the subagent can differ. Consider the following example in which the prefetch priority for the service class is initially set to MEDIUM:

Table 28. Differences between the views of a coordinator agent and subagent of an altered service class

Event order	Connection 1	Connection 2
1	Coordinating agent sends a request to remote member (prefetch priority of service class was previously set to MEDIUM)	

Table 28. Differences between the views of a coordinator agent and subagent of an altered service class (continued)

Event order	Connection 1	Connection 2
2		ALTER SERVICE CLASS issued; set prefetch priority to HIGH
3		COMMIT is issued (the altered service class property is committed at the catalog member and loaded to memory at all database members)
4	Remote subagent receives the request. At this time, the subagent sets the new prefetch priority of HIGH for the service class definition	

This situation described in the previous table is temporary, and only affects connections that issue subagent requests during the ALTER SERVICE CLASS operation. All new connections will see the updated service class definition with the prefetch priority of HIGH.

Procedure

To alter a service class:

1. Specify one or more of the following properties for the service class on the ALTER SERVICE CLASS statement:
   - Specify whether the service class is enabled or disabled. If you change a service class from enabled to disabled, existing connections or activities remain with the service class and continue to use previously allocated resources until complete. You can disable a service class if the work coming to the service class is overwhelming the system, or you want to reject all work coming to the service class.

     When a service superclass is disabled the following happens:

     a. The service superclass is disabled.
     b. Its service subclasses are disabled.

     The service subclasses are only disabled while their service superclass is disabled. When the service superclass is enabled, the service subclasses return to their previous states as defined in the catalog table.

     When a service subclass is disabled, its service superclass is not affected, nor other service subclasses associated with the service superclass.

     You cannot explicitly disable a default service subclass. To prevent new requests from running under a default service subclass, you must disable the associated service superclass.
   - Specify the agent priority for the service class. When the agent priority is set to DEFAULT, agents in the service class are assigned the same priority that the operating system assigns all DB2 threads. If you set the AGENT PRIORITY parameter to a value other than DEFAULT, the agent threads are set to a priority equal to the default priority, plus the value set when the next activity begins. For example, if the default priority is 20 and you set agent priority to -10, the resulting agent priority is set to 20 + (-10) = 10.

In the SYSCAT.SERVICECLASSES catalog view, an agent priority of DEFAULT is represented as -32768.

On Linux and UNIX, the valid values are -20 to 20 (a negative value indicates a higher relative priority). On Windows operating systems, the valid values are -6 to 6 (a negative value indicates a lower relative priority)

- Specify the prefetch priority. You can specify the priority with which agents in the service class can submit their prefetch requests. Depending on the value specified, the prefetch requests are routed to the high, medium, or low priority prefetch queues. The default prefetch priority is medium. If the prefetch priority is altered after a prefetch request is submitted, the request will not change its priority.
- Specify the buffer pool priority for the service class which affects how likely pages fetched by activities in the service class are to be swapped out. For service superclasses, the DEFAULT value internally maps to LOW. Service subclasses set to DEFAULT inherit the buffer pool priority from their parent superclasses.
- Specify the outbound correlator string if you want to associate the DB2 service class with an AIX class or a Linux class. A null value indicates no operating system workload manager association.

  If the outbound correlator is changed from a non-null value to a null value, all threads in the DB2 service class will disassociate with the operating system workload manager when the next activity begins.

  If the outbound correlator is set to NONE for a service subclass and the outbound correlator is specified for the associated service superclass, the service subclass inherits the outbound correlator specified for its service superclass.

  If a service superclass uses an outbound correlator, the agent priority of the service superclass must be set to default.

  If a service subclass uses an outbound correlator (either explicitly as part of the service subclass definition or implicitly through inheritance from the service superclass), the agent priority of the service subclass must be set to default.
- Specify the adding or dropping of a system temporary table space to or from the list of preferred temporary table spaces for the specified service subclass.
- Specify the activity data to collect. When activity data collection is enabled, information about an activity is sent from the coordinator member to the applicable event monitor at the end of the activity. You can write data to the event monitor that includes information about the statement that was run, its compilation environment, and any applicable input data values. You can also specify that no activity data is collected. By default, no activity data is collected.
- Collected aggregate activity information. The aggregate activity information used for the service class only changes after the ALTER SERVICE CLASS operation is committed.
- The monitoring request metrics collection level for requests submitted by connections mapped to a subclass under the specified service superclass. Note that the effective collection setting for requests running under a service superclass is the combination of both the service class collection level and the **mon_req_metrics** database configuration parameter.
- Whether to alter the histogram templates used by a service subclass that has enabled aggregate activity data collection using COLLECT AGGREGATE ACTIVITY DATA or aggregate request data collection using COLLECT AGGREGATE REQUEST DATA. Updating the histogram templates used by a

service subclass will update the corresponding rows in the SYSCAT.HISTOGRAMTEMPLATEUSE view which displays the histogram templates referenced by a service class or work action. For more information about histograms and histogram templates, see "Histograms in workload management" on page 253.

2. Commit your changes. When you commit your changes the service class is updated in the SYSCAT.SERVICECLASSES view.

Dropping a service class

You drop service classes using the DDL statement DROP SERVICE CLASS.

Before you begin

To drop a service class, you require WLMADM or DBADM authority.

See "Workload management DDL statements" on page 18 for more information about prerequisites.

You cannot drop the default service superclasses (SYSDEFAULTUSERCLASS, SYSDEFAULTMAINTENANCECLASS, and SYSDEFAULTSYSTEMCLASS) or their associated service subclasses. The only way to drop the default service superclasses and their associated service subclasses is to drop the database.

A service class you defined cannot be dropped if any of the following conditions apply:

- It is enabled
- It contains user-defined service subclasses
- It is referenced by any workload, work action, or threshold
- It is still referenced by a workload occurrence
- Any connection or activity is currently mapped to the service class
- If the service class is set as the target of a REMAP ACTIVITY action.

Procedure

To drop a service class:

1. Change workloads to not point to the service class, or disable the workload definitions. Alternatively, use the DROP WORKLOAD statement to drop all workloads that are associated with the service class. Issue a COMMIT statement after dropping each workload.

   Activities already running under the service class will continue to run. You can list agents that are currently mapped to a service class by using the WLM_GET_SERVICE_CLASS_AGENTS table function. If you do not want these activities to complete, you can use the application identifier returned by the table function and use the **FORCE APPLICATION** command to force these applications off the database.
2. Drop all applicable work actions that are associated with the service class you want to drop:
   - If you are dropping a service superclass and a work action set is associated with it, disable and drop that work action set. Use the ALTER WORK ACTION SET statement to disable a work action set, and the DROP WORK ACTION SET statement to drop the work action set. Issue a commit statement after dropping the work action set.

- If you are dropping a service subclass and a work action maps to that service subclass, drop the work action using the DROP WORK ACTION clause of the ALTER WORK ACTION SET statement. Alternatively, drop the work action set that contains the work action that maps to the service subclass by using the DROP WORK ACTION SET statement. Issue a COMMIT statement after dropping each work action, or after dropping the work action set.

3. Disable and drop all thresholds associated with the service class that you want to drop. Issue a COMMIT statement after dropping each threshold. Use the ALTER THRESHOLD statement to disable a threshold, and the DROP THRESHOLD statement to drop the threshold.
4. Depending on the object you are dropping, do the following:
   - If you are dropping a service subclass, use the DROP SERVICE CLASS statement to drop the service subclass.
   - If you are dropping a service superclass, use the DROP SERVICE CLASS statement to drop all service subclasses associated with the service superclass, and issue a COMMIT statement after dropping each service subclass. Then issue the DROP SERVICE CLASS statement to drop the service superclass.

     Note: You cannot manually drop the default service subclass for the service superclass. The default service subclass for a service superclass is dropped when the service superclass is dropped.
5. Disable the service class by using the ALTER SERVICE CLASS statement. If you are dropping a service superclass, this action disables all service subclasses associated with the service superclass. Disabling a service class prevents any additional activities from being associated with it. After disabling the service class, issue a COMMIT statement.
6. Commit your changes. When you commit your changes, the service class is removed from the SYSCAT.SERVICECLASSES view.

Example: Using service classes

The following example shows how to use service classes to control database workload.

This example occurs in the fictitious International Beer Emporium. International Beer Emporium is a medium-sized business made up of five major departments: Sales, Accounting, Engineering, Testing and Production. All five departments share the same product catalog database.

Initial implementation of a DB2 workload management solution

The product catalog database runs well most of the time. However, sometimes users complain that their applications cannot connect to the database because the maximum number of connections has been exceeded. After upgrading to DB2 Version 9.7, Bob, the database administrator, decides to try service classes. Bob wants to know the usage patterns of the product catalog database by each of the five departments and figure out why his database runs out of connections occasionally. Following are the steps Bob follows to set up the service classes:

1. First, Bob creates service superclasses for each of the departments (the default service subclass is also automatically created for each service superclass):
   - SALES is created for the Sales department:
     ```
     CREATE SERVICE CLASS SALES
     ```
   - ACCOUNTING is created for the Accounting department:

```
CREATE SERVICE CLASS ACCOUNTING
```

- ENGINEERING is created for the Engineering department:
  ```
  CREATE SERVICE CLASS ENGINEERING
  ```
- TESTING is created for the Testing department:
  ```
  CREATE SERVICE CLASS TESTING
  ```
- PRODUCTION is created for the Production department:
  ```
  CREATE SERVICE CLASS PRODUCTION
  ```

2. Bob creates session user groups with appropriate authorization IDs for each of the departments:
   - A session user group is created with the authorization ID SALESGRP. This group includes the authorization IDs of all users in the Sales department.
   - A session user group is created with the authorization ID ACCTNGRP. This group includes the authorization IDs of all users in the Accounting department.
   - A session user group is created with the authorization ID ENGINGRP. This group includes the authorization IDs of all users in the Engineering department.
   - A session user group is created with the authorization ID TESTGRP. This group includes the authorization IDs of all users in the Testing department.
   - A session user group is created with the authorization ID PRODGRP. This group includes the authorization IDs of all users in the Production department.
3. Bob creates workloads to map connections from each group to the associated service class:
   - Workload WL_SALES is created with its session user group set to SALESGRP. WL_SALES maps its connections to the service superclass SALES:
     ```
     CREATE WORKLOAD WL_SALES SESSION_USER GROUP ('SALESGRP')
     SERVICE CLASS SALES
     ```
   - Workload WL_ACCOUNTING is created with its session user group set to ACCTNGRP. WL_ACCOUNTING maps its connections to the service superclass ACCOUNTING:
     ```
     CREATE WORKLOAD WL_ACCOUNTING SESSION_USER GROUP ('ACCTNGRP')
     SERVICE CLASS ACCOUNTING
     ```
   - Workload WL_ENGINEERING is created with its session user group set to ENGINGRP. WL_ENGINEERING maps its connections to service class ENGINEERING:
     ```
     CREATE WORKLOAD WL_ENGINEERING SESSION_USER GROUP ('ENGINGRP')
     SERVICE CLASS ENGINEERING
     ```
   - Workload WL_TEST is created with its session user group set to TESTGRP. WL_TEST maps its connections to service class TESTING:
     ```
     CREATE WORKLOAD WL_TEST SESSION_USER GROUP ('TESTGRP')
     SERVICE CLASS TESTING
     ```
   - Workload WL_PRODUCTION is created with its session user group set to PRODGRP. WL_PRODUCTION maps its connections to service class PRODUCTION:
     ```
     CREATE WORKLOAD WL_PRODUCTION SESSION_USER GROUP ('PRODGRP')
     SERVICE CLASS PRODUCTION
     ```

Bob uses the default service class and workload settings. He wants to observe the database usage patterns before placing any controls on the service classes. The resulting service superclass definitions are as follows:

Table 29. Service class definitions

Service class
SALES
ACCOUNTING
ENGINEERING
TESTING
PRODUCTION
SYSDEFAULTUSERCLASS
SYSDEFAULTMAINTENANCECLASS
SYSDEFAULTSYSTEMCLASS

With a DB2 workload management solution implemented as described previously, work from each department is routed to its own service superclass. Work from departments not specifically accounted for is mapped to the SYSDEFAULTUSERCLASS default service superclass. Using this configuration, Bob can monitor the work in each of the service classes to determine the database usage pattern of the departments.

First refinement of the DB2 workload management implementation

Following the most recent connection spike, Bob queries service superclass statistics using the WLM_GET_SERVICE_SUPERCLASS_STATS table function and examines the connection high-water mark value for each service superclass. Bob discovers that the connection high-water mark for all departments except Testing is close to 100. However, the statistic for the Testing department shows that at one time, the test team established over 800 connections

Once a month, the Testing department performs its monthly intensive product testing. At this time, the department establishes up to 1000 concurrent connections. Because the database manager configuration parameter **max_connections** is set to 1000, the Testing department uses most of the available connections to the database. When the system has 1000 connections, all subsequent connections are rejected.

Because of memory constraints on the system, the **max_connections** and **maxagents** configuration values cannot be increased on the data server to permit more connections.

To prevent the Testing department from using all the connections, Bob decides to limit the number of connections from the Testing department and ensure that each of the other four departments can obtain sufficient connections to the database to meet their business objectives.

The other four departments ordinarily do not require more than 150 concurrent connections each. In addition, Bob also notices that the default user, default maintenance, and default system service superclasses rarely contain any connections, so he decides that 100 connections should be sufficient for these default service superclasses. After 700 connections (600 for the four departments and 100 for the default classes) are allocated from the **max_connections** pool of 1 000 available connections, 300 connections are available for the Testing department. By limiting the Testing department to a maximum of 300 connections, users from other departments should not have their connection requests rejected.

To limit the Testing group to a maximum of 300 concurrent connections, Bob creates a MAXSERVICECLASSCONNECTIONS threshold of 300 for the TESTING service class.

```
CREATE THRESHOLD MAXSERVICECLASSCONNECTIONS FOR SERVICE CLASS TESTING ACTIVITIES
ENFORCEMENT DATABASE PARTITION
WHEN TOTALSCMEMBERCONNECTIONS > 300 STOP EXECUTION
```

After implementing this change, the DB2 workload management configuration is as follows:

Table 30. Configuration after adding threshold for the TESTING service superclass

Service class	**MAXSERVICECLASSCONNECTIONS threshold**
SALES	N/A
ACCOUNTING	N/A
ENGINEERING	N/A
TESTING	300
PRODUCTION	N/A
SYSDEFAULTUSERCLASS	N/A
SYSDEFAULTMAINTENANCECLASS	N/A

Because the TESTING service class can contain a maximum of only 300 concurrent connections, all connection requests above this threshold are rejected. A MAXSERVICECLASSCONNECTIONS threshold is not applied on the other service classes, so these service classes share the remaining 700 available connections to the data server. Because there is no contention for connections among these service classes, Bob does not place connection thresholds on them.

Second refinement of the DB2 workload management implementation

Although connections from the Sales, Accounting, Engineering, and Production departments are no longer being rejected, users from these departments still complain about poor performance when the Testing department performs intensive product testing. Bob examines the queries that the Testing department runs during its product test cycle and discovers that the queries contain complicated joins that involve large amounts of data. These queries generate considerable prefetch activity, which prevents connections from other departments having their prefetch requests processed. Bob decides to lower the prefetch priority of the connections from the Testing department and alters the TESTING service class to set its prefetch priority to LOW:

```
ALTER SERVICE CLASS TESTING PREFETCH PRIORITY LOW
```

The DB2 workload management configuration is as follows:

Table 31. Configuration after changing prefetch priority for the TESTING service superclass

Service class	**MAXSERVICECLASSCONNECTIONS threshold**	**Prefetch priority**
SALES	N/A	DEFAULT

Table 31. Configuration after changing prefetch priority for the TESTING service superclass (continued)

Service class	MAXSERVICECLASSCONNECTIONS threshold	Prefetch priority
ACCOUNTING	N/A	DEFAULT
ENGINEERING	N/A	DEFAULT
TESTING	300	LOW
PRODUCTION	N/A	DEFAULT
SYSDEFAULTUSERCLASS	N/A	DEFAULT
SYSDEFAULTMAINTENANCECLASS	N/A	DEFAULT

Setting the prefetch priority of the TESTING service class to LOW causes prefetch requests from connections issued from the Testing department to be serviced only after all prefetch requests from the other departments are processed. This change increases the query throughput of the other departments and decreases the throughput of the Testing department during its product testing phase.

Third refinement of the DB2 workload management implementation

After the prefetch problem is resolved, the Engineering department tells Bob that it needs a few connections for an experimental application called Brewmeister. Because the application is experimental, Bob wants to ensure that it does not consume too many database connections and that queries from the application will not compete for prefetchers when the system is busy. To accomplish these objectives, he creates a new service subclass under the ENGINEERING service superclass for the experimental application and a workload to map connections from the application to the new service subclass. Bob updates the service class and workloads as follows:

- Service subclass EXPERIMENT is created under the service superclass ENGINEERING:
```
CREATE SERVICE CLASS EXPERIMENT UNDER ENGINEERING
```
- Threshold MAXSERVICECLASSCONNECTIONS of 50 is created for the service subclass EXPERIMENT:
```
CREATE THRESHOLD MAXSERVICECLASSCONNECTIONS FOR SERVICE CLASS EXPERIMENT
UNDER ENGINEERING ACTIVITIES
ENFORCEMENT DATABASE WHEN TOTALMEMBERCONNECTIONS > 50 STOP EXECUTION
```
- Workload WL_EXPERIMENT is created to map connections from the application BREWMEISTER to the service subclass EXPERIMENT:
```
CREATE WORKLOAD WL_EXPERIMENT APPLNAME ('BREWMEISTER') SERVICE CLASS EXPERIMENT
UNDER ENGINEERING
```
- The prefetch priority for the EXPERIMENT service subclass is set to LOW:
```
ALTER SERVICE CLASS EXPERIMENT UNDER ENGINEERING PREFETCH PRIORITY LOW
```

The DB2 workload management configuration is as follows:

Table 32. Configuration with EXPERIMENT service subclass

Service class	MAXSERVICECLASSCONNECTIONS threshold	Prefetch priority
SALES	N/A	DEFAULT
ACCOUNTING	N/A	DEFAULT

Table 32. Configuration with EXPERIMENT service subclass (continued)

Service class	MAXSERVICECLASSCONNECTIONS threshold	Prefetch priority
ENGINEERING	N/A	DEFAULT
EXPERIMENT	50	LOW
TESTING	300	LOW
PRODUCTION	N/A	DEFAULT
SYSDEFAULTUSERCLASS	N/A	DEFAULT
SYSDEFAULTMAINTENANCECLASS	N/A	DEFAULT

With this configuration, the BREWMEISTER application can only maintain 50 concurrent connections to the database. In addition, prefetch requests from this application are sent to the low priority prefetch queue. The Engineering department can now safely experiment with the application, knowing that it cannot accidentally overwhelm the database system.

Example: Analyzing a service class–related system slowdown

If you notice a system slowdown (for example, some applications take much longer than expected to complete) and are unsure whether the problem is related to the configuration of the service classes, you can use table function data to investigate and, if necessary, correct the problem.

First, obtain a high-level overview of what is occurring in the service classes. This high-level overview should include the average activity lifetime, the number of activities that completed normally rather than abnormally,and the high watermark for concurrent coordinator activities in the system. To obtain this information, you can create a general query with aggregation across service classes and database members by using the data obtained from the table function WLM_GET_SERVICE_SUBCLASS_STATS. Set the first and second arguments to empty strings and the third argument to -2 (a wildcard character) to indicate that data is to be gathered for all service classes on all database members. Your query might resemble the following one:

```
SELECT SUBSTR(SERVICE_SUPERCLASS_NAME,1,19) AS SUPERCLASS_NAME,
       SUBSTR(SERVICE_SUBCLASS_NAME,1,18) AS SUBCLASS_NAME,
       SUBSTR(CHAR(SUM(COORD_ACT_COMPLETED_TOTAL)),1,13) AS ACTSCOMPLETED,
       SUBSTR(CHAR(SUM(COORD_ACT_ABORTED_TOTAL)),1,11) AS ACTSABORTED,
       SUBSTR(CHAR(MAX(CONCURRENT_ACT_TOP)),1,6) AS ACTSHW,
       CAST(CASE WHEN SUM(COORD_ACT_COMPLETED_TOTAL) = 0 THEN 0
                 ELSE SUM(COORD_ACT_COMPLETED_TOTAL * COORD_ACT_LIFETIME_AVG)
                 / SUM(COORD_ACT_COMPLETED_TOTAL) END / 1000 AS DECIMAL(9,3))
       AS ACTAVGLIFETIME
FROM TABLE(WLM_GET_SERVICE_SUBCLASS_STATS ('', '', -2)) AS SCSTATS
GROUP BY SERVICE_SUPERCLASS_NAME, SERVICE_SUBCLASS_NAME
ORDER BY SERVICE_SUPERCLASS_NAME, SERVICE_SUBCLASS_NAME
```

Assume that on previous occasions, the query reported the following results:

```
SUPERCLASS_NAME     SUBCLASS_NAME      ACTSCOMPLETED ACTSABORTED ACTSHW ACTAVGLIFETIME
------------------- ------------------ ------------- ----------- ------ --------------
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 8             0           1               3.750
BI_APPS             SYSDEFAULTSUBCLASS 4             0           1               5.230
BATCH               SYSDEFAULTSUBCLASS 1             0           1              25.600
```

The data returned by this query might be sufficient to show that the slowdown is occurring in the BI_APPS service class because its average activity lifetime is significantly higher than usual. This situation could indicate that the available resources for that particular service class are becoming exhausted.

If the averages for the service classes for all database members do not isolate the problem, consider analyzing average values for each member. Aggregating the average for each member into a global average can hide large discrepancies between database members. In this situation, the assumption is that every member is being used as a coordinator member. If this assumption is incorrect, the average lifetime computed at non-coordinator members is zero.

```
SELECT SUBSTR(SERVICE_SUPERCLASS_NAME,1,19) AS SUPERCLASS_NAME,
       SUBSTR(SERVICE_SUBCLASS_NAME,1,18) AS SUBCLASS_NAME,
       SUBSTR(CHAR(MEMBER),1,4) AS MEM,
       CAST(COORD_ACT_LIFETIME_AVG / 1000 AS DECIMAL(9,3)) AS AVGLIFETIME
FROM TABLE(WLM_GET_SERVICE_SUBCLASS_STATS('', '', -2)) AS SCSTATS
ORDER BY SUPERCLASS_NAME, SUBCLASS_NAME

SUPERCLASS_NAME     SUBCLASS_NAME      MEMB AVGLIFETIME
------------------- ------------------ ---- -----------
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 0          3.425
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 1          2.752
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 2          8.230
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 3          0.593
```

In this example, member 2 might be receiving more work than usual because its average activity lifetimes are much higher than those of the other database members.

Many different situations can cause a system slowdown. Use the following principles to make the best use of the information provided by the DB2 workload management table functions:

- Address large numbers of locking conflicts at the level of the application logic and environment (isolation level and so on).
- If the service class is running close to its threshold levels (the number of concurrent requests and so on), you might need to increase the thresholds.
- If the resources allotted to a service class are becoming exhausted and OUTBOUT CORRELATOR is set, the mapping to the operating system service classes might be the cause of the problem (that is, the operating system service class corresponding to the service class is not getting enough processor resources).
- Higher numbers of activities than expected might be running in the service class, which might be consuming more resources than normal. Check the number of completed activities to determine whether the amount of work being done in the service class is reasonable.
- Activities might be spending more time in queues if more activities are being submitted than expected and concurrency thresholds are defined. Check whether the average queue time for activities has increased by the same amount as the average lifetime. If they have increased by the same amount, the queues are behaving as expected; however, if the lifetime is unacceptable, consider allocating more resources to the service class and reducing the concurrency threshold.

Example: Investigating agent usage by service class

DB2 workload management provides the WLM_GET_SERVICE_CLASS_AGENTS table function, which you can use to determine the relative distribution of agents among service classes.

Situations can arise in which a data server resource, such as an agent, is overutilized by a group of users or an application. For example, assume that a group of users is using almost all of the available agents and that a user from outside this group voices a concern about that to you.

The first step to take is to determine how many agents are working for each service class. You might use a query such as the following one:

```
SELECT SUBSTR(AGENTS.SERVICE_SUPERCLASS_NAME,1,19) AS SUPERCLASS_NAME,
       SUBSTR(AGENTS.SERVICE_SUBCLASS_NAME,1,19) AS SUBCLASS_NAME,
       COUNT(*) AS AGENT_COUNT
FROM TABLE(WLM_GET_SERVICE_CLASS_AGENTS('', '', CAST(NULL AS BIGINT), -2))
AS AGENTS
WHERE AGENT_STATE = 'ACTIVE'
GROUP BY SERVICE_SUPERCLASS_NAME, SERVICE_SUBCLASS_NAME
ORDER BY SERVICE_SUPERCLASS_NAME, SERVICE_SUBCLASS_NAME

SUPERCLASS_NAME     SUBCLASS_NAME       AGENT_COUNT
------------------- ------------------- -----------
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS            7
TEST                SYSDEFAULTSUBCLASS           20
```

If you conclude that a particular service class is using more than its fair share of agents, you can take actions to restrict the number of activities permitted for a workload or a service class. Alternatively, you can restrict the number of connections for a service class.

Apply controls to types of activities with work action sets

Work action sets contain work actions that apply controls to activities of a certain type in a specific service superclass, in a specific workload, or to the database as a whole.

A work action provides an action that can be applied to a work class, which represent activities of a certain type like LOAD or READ activities. Work actions are applied to the activities that fall within the work class to which the work action was applied before the activity begins to execute. If, however, the work action is PREVENT EXECUTION, the activity will be prevented from running and no other work action will be applied to it.

If you apply a work action set to a database, there are several types of actions that you can apply to activities that fall within a work class, such as threshold definitions, prevent execution, collect activity data, and count activity. Defining a threshold for a work action is the most powerful database work action. For example, perhaps you want to prevent SQL from reading and returning more than 100 000 rows. You can define a single work class for a work action set that identifies SQL READ statements and a work action with a threshold that would stop execution if the number of rows returned is more than 100 000. For information about the possible actions, see “Work actions and the work action set domain” on page 106.

If you apply a work action set to a workload, the different types of actions that you can apply to activities include defining thresholds, preventing execution, collecting activity data and aggregate activity data, and counting the activities.

If you define the work action set for a service superclass, the different types of actions that you can apply to activities include mapping activities to a service subclass, preventing execution, collecting activity or aggregate activity data, and counting the activities. Typically, the work action maps an activity to a service subclass and has thresholds defined on the subclass to help manage the activity.

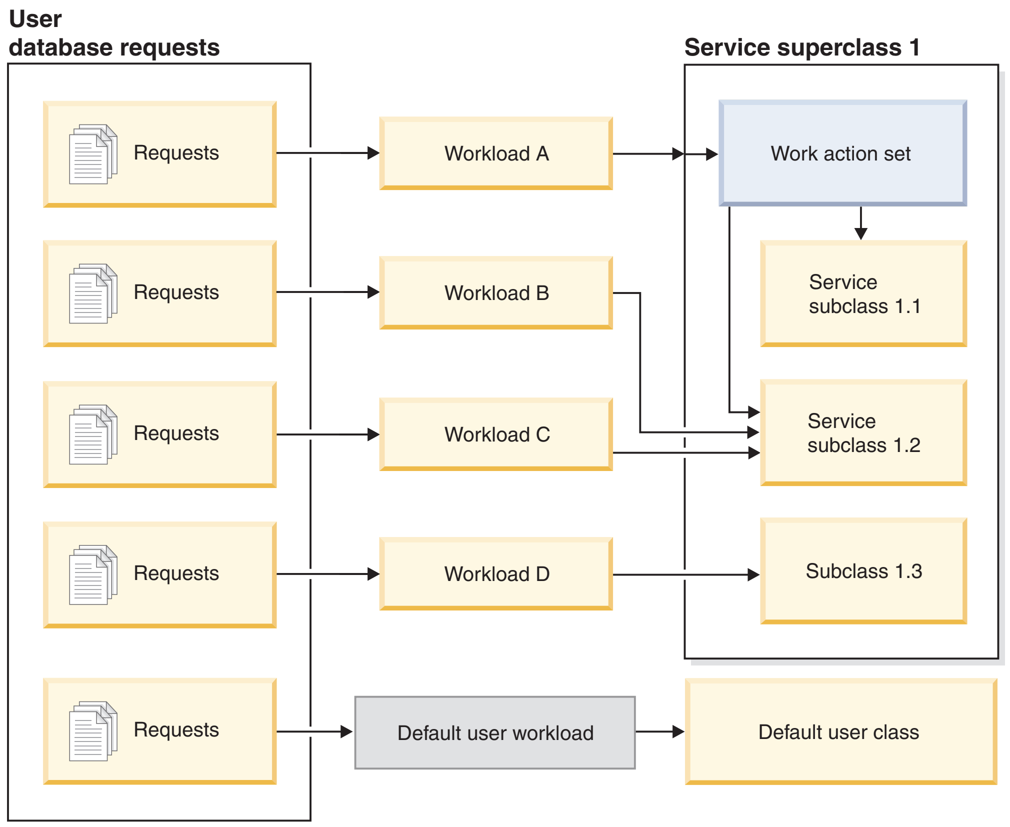


Figure 15. Work action set mapping for a service superclass

How work classes, work class sets, work actions, and work action sets work together and are associated with other DB2 objects

Work classes and work actions work together to apply specific actions to specific activity types. The best way to describe how this works is through an example.

The following diagram shows a high-level view of how work classes, work class sets, work actions, and work action sets work together and are associated with other DB2 objects.

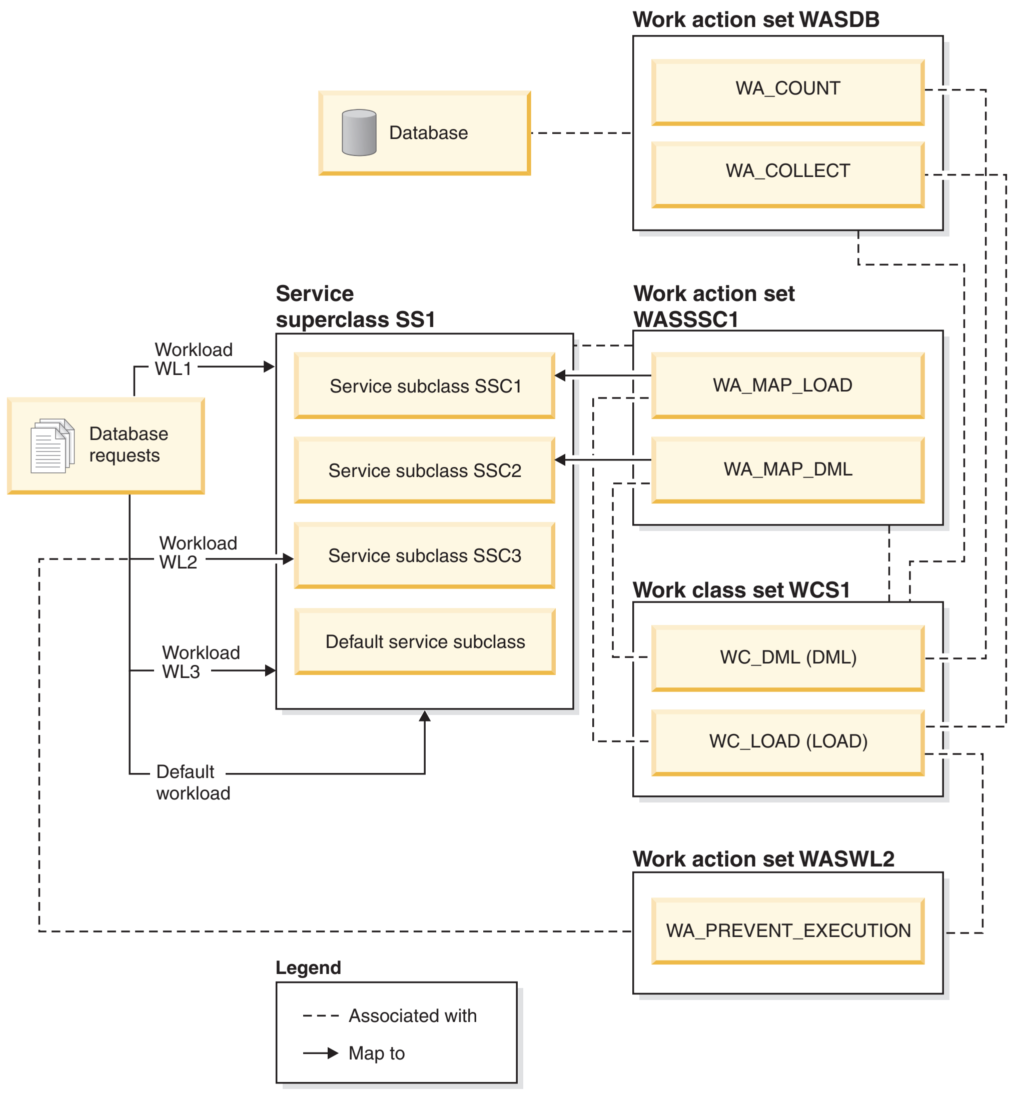


Figure 16. Overview of work action sets and work class sets

In the diagram, some database activities are mapped, through workload WL1, workload WL3, and the default user workload, SYSDEFAULTUSERWORKLOAD, to the service superclass SS1. Because work action set WASDB is applied to the database, all activities that enter the database (regardless of the workload) and that are classified as either the WC_DML or WC_LOAD work class will have the work actions in the WASDB work action set applied to them. That is, activities with the DML work type are counted, and activities with the LOAD work type have activity data collected for them and written to an active event monitor (if one is available).

The work action set WASSSC1 is applied to the service superclass SS1. Any activities that are assigned to the default user workload, the WL1 workload, or the WL3 workload, and that fall under the WC_DML work class and the WC_LOAD work class will also have the WA_MAP_DML and WA_MAP_LOAD work actions applied to them, because those workloads direct work to the SS1 service superclass. That is, activities with a work type of LOAD will be mapped to the SSC1 service subclass by the WA_MAP_LOAD work action, and activities with a work type of DML will be mapped to the SSC2 service subclass by the WA_MAP_DML work action.

Activities that are assigned to the WL2 workload are mapped directly to a service subclass (SSC3). When a workload maps activities directly to a service subclass, no work actions from the work action set WASSSC1 are applied to those activities. However, because WASWL2 is applied to WL2, any activities assigned to WL2 and fall under WL_LOAD will have work actions in the WASWL2 work action set applied to the. That is, LOAD activities will not be allowed to be run, due to the PREVENT EXECUTION work action.

Work actions and work action sets

A work action, when used in conjunction with a work class, can be used to help control specific types of activities. For example, you can apply different work actions to LOAD activities so that they are processed differently than DML. Work actions are grouped into work action sets.

Work actions

A work action consists of the following attributes:

- A user-supplied work action name, which must be unique in the work action set.
- The work class identifier the work action is to be applied to. You can define more than one work action for a work class, but each work action must perform a different action on that work class.
- The action that is to be applied to the database activity that matches the work class. The valid action type for a work action depends on whether the work action set that the work action belongs to is applied to a database, a workload, or a service superclass. When a work action set is applied to a database, all work entering the database is evaluated by the work action set. When a work action set is applied to a workload, all work submitted through workload occurrences associated with that workload are evaluated by that work action set. When a work action set is applied to a service superclass, all work submitted for execution directly to the service superclass is evaluated by that work action set; that is, workload definitions that specifically name the service superclass as their target service class will have their submitted work evaluated by the work action set defined on the service superclass. For example:
  - A work action set that is applied to a database or a workload can contain threshold work actions. If an activity gets assigned to a work class that has a threshold work action defined for it, the threshold is applied to that activity.
  - A work action set that is applied to a service superclass can contain a work action that maps the activity to a service subclass in the service superclass. If an activity corresponds to a specific work class in a work class set, and the work action set has a mapping work action that is defined for that work class, that activity is mapped to the service subclass specified by the work action.

  For a list of the supported actions, see “Work actions and the work action set domain” on page 106.
- An object that is the target of the specified action. Depending on the action, the object can be a service subclass that the activity is mapped to, a threshold that specifies which threshold to apply to the activity, or null if the action is to prevent execution, one of the collect actions, or count activity.
- The template describing the histogram that collects statistical information about the number of microseconds that activities associated with the work class to which this work action is assigned required to run during a specific interval. This information is only collected when the work action type is COLLECT

AGGREGATE ACTIVITY DATA (either BASE or EXTENDED). For more information on histograms and histogram templates, see "Histograms in workload management" on page 253.
- Whether or not the work action is enabled.
- An automatically generated identifier that identifies the work action.

You can create a work action by using either the WORK ACTION keyword in the CREATE WORK ACTION SET statement or the ADD keyword in the ALTER WORK ACTION SET statement. You can alter a work action by using the ALTER keyword in the ALTER WORK ACTION SET statement. You can remove a work action from a work action set by using the DROP keyword in the ALTER WORK ACTION SET statement, or by dropping the entire work action set.

You can view your work actions by querying the SYSCAT.WORKACTIONS view.

Work action sets

A work action set consists of the following attributes:
- A work action set name that is unique in a database.
- The name of the work class set containing one or more work classes that the group of actions is to apply to.

  Because the definitions of the work class sets are separate from the work action sets defined for them, you can define more than one work action set for a work class set.
- The type of object that the work action set is associated with (database, service superclass, or workload).
- The name of the service superclass that the actions and work class set apply to (for work action sets associated with a service superclass).
- Whether or not the work action set is enabled.
- User comments.
- One or more work actions (a work action set does not have to contain any work actions).
- An automatically generated ID that uniquely identifies the work action set.

You can create a work action set using the CREATE WORK ACTION SET statement, alter a work action set using the ALTER WORK ACTION SET statement, and drop a work action set using the DROP WORK ACTION SET statement.

You can view your work action sets by querying the SYSCAT.WORKACTIONSETS view.

When you create a work action set, you must specify the object that the work action set is to be applied to. The valid object types are the database, a workload, or a service superclass. You must also specify which work class set the work action set is to work with. This permits you to use the work classes in the work class set to identify the types of activities that you want to apply the work actions to.

If you create a work action set on a service superclass, these are important aspects to remember:
1. If you set up a workload to map its database activities directly to a service subclass, the work action set associated with that service superclass is never used for the activities issued by that workload. In other words, if a workload

maps activities directly to a service subclass, the work action set is bypassed. None of the work actions in the work action set will be applied to the activities that are mapped directly to the service subclass.
2. Any activity, not mapped to a service subclass by a work action within the work action set on the superclass, executes in the SYSDEFAULTSUBCLASS of the service superclass.
3. All work submitted by a workload associated with the superclass that is not recognized as an activity, such as a PREPARE request or **RUNSTATS**, executes in the SYSDEFAULTSUBCLASS of the service superclass since the work action set does not affect them.

Creating a work action

Use the CREATE WORK ACTION SET statement or the ALTER WORK ACTION SET statement to create a work action.

Before you begin

To create a work action, you require WLMADM or DBADM authority.

For additional prerequisites, see the following topics:
- "Workload management DDL statements" on page 18
- Appendix A, "General naming rules," on page 491

When you create a work action:
- You associate a work action with a work class. The work class must already exist in the work class set that the work action set is applied to.
- If the work action is a threshold, the work action set must be defined for a workload or for the database. For the list of supported thresholds for work actions, see "Thresholds that can be used in work actions" on page 110.
- If you are creating a mapping work action, the work action set must be defined for a service superclass. The service subclass being mapped to must already exist in the service superclass this work action set is being defined for. In addition, you cannot specify the default service subclass.
- More than one work action can be applied to a single work class, but they must be different work action types. For example, you can apply a mapping work action and a collect work action to the same work class. You can, however, only apply one work action of the same type to the same work class. For example, you cannot apply more than one mapping work action to the same work class. The one exception to this is if the work action represents a threshold. You can apply more than one threshold work action to a single work class but each threshold must be of a different type.
- If you are creating a collect aggregate activity data work action, the work action set must be defined for a service superclass or a workload.

Procedure

To create a work action:
1. Use the *work-action-definition* keyword of the CREATE WORK ACTION SET statement, or the ADD *work-action-definition* keyword of the ALTER WORK ACTION SET statement. Specify one or more of the following for the work action:
   - A name for the work action. The name of the work action must be unique within the work action set.

- The name of the work class to which this work action applies. The work class must be one of the work classes in the work class set that the work action set is associated with. For example, to apply this work action to the work class `LARGEDML`, you would specify:

  ```
  ON WORK CLASS LARGEDML
  ```
- The action that is to apply to activities that match the work class for this work action:
  - If the work action set is associated with a service superclass, you can specify the MAP ACTIVITY keyword so that the work action maps activities to a service subclass in the service superclass. By default, mapping work actions cause activities that are nested to be mapped to the same service subclass as its parent. A cursor that has been opened inside a routine is an example of a nested activity.

    For example, if you want the work action to map to the service subclass `SMALLREAD`, and you want all nested activities to be mapped to the same service subclass, you would specify:

    ```
    MAP ACTIVITY TO SMALLREAD
    ```
    You could also specify:

    ```
    MAP ACTIVITY WITH NESTED TO SMALLREAD
    ```
    If you want the work action to map to the service subclass and to not map nested activities to this service subclass, you would specify:

    ```
    MAP ACTIVITY WITHOUT NESTED TO SMALLREAD
    ```

    If you define the work action as WITHOUT NESTED, nested activities are handled according to their activity type instead of automatically being mapped to the same service subclass as the parent activity. For example, if a CALL activity is mapped to service subclass `subsc1`, and the routine has an open cursor inside it, the open cursor might be mapped to a different service subclass if it falls under another work class that has another mapping work action applied to it.
- If the work action set is associated with a database or a workload, you can specify a WHEN keyword to indicate a threshold to apply to the activity, and the action to take if the activity causes the threshold to be violated. You can specify the following thresholds for a work action:
  - ACTIVITYTOTALTIME
  - ESTIMATEDSQLCOST
  - CONCURRENTDBCOORDACTIVITIES
  - CPUTIME
  - SQLROWSREAD
  - SQLTEMPSPACE
  - SQLROWSRETURNED

  If the threshold is violated, you can specify the following actions to be taken:
  - Whether activity data is to be collected about the activity that caused the threshold to be violated. If collected, when the activity completes execution, the activity data is written to an active activities event monitor. By default, no data about the activity is collected. If you want to collect data about this activity, you can collect it from the coordinator member, a specific member, or from all database members. You have the option of collecting this data with or without details about the statement and its compilation environment. If you want to collect details about the statement and compilation environment, you can also specify that the input data values used in the activity.

– Whether the activity that caused the threshold to be violated is to be permitted to continue running or not. By default, the activity is stopped.

For example, if you want the work action to check for DML statements that have a cost over 2 000 timerons, collect the basic data about this activity when the threshold is violated and continue to run, you would specify:

```
WHEN ESTIMATEDSQLCOST > 2000 COLLECT ACTIVITY DATA CONTINUE
```

- To prevent any activities that correspond to the work class defined for this work action from executing, you can use the PREVENT EXECUTION keyword.
- To count the number of database activities associated with the work class without incurring the additional overhead of another action (such as collecting data or mapping an activity), you can specify the COUNT ACTIVITY keyword.
- To collect activity data for activities that fall under the work class, specify the COLLECT ACTIVITY DATA keyword. If collected, when the activity completes execution, the activity data is written to an active activities event monitor. By default, no data about the activity is collected. If you want to collect data about this activity, you can collect it from the coordinator member or from all members. If you want to collect activity details such as the statement and the compilation environment information, you can do so by specifying the WITH DETAILS keyword. You can also use the AND VALUES keyword to have input data values (for those activities that have them) sent to the activities event monitor.

  For example, assume that you have a work action set that is applied to a service superclass. You want to have activity data for all activities that are assigned to this work action written to the applicable event monitor, including all aggregate activity information, information about the compilation environment, and any input data values. You would specify:

  ```
  COLLECT ACTIVITY DATA ON ALL WITH DETAILS AND VALUES
  ```

- If the work action set is associated with a service superclass or a workload, you can specify the COLLECT AGGREGATE ACTIVITY DATA keyword to collect aggregate activity data for activities that fall under the work class. If collected, aggregate activity data is captured and sent to the applicable event monitor. This information is collected periodically on an interval that is specified by the **wlm_collect_int** database configuration parameter.

  For example, assume that you have a work action set that is applied to a service superclass. You want to have aggregate activity data for all activities that are assigned to this work action written to the applicable event monitor, including the base data, the activity data manipulation language (DML) estimated cost histogram, and the activity DML inter-arrival time histogram. You would specify

  ```
  COLLECT AGGREGATE ACTIVITY DATA EXTENDED
  ```

- The histogram templates used by a COLLECT AGGREGATE ACTIVITY DATA work action to describe the histograms created for the corresponding work class. Specifying the histogram templates used by a work action adds the corresponding rows in the SYSCAT.HISTOGRAMTEMPLATEUSE, view which displays the histogram templates referenced by the service class or work action. For example, if you want to collect interarrival statistics for the default interarrival histogram template, you would specify:

  ```
  INTERARRIVALTIME HISTOGRAM TEMPLATE SYSDEFAULTHISTOGRAM
  ```

  For more information about histograms and histogram templates, see "Histograms in workload management" on page 253.

- Whether the work action is enabled or disabled. By default a work action is created as enabled, but you can specify whether it is enabled or disabled by using the ENABLE or DISABLE keyword. If the work action is disabled, the data server does not consider this work action when activities enter the database or service superclass (depending on the object you created the work action set for).

2. Commit your changes. When you commit your changes, the work action is added to the SYSCAT.WORKACTIONS view. If the work action is a threshold, the threshold is added to the SYSCAT.THRESHOLDS view.

   A new work action takes effect in the database only after it is committed, and does not affect any database activities currently running.

Altering a work action

If you need to alter a work action, use the ALTER WORK ACTION SET statement.

Before you begin

To alter a work action, you require SQLADM, WLMADM or DBADM authority. To specify any clause other than a COLLECT clause, the authorization ID must include WLMADM or DBADM authority.

See "Workload management DDL statements" on page 18 for additional prerequisites.

Procedure

To alter a work action:

1. Use the ALTER keyword of the ALTER WORK ACTION SET statement to change one or more of the following characteristics of the work action.
   - You can alter the work class to which the work action is applied. The work class must already exist in the work class set to which the work action set is applied.
   - If the work action maps to a service subclass, you can alter which service subclass the database activity is to be mapped. You can only change the mapping to a service subclass in the same service superclass. You cannot map to the default service subclass. You can also change whether nested activities in the activity are mapped to the same service subclass or not. For example, if the work action is currently defined as WITH NESTED, you can change this to WITHOUT NESTED. This change would cause the nested activities to be handled according to their activity type instead of automatically being mapped to the same service subclass as the parent activity. For example, if a CALL statement is mapped to service subclass SUBSC1, and the routine has an open cursor inside it, the open cursor might be mapped to a different service subclass if it falls under another work class that has another mapping work action applied to it.
   - You can alter the action type specified for the work action (that is, mapping, threshold, prevent execution, count activity, collect actions), but you must alter it to a valid work type. For example, if the work action is to map the activity to a service subclass, you cannot change the work action to a threshold, or the reverse. The reason is because, in this example, the work action set must have been applied to a service superclass in order to have a mapping action and threshold actions are not valid for work action sets applied to service superclasses. If you alter the type of a work action that is a threshold work action or alter the type of work action to a threshold, the following occurs:

- If the work action was a threshold and has been changed to a non-threshold, the threshold is removed from the SYSCAT.THRESHOLDS view.
- If the work action was not a threshold and has been changed to a threshold, a new threshold will be created in the SYSCAT.THRESHOLDS view.

Note: If the action is a threshold, you cannot alter the type of threshold to a different threshold. So, for example, if the work action was an SQLROWSRETURNED threshold, you cannot change it to a SQLTEMPSPACE threshold. In addition, you cannot change the work action type of an enabled CONCURRENTDBCOORDACTIVITIES work action threshold.

- You can alter the histogram templates used by a COLLECT AGGREGATE ACTIVITY DATA work action to describe the histograms created for the corresponding work class. Updating the histogram templates used by a work action updates the corresponding rows in the SYSCAT.HISTOGRAMTEMPLATEUSE view, which displays the histogram templates referenced by the service class or work action. For more information about histograms and histogram templates, see "Histograms in workload management" on page 253.
- You can alter whether you want to enable or disable the work action. By default, work actions are enabled. When enabled, the data server considers the work action for application against the activity that falls under the work class for the work action. If the work action is disabled, the data server ignores it.

2. Commit your changes. When you commit your changes, the work action is updated in the SYSCAT.WORKACTIONS view.

Disabling a work action

You can disable a work action that you do not want applied to a work class. At runtime, the disabled work action is treated as if it does not exist.

Before you begin

To disable a work action, you require WLMADM or DBADM authority.

Procedure

To disable a work action:

1. Use one of the following statements, depending on whether you are creating or altering a work action set:
   - Use the DISABLE keyword and the ADD keyword of the CREATE WORK ACTION SET statement. For example:
     ```
     ADD WORK ACTION work-action-name ON WORK CLASS work-class-name ... DISABLE
     ```
   - Use the DISABLE keyword and the ALTER keyword of the ALTER WORK ACTION SET statement. For example:
     ```
     ALTER WORK ACTION work-action-name ... DISABLE
     ```
2. Commit your changes. When you commit your changes, the work action is updated in the SYSCAT.WORKACTIONS view.

Dropping a work action

If you no longer require a work action, you can drop it from the work action set.

Before you begin

- To drop a work action, you require WLMADM or DBADM authority.
- See "Workload management DDL statements" on page 18 for additional prerequisites.

Procedure

To drop a work action:

1. Use the DROP keyword of the ALTER WORK ACTION SET statement. If you want to drop a CONCURRENTDBCOORDACTIVITIES threshold work action, you must disable the work action in one ALTER WORK ACTION SET operation, commit the change, verify that there are no queued activities, and then drop the threshold in a second ALTER WORK ACTION SET operation.
2. Commit your changes. When you commit your changes, the work action is removed from the SYSCAT.WORKACTIONS view. If the work action is a threshold work action, the threshold is also removed from the SYSCAT.THRESHOLDS view.

   An altered work action set and work action only takes effect in the database after it is committed, and does not affect any database activities currently running.

Creating a work action set

To create a work action and a work action set, use the CREATE WORK ACTION SET statement.

Before you begin

To create a work action set, you require WLMADM or DBADM authority.

For additional prerequisites, see the following topics:

- "Workload management DDL statements" on page 18

When you create a work action set:

- You associate it with a work class set. The work class set must already exist.
- You also associate it with a database, a workload, or a service superclass. If you are associating the work action set with a service superclass, the service class must already exist. You cannot define the work action set for the default system service class (SYSDEFAULTSYSTEMCLASS), the default user class (SYSDEFAULTUSERCLASS) or the default maintenance service class (SYSDEFAULTMAINTENANCECLASS). If you are associating the work action set with a workload, the workload must exist in the current server. You cannot associate the work action set with the default administration workload (SYSDEFAULTADMWORKLOAD).

Procedure

To create a work action set:

1. Use the CREATE WORK ACTION SET statement with the following options:
   - Specify a name for the work action set. The name of the work action set must be unique in the database.
   - Specify the object with which the work action set is associated. You can specify a database, a workload, or a service superclass. If you specify that the work action set is associated with a database, none of the work actions in the

work action set can be mapping work actions or collect aggregate actions. If you specify that the work action set is associated with a service superclass, none of the work actions in the work action set can be thresholds. If you specify that the work action set is associated with a workload, then none of the work actions in the work action set can be mapping work actions. For example, to apply the work action set to the REPORTS service superclass, you would specify:

```
FOR SERVICE CLASS REPORTS
```

To apply the work action set to the database, you would specify:

```
FOR DATABASE
```

To apply the work action set to a workload named WL1, you would specify:

```
FOR WORKLOAD WL1
```

- Specify the work class set with which the work action set is associated. The work classes in the work class set classify the database activities that the work actions in the work action set will apply to. For example, to associate the work action set with the LARGEREADS work class set, you would specify:

  ```
  USING WORK CLASS SET LARGEREADS
  ```
- Optional: Create one or more work actions for the work action set. For instructions, see "Creating a work action" on page 98.
- Optional: Specify whether the work action set is enabled or disabled. By default, the work action set is enabled. If the work action set is disabled, the data server does not consider this work action set (or any work actions in it) when activities are run.

2. Commit your changes. When you commit your changes the work action set is added to the SYSCAT.WORKACTIONSETS view.

   A new work action set only takes effect in the database after it is committed, and does not affect any database activities currently running.

Altering a work action set

To add, alter, or drop a work action from a work action set, or to enable or disable the work action set, use the ALTER WORK ACTION SET statement.

Before you begin

To alter a work action set, you require SQLADM, WLMADM, or DBADM authority. To specify any clause other than a COLLECT clause, the authorization id must include WLMADM or DBADM authority.

For additional prerequisites, see the following topics:
- "Workload management DDL statements" on page 18
- Appendix A, "General naming rules," on page 491

When you create a work action set to work with a specific work class set, you cannot change it to work with a different work class set because the work actions in the work action set have a dependency on the work classes in the work class set. If you want to change the work class set this work action set is to be applied to, you must drop and recreate the work action set.

You cannot change which object the work action set applies to because the type of work actions in the work action set depends on which object (database, workload, or service superclass) the work action set is defined for. If you want to change which object the work action set is associated with, you must drop and recreate the work action set.

Procedure

To alter a work action set:

1. If you want to add a new work action to the work action set, use the ADD keyword. For information about the parameters that you can specify when adding a work action to a work action set, see “Creating a work action” on page 98
2. If you want to alter an existing work action, use the ALTER keyword. For information about altering a work action, see “Altering a work action” on page 101.
3. If you want to drop a work action, use the DROP keyword. For information about dropping a work action from a work action set, see “Dropping a work action” on page 102.
4. You can enable a work action set that is not currently enabled, and the reverse. If you disable an enabled work action set, the data server ignores it after you commit your changes. For more information, see “Disabling a work action set.” If you enable the work action set, after you commit your changes, the work action set is applied to the next applicable activity that enters the database.

   Note: Disabling a work action set does not disable the work actions within the work action set, but the work action set will no longer affect any work. If you want to drop a work action set that contains a concurrency work action threshold, you must first disable the concurrency work action before the work action set can be dropped, because concurrency thresholds must be disabled before they can be dropped.
5. Commit your changes. When you commit your changes, the work action set is updated in the SYSCAT.WORKACTIONSETS view. The SYSCAT.WORKACTIONS view is updated for any added, altered, or dropped work actions.

Disabling a work action set

To disable a work action set, use the DISABLE keyword of the CREATE WORK ACTION SET statement or the ALTER WORK ACTION SET statement.

Before you begin

To disable a work action set, you require WLMADM or DBADM authority.

About this task

Disabling a work action set does not disable the work actions within the work action set, but the work action set will no longer affect any work. At runtime, a disabled work action set is treated as if it does not exist.

Note: If you want to drop a work action set that contains a concurrency work action threshold, you must first disable the concurrency work action before the work action set can be dropped, because concurrency thresholds must be disabled before they can be dropped.
For example, assume that you have a work action set called READACTIVITIES that is associated with a work class set called READCLASSES, and that work action set is defined for a service superclass called READSERVICECLASS. The SMALLREAD work action set has a work action in it that remaps all SELECT

statements to the service subclass SMALLREADSERVICECLASS. If the READACTIVITIES work action set is disabled, all SELECT statements are treated as though the READACTIVITIES work action set does not exist, and are mapped to the default service subclass.

Procedure

To disable a work action set:

1. Use one of the following statements, depending on whether you are creating or altering a work action set:
   - To create a work action set that is disabled:
     ```
     CREATE WORK ACTION SET work-action-set-name ... DISABLE
     ```
   - To disable an already existing work action set:
     ```
     ALTER WORK ACTION SET work-action-set-name ... DISABLE
     ```
2. Commit your changes. When you commit your changes, the work action set is updated in the SYSCAT.WORKACTIONSETS view.

Dropping a work action set

Use the DROP WORK ACTION SET statement to drop a work action set.

Before you begin

To drop a work action set, you require WLMADM or DBADM authority.

About this task

Dropping a work action set drops the work action set and all work actions in it.

If the work action set contains a CONCURRENTDBCOORDACTIVITIES threshold work action, that work action must first be disabled before the work action set can be dropped.

Procedure

To drop a work action set:

1. Use the DROP WORK ACTION SET statement.
2. Commit your changes. When you commit your changes the work action set is removed from the SYSCAT.WORKACTIONSETS view. In addition, all work actions that were part of the work action set are removed from the SYSCAT.WORKACTIONS view. If the work action set contains threshold work actions, the thresholds are removed from the SYSCAT.THRESHOLDS view.

Work actions and the work action set domain

You can define a work action set for a database, a service superclass, or workload. The type of work actions that can be defined for a work action set depends on the type of object the work action set is defined for.

If the work action set is defined for a database, the work actions in the work action set must be any of the following actions:

- A threshold

  The following thresholds apply to each individual activity in the matching work class:
  - ACTIVITYTOTALTIME

  - CPUTIME
  - ESTIMATEDSQLCOST
  - SQLROWSREAD
  - SQLROWSRETURNED
  - SQLTEMPSPACE

  The following threshold applies to all activities in the matching work class as a group:
  - CONCURRENTDBCOORDACTIVITIES

  The actual threshold is specified by the `WHEN` *`threshold-type`* clause. Multiple threshold work actions can be applied to a single work class if all the thresholds are of different types. If this action is specified, the threshold is applied to all database activities associated with the work class.
- PREVENT EXECUTION

  If this action is specified, all database activities that match the associated work class are not permitted to run.
- COLLECT ACTIVITY DATA

  If this action is specified, information about the database activities corresponding to the work class for which this work action is defined are written to the active ACTIVITIES event monitor when the activities complete execution. For more information, see "Collecting data for individual activities".
- COUNT ACTIVITY

  If this action is specified, all database activity that maps to the associated work class causes the turnstile counter for that work class type to be incremented. (The turnstile counter for the work class is incremented by 1 each time an activity is associated with that work class). The COUNT ACTIVITY work action provides an efficient way to ensure this counter is updated. If no work action is applied to an activity corresponding to a work class, the work class activity counter is not incremented. Sometimes the only action you care about is obtaining a count of activities of a given type. For more information, see "Collecting data for individual activities".

If the work actions in the work action set defined for a database are not any of these actions, SQL4720N is returned.

If you are defining a work action set for a service superclass, the work actions in the work action set must be any of the following actions:
- A mapping action

  You can map an activity to any service subclass in the service superclass except for the default service subclass. You specify the service subclass to map the activity to using the MAP ACTIVITY TO SERVICE CLASS keyword. Only one map work action in the work action set can be applied to the same work class.
- PREVENT EXECUTION

  Behavior is the same as for the database work action.
- COLLECT ACTIVITY DATA

  Behavior is the same as for the database work action.
- COLLECT AGGREGATE ACTIVITY DATA

  If this action is specified, aggregate database activity data that corresponds to the work class for which this work action is defined is collected.
- COUNT ACTIVITY

  Behavior is the same as for the database work action.

If the work actions in the work action set defined for a service superclass are not any of these actions, SQL4720N is returned.

If the work action set is defined for a workload, the work actions in the work action set must be any of the following actions:

- A threshold

  The following thresholds apply to each individual activity in the matching work class:
  - ACTIVITYTOTALTIME
  - CPUTIME
  - ESTIMATEDSQLCOST
  - SQLROWSREAD
  - SQLROWSRETURNED
  - SQLTEMPSPACE

  The following threshold applies to all activities in the matching work class as a group:
  - CONCURRENTDBCOORDACTIVITIES

  The actual threshold is specified by the `WHEN` *`threshold-type`* clause. Multiple threshold work actions can be applied to a single work class if all the thresholds are of different types. If this action is specified, the threshold is applied to all database activities associated with the work class.
- PREVENT EXECUTION

  Behavior is the same as for the database work action.
- COLLECT ACTIVITY DATA

  Behavior is the same as for the database work action.
- COLLECT AGGREGATE ACTIVITY DATA

  Behavior is the same as for the service superclass work action.
- COUNT ACTIVITY

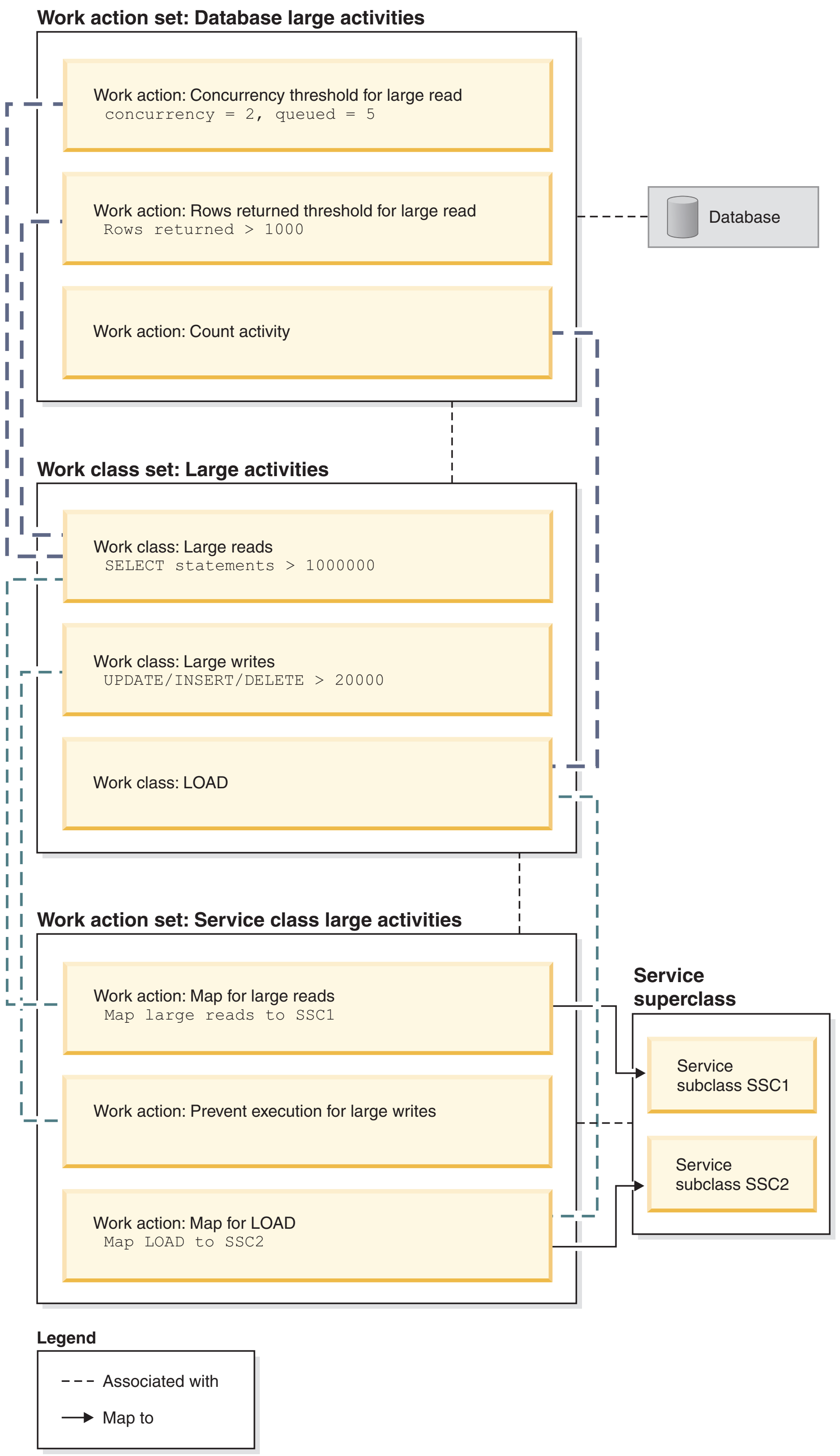
  Behavior is the same as for the database work action.

If the work actions in the work action set defined for a workload are not any of these actions, SQL4720N is returned.

Example: Applying work class activities

The following figure shows an example of how the work classes in a work class set called LARGE ACTIVITIES are to be applied to both the database and a service superclass. To meet this objective, two work action sets, "Database large activities" and "Service class large activities" are created.

Although this example does not show it, you can also apply the classes in the LARGE ACTIVITIES work class set to a workload, by creating a work action set associated with the workload and then associating the work action set with the LARGE ACTIVITIES work class set.



Work action set: Database large activities
Work action: Concurrency threshold for large read
concurrency = 2, queued = 5
Work action: Rows returned threshold for large read
Rows returned > 1000
Work action: Count activity
Database
Work class set: Large activities
Work class: Large reads
SELECT statements > 1000000
Work class: Large writes
UPDATE/INSERT/DELETE > 20000
Work class: LOAD
Work action set: Service class large activities
Work action: Map for large reads
Map large reads to SSC1
Work action: Prevent execution for large writes
Work action: Map for LOAD
Map LOAD to SSC2
Service superclass
Service subclass SSC1
Service subclass SSC2
Legend
Associated with
Map to

Figure 17. Example of work actions, work actions sets, work classes, and work class set

The work action sets are as follows:

- `Database large activities` contains:

    - `Concurrency threshold for large reads`, which permits two large reads to run concurrently, and five large reads to be queued
    - `Rows returned threshold for large reads`, which prevents large reads from returning more than 1000 rows
    - `Count activity for load`, which counts the number of times the load utility runs on the database.
- `Service class large activities` contains:
    - `Map for large reads`, which maps large reads to service subclass 1
    - `Map for large writes`, which prevents large writes from executing.
    - `Map for LOAD`, which maps loads to service subclass 2

A work action set does not have to contain an action for every work class in the work class set to which the work action set is applied. In addition, a work class can have more than one work action applied to it as long as the action types are different. A work class can have more than one threshold work action applied to it as long as the threshold types are different.

Thresholds that can be used in work actions

Work action sets that you define for databases can contain work actions that specify thresholds.

The following thresholds are supported:

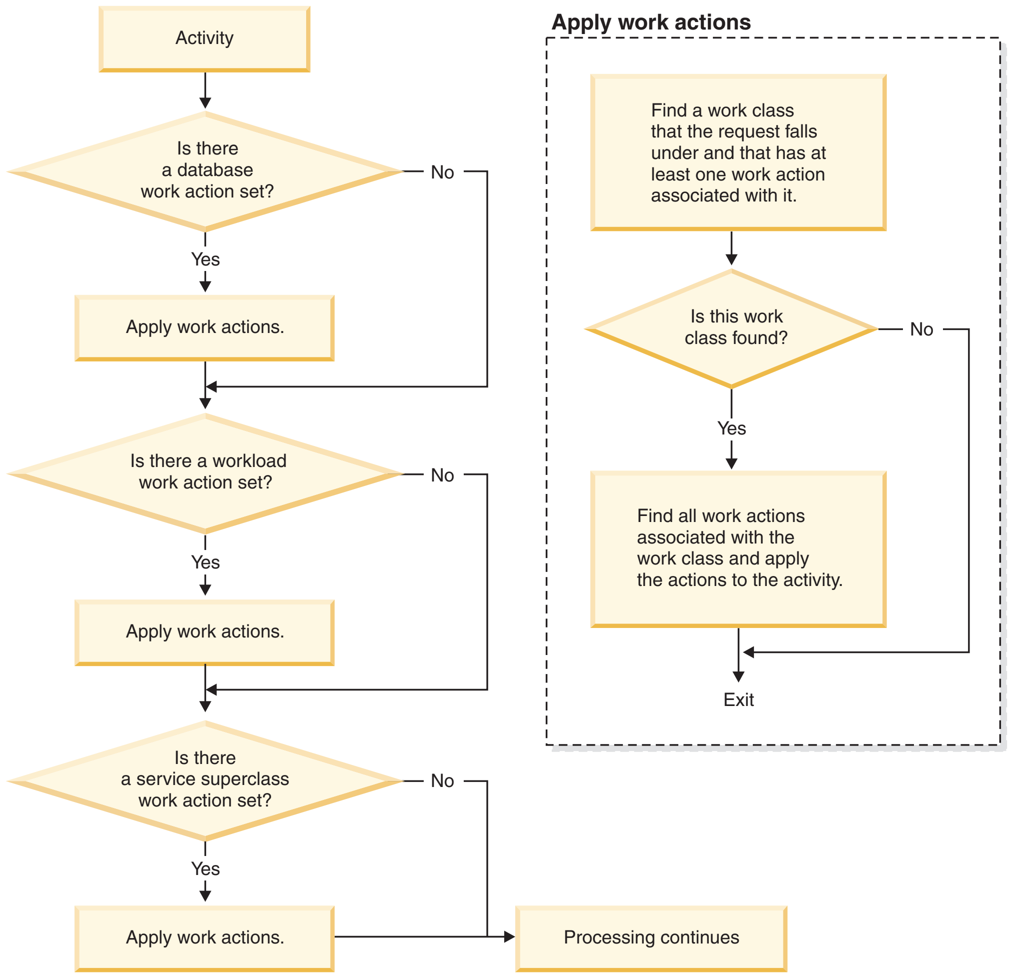
- Aggregate threshold:
    - CONCURRENTDBCOORDACTIVITIES
    - CONCURRENTWORKLOADACTIVITIES
- Activity thresholds:
    - SQLTEMPSPACE
    - SQLROWSRETURNED
    - ACTIVITYTOTALTIME
    - ESTIMATEDSQLCOST
    - CPUTIME
    - SQLROWSREAD

Application of work actions to database activities

One, and only one work action set can be applied to a database, a service superclass, or a workload.

When work is submitted to the data server, it is associated with a workload, either a user-defined workload or the default workload, then mapped to a service class.

The following figure shows the process of how a work action is applied to an activity.



Activity
Is there a database work action set?
No
Yes
Apply work actions.
Is there a workload work action set?
No
Yes
Apply work actions.
Is there a service superclass work action set?
No
Yes
Apply work actions.
Processing continues
Apply work actions
Find a work class that the request falls under and that has at least one work action associated with it.
Is this work class found?
No
Yes
Find all work actions associated with the work class and apply the actions to the activity.
Exit

Figure 18. Application of a work action to an activity

A work action is assigned to an activity as follows:

1. When an activity is mapped to a service superclass or a service subclass, the data server checks whether an enabled database-level work action set exists.
2. If an enabled database-level work action set exists, the data server then checks whether the activity falls under any of the work classes in the work class set that the database-level work action set is associated with.
3. If the activity falls under a work class and that work class has any work actions applied to it, those work actions are applied to the activity.
4. The data server checks whether an enabled workload-level work action set exists. If it does, the data server then checks whether the activity falls under any of the work classes in the work class set that the workload-level work action set is associated with.
5. If the activity falls under a work class and that work class has any work actions applied to it, those work actions are applied to the activity.
6. Next, if the activity is mapped by the workload to a service superclass, the data server checks whether a work action set is applied to the service superclass.
7. If a work action set is applied to the service superclass, the data server then checks whether the activity falls under any of the work classes in the work class set that the service superclass-level work action set is associated with.

8. If the activity falls under a work class and that work class has any work actions applied to it, those work actions are applied to the activity.

Note that, if a mapping work action is applied to a stored procedure, then depending on whether the WITH NESTED or WITHOUT NESTED clause is specified in the work action definition, child activities of a stored procedure can run in the same service subclass or in different service subclasses than the parent activity.

In the following situations an activity is not affected by a work action set:
- Activities fall in the default system (SYSDEFAULTSYSTEMCLASS) and default maintenance (SYSDEFAULTMAINTENANCECLASS) service classes.
- Activities are assigned to the default administration workload, SYSDEFAULTADMWORKLOAD.
- Activities are inside a load operation. The load operation itself does go through work action set evaluation.
- Child activities of system stored procedures. The only exception is the SYSPROC.ADMIN_CMD stored procedure. Child activities of SYSPROC.ADMIN_CMD go through work action set evaluation.
- The work action set is disabled.
- The workload maps the activity directly to a service subclass.

Concurrency control at the workload level using work action sets

At the workload level, you control the concurrency of incoming work using concurrency thresholds applied with a work action set defined on the workload. You can combine workload-level concurrency control with priority aging at the service class level.

Figure 1 illustrates an example scenario using work action sets to control the concurrency of incoming work based on the source of the connection while all work in the database is controlled using priority aging.

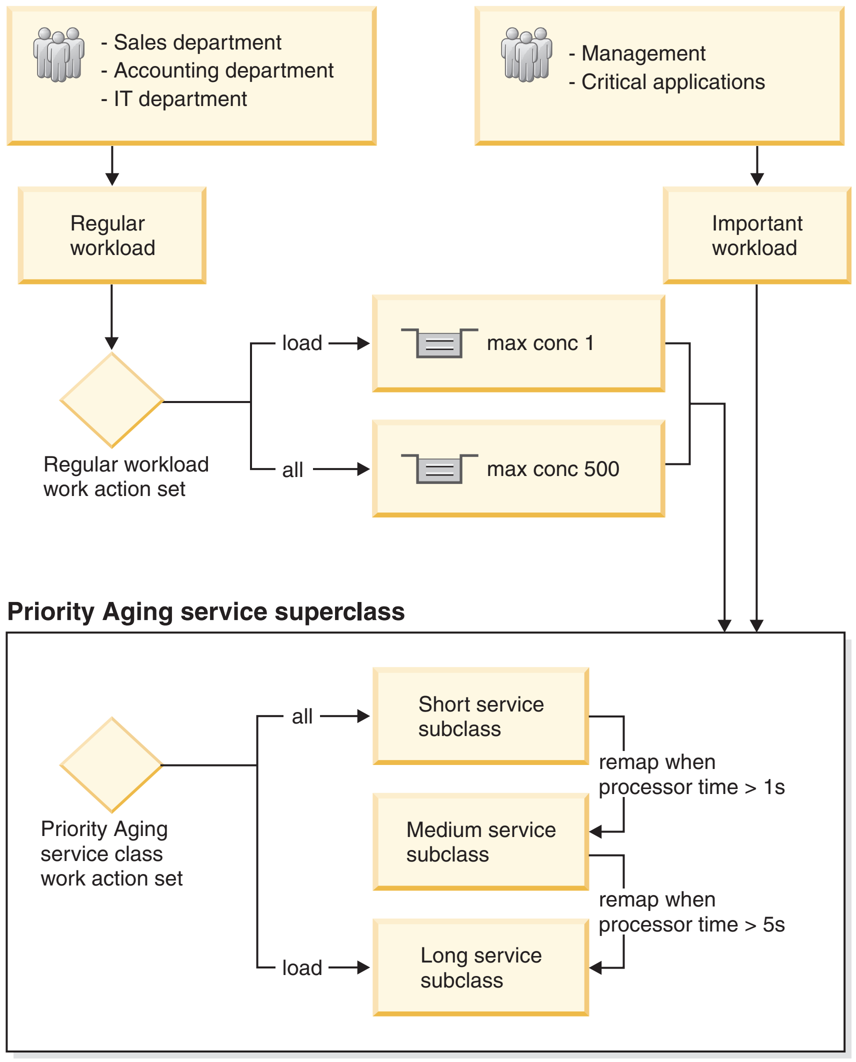


Figure 19. Concurrency control at the workload level using work action sets

In the example scenario, two workloads are created to identify and differentiate the work coming from different sources. Connections to the database from the sales, accounting, and IT departments are mapped to the Regular workload. Connections to the database from management and critical applications are mapped to the Important workload. Work from the Important workload has higher priority and needs to be able to complete within the shortest amount of time. To ensure the database has sufficient capacity for work in the Important workload, concurrency thresholds are placed on the work in the Regular workload. A workload level work action set, called Regular workload level work action set, is created on the Regular workload and is applied to a work class set that has two work classes. Load activities are mapped to one work class, while all other activities are mapped to the other work class. A CONCURRENTDBCOORDACTIVITIES threshold is created as a work action in the Regular workload level work action set to allow only one load activity in the system at a time while queuing the other load activities. In addition, another CONCURRENTDBCOORDACTIVITIES threshold is created as a work action in the Regular workload level work action set to allow a maximum of 500 concurrent activities, while activities exceeding the maximum are queued.

Note: If a threshold action of CONTINUE is specified for a queuing threshold, it effectively makes the size of the queue unbounded, regardless of any hard value specified for the queue size.

Connections to the database from both the Regular and Important workloads are mapped to the Priority Aging service superclass. This service superclass is created to implement priority aging that favors short activities. The Priority Aging service class work action set is created for the Priority Aging service superclass to separate the long-running load activities from all the short-running activities. All activities, other than load, are mapped to the Short service subclass. The Short service subclass is configured to have the highest agent, prefetch, and buffer pool priorities. A CPUTIMEINSC threshold is created on the Short service subclass to remap an activity to the Medium service subclass after it consumes more than 1 second of processor time in the Short service subclass. The Medium service subclass has medium agent, prefetch, and buffer pool priorities. A CPUTIMEINSC threshold is created on the Medium service subclass to remap an activity to the Long service subclass after it consumes more than 5 seconds of processor time in the Medium service subclass. The Long service subclass has the lowest agent, prefetch, and buffer pool priorities. Load activities are mapped directly to the Long service subclass by the Priority Aging service class work action set because load activities can be long running, resource intensive, and less time critical for completion.

Workload and work action set comparison

Depending on the type of control that you want to maintain over your database activities, you can use workloads by themselves or both workloads and work classes (when used with work actions) to map activities to service classes.

With workloads, requests are identified and assigned to a service class based on connection attributes. Workloads are the primary method for routing work to a specific DB2 service class for execution. If you want to further refine how requests are identified, you can use work classes to classify the activities based on their type and other activity attributes. For example, you can classify READ activities, WRITE activities, and LOAD activities into different work classes and have each activity type treated differently.

If you use work classes (which are grouped into work class sets), you can use work actions to exercise control over the different types of activities. For example, you can use a work action in a work action set defined on a service superclass to map a specific type of activity to a service subclass. In a work action set defined on the database or workload, you can define a work action to apply a control known as a threshold to ensure that the same type of activity does not exceed certain conditions.

Work actions are grouped into work action sets. A single work action set can apply to activities in the database, to activities in a service superclass, or to activities in a workload. However, the same work action set cannot apply to more than one object. Work class sets and work action sets work together. That is, a work class must exist for categorizing an activity as a specific type of work before a work action can be applied to it. A work class set can be associated with more than one work action set, but a work action set can be associated with only one work class set.

Figure 1 shows an example of a DB2 workload manager implementation that uses workloads and work action sets. In this figure, assume that a request is assigned to workload WL_A based on the connection attributes of the connection that submitted the request. Workload WL_A specifies that the request is to be executed in service superclass SC_A. Assume that a work class in work class set WCS_1 matches the type of work that the request that is associated with workload WL_A is going to perform.

Now assume that an activity that does not update the catalogs (a READ activity) enters the system. The database-level work action set WAS_1 (that is associated with work class set WCS_1) contains a work action that is applied to the READ work class. The request is then mapped to service superclass SC_A (by workload WL_A). Here, the request encounters the service superclass-level work action set WAS_2, which is also associated with work class set WCS_1, and applies to activities in service superclass SC_A. This work action set contains a mapping work action, which is also applied to the READ work class so that all READ activities will be mapped to service subclass SSC_1a in service superclass SC_A.

A somewhat similar situation occurs with the request that is associated (again, based on its connection attributes) with workload WL_B. Workload WL_B maps activities to service superclass SC_B. Assume that the request is for a LOAD activity and that work class set WCS_2 contains a work class that applies to LOAD activities. Work class set WCS_2 is associated with the service superclass-level work action set WAS_3, which applies to activities in service superclass SC_B. Assume that work action set WAS_3 contains a mapping work action that is applied to the LOAD work class, so that when the LOAD activity is mapped to service superclass SC_B by workload WL_B, it will then be mapped by the work action to service subclass SSC_1b for execution.

The purpose of workload WL_C in this is example is to map incoming requests directly to service subclass SSC_1b, independent of the service superclass-level work action set WAS_3 and its mapping work action. If an incoming request is associated with workload WL_C that is a LOAD activity, then this request is also mapped directly to service subclass SSC_1b for execution, and is unaffected by the mapping work action that applies to the LOAD work class.

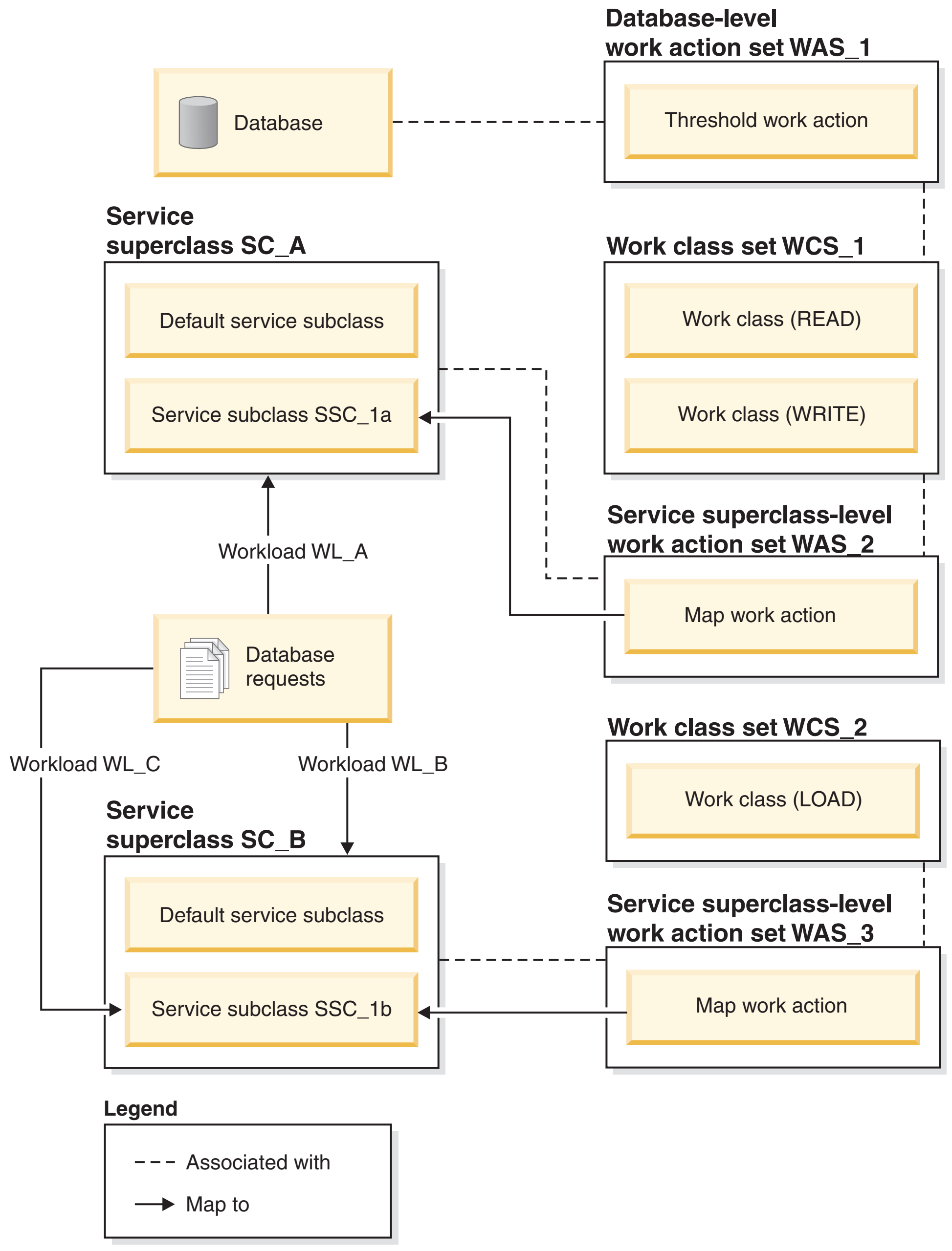


Figure 20. Workloads and work action sets

Example: Using a database work action set and database threshold

This example shows different approaches to using work action sets and thresholds to control the resources consumed by DB2 activities. Before creating DB2 workload management objects, you need to understand how they are used.

Assume that you have a work class set called ALLSQL, and it contains the following work classes in this order:

1. SMALLDML, which is for all DML-type SQL statement that have an estimated cost of less than 1 000 timerons

2. MEDDML, which is for all DML-type SQL statements that have an estimated cost between 1 000 and 20 000 timerons
3. LARGEDML, which is for all DML-type SQL statements that have an estimated cost greater than 20 000 timerons
4. ALLDDL, which is for all DDL-type SQL statements
5. ALLACTIVITY, which is for all database activity

The following SQL statements create the work class set and the work classes:

```
CREATE WORK CLASS SET ALLSQL
  (WORK CLASS SMALLDML WORK TYPE DML FOR TIMERONCOST FROM 0 TO 1000,
   WORK CLASS MEDDML WORK TYPE DML FOR TIMERONCOST FROM 1001 TO 20000,
   WORK CLASS LARGEDML WORK TYPE DML FOR TIMERONCOST FROM 20001 TO UNBOUNDED,
   WORK CLASS ALLDDL WORK TYPE DDL,
   WORK CLASS ALLACTIVITY WORK TYPE ALL)
```

These work classes already have work actions, such as COUNT ACTIVITY, COLLECT, and thresholds (that are not ACTIVITYTOTALTIME thresholds) applied to them.

Assume that you want to permit large DML activities to run for no longer than 5 hours. All other SQL can take no longer than 30 minutes to run. The following two examples show possible methods for accomplishing this objective.

Method 1

One method is to set up a work action set at the database level containing work actions that specify an ACTIVITYTOTALTIME threshold for each work class, as follows:

Table 33. ACTIVITYTOTALTIME threshold specified for each work class

Work action	Work class applied to	Threshold type and value	Actions
SMALLDMLTIMEALLOWED	SMALLDML	ACTIVITYTOTALTIME > 30 MINUTES	• Stop execution • Collect activity data
MEDDMLTIMEALLOWED	MEDDML	ACTIVITYTOTALTIME > 30 MINUTES	• Stop execution • Collect activity data
LARGEDMLTIMEALLOWED	LARGEDML	ACTIVITYTOTALTIME > 5 HOURS	• Stop execution • Collect activity data
ALLDDLTIMEALLOWED	ALLDDL	ACTIVITYTOTALTIME > 30 minutes	• Stop execution • Collect activity data
ALLACTIVITYTIMEALLOWED	ALLACTIVITY	ACTIVITYTOTALTIME > 30 minutes	• Stop execution • Collect activity data

The SQL statements for this method are:

```
CREATE WORK ACTION SET WASNICK FOR DATABASE USING WORK CLASS SET WCSNICK
  (WORK ACTION SMALLDMLTIMEALLOWED ON WORK CLASS SMALLDML
     WHEN ACTIVITYTOTALTIME > 30 MINUTES COLLECT ACTIVITY DATA STOP EXECUTION,
   WORK ACTION MEDDMLTIMEALLOWED ON WORK CLASS MEDDML
      WHEN ACTIVITYTOTALTIME > 30 MINUTES COLLECT ACTIVITY DATA STOP EXECUTION,
   WORK ACTION LARGEDMLTIMEALLOWED ON WORK CLASS LARGEDML
      WHEN ACTIVITYTOTALTIME > 5 HOURS COLLECT ACTIVITY DATA STOP EXECUTION,
   WORK ACTION ALLDDLTIMETIMEALLOWED ON WORK CLASS ALLDDL
```

```
      WHEN ACTIVITYTOTALTIME > 30 MINUTES COLLECT ACTIVITY DATA STOP EXECUTION,
   WORK ACTION ALLACTIVITYTIMEALLOWED ON WORK CLASS ALLACTIVITY
      WHEN ACTIVITYTOTALTIME > 30 MINUTES COLLECT ACTIVITY DATA STOP EXECUTION)
```

Method 2

Another method might be to use only one work class, LARGEDML, then create a work action set for the database that has one work action, LARGEDMLTIMEALLOWED, applied to the work class.

Table 34. LARGEDMLTIMEALLOWED work action applied to the LARGEDML work class

Work action	Work class applied to	Threshold type and value	Action
LARGEDMLTIMEALLOWED	LARGEDML	ACTIVITYTOTALTIME < 5 HOURS	• Stop execution • Collect activity data

You would then apply an ACTIVITYTOTALTIME threshold of less than 31 MINUTES to the database. Using this method, only those activities that correspond to the LARGEDML work class have the 5 hour threshold applied to them. Other activities will have the ACTIVITYTOTALTIME database time threshold of less than 31 minutes applied to them.

The SQL statements for this method are:

```
CREATE WORK ACTION SET WASNICK FOR DATABASE USING WORK CLASS SET WCSNICK
  (WORK ACTION LARGEDMLTIMEALLOWED ON WORK CLASS LARGEDML
     WHEN ACTIVITYTOTALTIME > 5 HOURS COLLECT ACTIVITY DATA STOP EXECUTION)

CREATE THRESHOLD THTEST FOR DATABASE ACTIVITIES ENFORCEMENT DATABASE
   WHEN ACTIVITYTOTAL TIME > 30 MINUTES COLLECT ACTIVITY DATA STOP EXECUTION
```

Example: Using work action sets to determine the types of work being run

Using work class sets, work classes, work action sets, work actions, and some of the DB2 workload manager monitoring features, you can determine the different types of work running on your system, and the distribution of the work.

One way of accomplishing this task is described here. First create a work class set that contains work classes for the different types of work you are interested in. For example, if you want to know how many READ activities, WRITE activities, DDL activities, and LOAD activities are running on your system, you would create a work class set, ACTIVITYTYPES, as in the following example:

```
CREATE WORK CLASS SET ACTIVITYTYPES
(WORK CLASS READWC WORK TYPE READ,
WORK CLASS WRITEWC WORK TYPE WRITE,
WORK CLASS DDLWC WORK TYPE DDL,
WORK CLASS LOADWC WORK TYPE LOAD)
```

Next, you would create a database-level work action set, COUNTACTIONS, to apply to the ACTIVITYTYPES work class set. The work action set would contain a COUNT ACTIVITY work action for each work class in the ACTIVITYTYPES work class set, as in the following example:

```
CREATE WORK ACTION SET COUNTACTIONS FOR DATABASE USING WORK CLASS SET ACTIVITYTYPES
(WORK ACTION COUNTREAD ON WORK CLASSREADWC COUNT ACTIVITY,
WORK ACTION COUNTWRITE ON WORK CLASS WRITEWC COUNT ACTIVITY,
WORK ACTION COUNTDDL ON WORK CLASS DDLWC COUNT ACTIVITY,
WORK ACTION COUNTLOAD ON WORK CLASS LOADWC COUNT ACTIVITY)
```

After a sufficient amount of time has passed, you can determine the number of each type of activity that has run by using the WLM_GET_WORK_ACTION_SET_STATS table function:

```
SELECT SUBSTR(CHAR(MEMBER),1,4) AS MEMB,
LAST_RESET,
SUBSTR(WORK_CLASS_NAME,1,15) AS WORK_CLASS_NAME,
SUBSTR(CHAR(ACT_TOTAL),1,14) AS TOTAL_ACTS
FROM TABLE(WLM_GET_WORK_ACTION_SET_STATS(CAST(NULL AS VARCHAR(128)), -2))
AS WASSTATS WHERE WORK_ACTION_SET_NAME = 'COUNTACTIONS'
ORDER BY WORK_CLASS_NAME, MEMB
```

Control of work with thresholds

You can use thresholds to maintain stability in the system by identifying work that behaves abnormally. You can identify abnormal behavior predictively, before the work begins running, based on the projected impact. You can also identify abnormal behavior reactively, as the work is running and consuming resources.

An example of work that can be controlled with thresholds is a query that consumes large amounts of processor time at the expense of all other work running on the system. Such a query can be controlled either before it even begins executing, based on estimated cost, or after it has begun executing and is consuming more than the permitted amount of resources.

Types of thresholds

Connection thresholds
If you want to limit how long a connection can sit idle, use a connection threshold. These thresholds can be used to detect connections that sit idle for too long.

Table 35. Connection thresholds

Threshold	Description
CONNECTIONIDLETIME	Controls the amount of time that a connection sits idle and is not working on behalf of user requests. Use this threshold to detect inefficient use of data server resources and application wait conditions.

Unit of work thresholds
If you want to limit how long a unit of work executes, use a unit of work threshold. These thresholds limit the maximum amount of time that a unit of work may spend in the DB2 engine, and can be used to detect units of work that take too long to complete.

Table 36. Unit of work thresholds

Threshold	Description
UOWTOTALTIME	Controls the amount of time that a unit of work takes to execute.

Activity thresholds
If you want to limit the impact that specific activities can have on how the data server is running, activity thresholds provide you with one of the means you can use. Excess execution time, abnormally high volumes of data returned, or abnormally high amounts of resources consumed are all examples of warning flags that potentially troublesome activities could be consuming excessive resources, which you can control with activity thresholds.

Table 37. Activity thresholds

Threshold	Description
ACTIVITYTOTALTIME	Controls the amount of time that any given activity can spend from submission to completion, for both execution and queue time. Use this threshold to detect jobs that are taking an abnormally long time to complete.
CPUTIME	Controls the maximum amount of combined user and system processor time that an activity may consume on a particular member during the execution of the activity. Use this threshold to detect and control activities which are consuming excessive processor resources.
CPUTIMEINSC	Controls the maximum amount of combined user and system processor time that an activity may consume on a particular member while executing in a specific service subclass. Use this threshold to detect and control activities which are consuming excessive processor resources within the current service class.
DATATAGINSC	Controls the data that can be touched or not touched by an activity while running a particular service subclass.
ESTIMATEDSQLCOST	Controls DML activities that the query optimizer determines to have a large estimated cost. Use this threshold to predict potentially resource-heavy SQL before it starts executing on the system and identifying poorly written SQL.
SQLROWSREAD	Controls the maximum number of rows which can be read on any member by an activity. Use this threshold to detect and control activities which are reading an excessive number of rows.
SQLROWSREADINSC	Controls the maximum number of rows which can be read by an activity on a particular member while executing in a specific service subclass. Use this threshold to detect and control activities which are reading an excessive number of rows within the current service class.
SQLROWSRETURNED	Controls the number of rows returned when executing SQL. Use this threshold to identify when the amount of data exceeds a reasonable volume.
SQLTEMPSPACE	Controls the amount of temporary table space a given activity can consume on a member. Use this threshold to prevent certain SQL statements from using up a disproportionate amount of temporary space, impeding the progress of other work.

The data server considers requests from utilities such as REORGCHK, IMPORT, and EXPORT to be user logic, and thus these requests are subject to any defined thresholds.

Aggregate thresholds

If you want to control the collective impact that certain activities, workloads, or connections can have on your data server, you can define aggregate thresholds. Aggregate thresholds often, but not always, enforce concurrency control in cases where you need to limit the number of certain activities running at the same time. Some aggregate thresholds have a built-in queue and are known as queuing thresholds.

Table 38. Aggregate thresholds

Threshold	Description
AGGSQLTEMPSPACE	Controls the maximum amount of system temporary table space that can be consumed in total across all activities in the service subclass. Use this threshold to detect and control activities that belong to a service subclass whose activities are consuming too much system temporary table space in aggregate across all of the activities in the service subclass.
CONCURRENTWORKLOADOCCURRENCES	Controls the number of active occurrences of a workload that can run on a coordinator member at the same time. Use to control the spread of connections from a specific source.

Table 38. Aggregate thresholds (continued)

Threshold	Description
CONCURRENTWORKLOADACTIVITIES	Controls the number of individual activities that can run within a workload occurrence. Use to limit work within an individual workload occurrence.
CONCURRENTDBCOORDACTIVITIES	Controls the number of concurrent activities in the domain that the threshold is associated with (database, work action, service superclass, or service subclass).
TOTALMEMBERCONNECTIONS	Controls the number of database connections to a given member that can be established at the same time. Use to prevent a given member from becoming overloaded.
TOTALSCMEMBERCONNECTIONS	Controls the number of database connections to a given member for work executing within a given service class at the same time. Similar to the total member connections but more granular because the connection is linked to a service class.

For those aggregate thresholds that support it, concurrency control is provided through a system of execution 'tickets.' Each incoming activity must claim a ticket from the applicable concurrency threshold before it can begin executing. Once all tickets are consumed, additional activities are queued until a ticket becomes available or an error is returned, depending on how you defined the threshold. If the concurrency threshold has queuing enabled, then a ticket passes from an activity that has finished execution to another activity that is in the queue. This activity can then leave the queue and begin execution. How many tickets are available per concurrency threshold depends on how you defined the threshold. For example, if you defined a CONCURRENTDBCOORDACTIVITIES threshold to limit the number of concurrently running database activities to 10, then there are 10 execution tickets available.

For stored procedures, activity thresholds are applied to the stored procedure and to its child activities. Concurrency thresholds are only applied to the child activities of the stored procedure and not to the CALL statement itself.

Taking action when thresholds are violated

The action that is taken dynamically when a threshold is violated depends on how you define the threshold.

Stop execution (STOP EXECUTION)

A common action when a threshold is violated is to stop the activity from executing. In this case, an error code is returned to the submitting application indicating that the threshold was violated. Note that for TOTALMEMBERCONNECTIONS and TOTALSCMEMBERCONNECTIONS thresholds, a STOP EXECUTION action prevents a connection from being established. For CONNECTIONIDLETIME thresholds, the connection is closed. For CONCURRENTWORKLOADOCCURRENCES, a new workload occurrence is prevented from being created. For all activity-related thresholds, the activity is stopped from continuing to execute. If a THRESHOLDVIOLATIONS event monitor is active, a record is written to the event monitor indicating that the threshold was violated.

Continue execution (CONTINUE)

In some situations, stopping the execution of an activity is too harsh a response. A preferable response is to permit the activity to continue to run and to collect the relevant data for an administrator to perform future analysis to determine how to prevent this condition from happening again. In this situation, no error code is returned to the submitting application. If the action is to continue, the user receives no indication that the threshold was violated. If a THRESHOLDVIOLATIONS event monitor is active, a record is written to the event monitor. If a CONTINUE threshold action is specified for a queuing threshold, this effectively renders the size of the queue unbounded, regardless of any hard value you include.

Force the application (FORCE APPLICATION)
When the UOWTOTALTIME threshold is violated, you can specify that the local or remote users or applications are forced off the system. This benefits other applications competing for server resources.

Remap the activity (REMAP ACTIVITY TO)
When an activity violates a certain limit, you may simply wish to assign different resource controls to it but to let the activity continue executing otherwise. Such a response permits you to dynamically raise or lower the amount of resources an activity can consume throughout its lifetime. In this case, an already executing activity is permitted to continue with no indication to the user or application that the threshold was violated, although the activity now runs with different resources available to it. Remapping is available with any of the in-service-class thresholds like CPUTIMEINSC, SQLROWSREADINSC, and DATATAGINSC.

Collect data (COLLECT ACTIVITY DATA)
When some thresholds are violated, data is collected. By default the fact that an activity threshold was violated is recorded in an activated threshold violations event monitor. If you want more detailed information about the activity that violated the threshold, you can request that information for the activity be written to the active event monitor for activities when the activity completes execution using the COLLECT ACTIVITY DATA clause

Threshold domain and enforcement scope

Each threshold operates on a domain. Only activities taking place in the domain of a threshold can be affected by that threshold.

The following threshold domains exist:
- Database
- Service superclass
- Service subclass
- Work action
- Workload
- Statement

Within each of these threshold domains, a threshold has a scope over which it is enforceable, such as a single workload occurrence, a member, the execution of a specific statement, or all members. This is known as the *enforcement scope* of the threshold. For example: Service class aggregate thresholds can have one of two enforcement scopes: database and member. An example of an aggregate threshold that applies only at the member level is the maximum number of concurrent connections for a service superclass on a member (TOTALSCMEMBERCONNECTIONS). Similarly, the following table shows that you can specify the processor time threshold (CPUTIME) at the database, superclass, subclass, work action or workload domain and that it is enforced per member. That is, the upper boundary specifies the maximum amount of user and system processor time per member that an activity may use.

Table 39. Threshold domains and enforcement scopes

Threshold domain	Thresholds with database enforcement scope	Thresholds with member enforcement scope	Thresholds with workload occurrence enforcement scope
Database	• "ACTIVITYTOTALTIME threshold" on page 131 • "CONCURRENTDBCOORDACTIVITIES threshold" on page 141[1] • "CONNECTIONIDLETIME threshold" on page 130 • "ESTIMATEDSQLCOST threshold" on page 135 • "SQLROWSRETURNED threshold" on page 138 • "UOWTOTALTIME threshold" on page 147	• "CONCURRENTDBCOORDACTIVITIES threshold" on page 141(Database enforcement scope is only allowed in environments other than DB2 pureScale® environments. In a DB2 pureScale environment, only member enforcement scope is allowed.) • "CPUTIME threshold" on page 132 • "SQLROWSREAD threshold" on page 136 • "SQLTEMPSPACE threshold" on page 139 • "TOTALMEMBERCONNECTIONS threshold" on page 145	Not applicable
Work action	• "ACTIVITYTOTALTIME threshold" on page 131 • "CONCURRENTDBCOORDACTIVITIES threshold" on page 141[1] • "ESTIMATEDSQLCOST threshold" on page 135 • "SQLROWSRETURNED threshold" on page 138	• "CONCURRENTDBCOORDACTIVITIES threshold" on page 141[1] • "CPUTIME threshold" on page 132 • "SQLROWSREAD threshold" on page 136 • "SQLTEMPSPACE threshold" on page 139	Not applicable
Service superclass	• "ACTIVITYTOTALTIME threshold" on page 131 • "CONCURRENTDBCOORDACTIVITIES threshold" on page 141[1] • "CONNECTIONIDLETIME threshold" on page 130 • "ESTIMATEDSQLCOST threshold" on page 135 • "SQLROWSRETURNED threshold" on page 138 • "UOWTOTALTIME threshold" on page 147	• "CONCURRENTDBCOORDACTIVITIES threshold" on page 141[1] • "CPUTIME threshold" on page 132 • "SQLROWSREAD threshold" on page 136 • "SQLTEMPSPACE threshold" on page 139 • "TOTALSCMEMBERCONNECTIONS threshold" on page 145	Not applicable
Service subclass	• "ACTIVITYTOTALTIME threshold" on page 131 • "CONCURRENTDBCOORDACTIVITIES threshold" on page 141[1] • "ESTIMATEDSQLCOST threshold" on page 135 • "SQLROWSRETURNED threshold" on page 138	• "AGGSQLTEMPSPACE threshold" on page 140 • "CONCURRENTDBCOORDACTIVITIES threshold" on page 141[1] • "CPUTIME threshold" on page 132 • "CPUTIMEINSC threshold" on page 133 • "DATATAGINSC threshold" on page 134 • "SQLROWSREAD threshold" on page 136 • "SQLROWSREADINSC threshold" on page 137 • "SQLTEMPSPACE threshold" on page 139	Not applicable
Workload	• "ACTIVITYTOTALTIME threshold" on page 131 • "ESTIMATEDSQLCOST threshold" on page 135 • "SQLROWSRETURNED threshold" on page 138 • "UOWTOTALTIME threshold" on page 147	• "CONCURRENTWORKLOADOCCURRENCES threshold" on page 144 • "CPUTIME threshold" on page 132 • "SQLROWSREAD threshold" on page 136 • "SQLTEMPSPACE threshold" on page 139	• "CONCURRENTWORKLOADACTIVITIES threshold" on page 142
Statement	• "ACTIVITYTOTALTIME threshold" on page 131 • "ESTIMATEDSQLCOST threshold" on page 135 • "SQLROWSRETURNED threshold" on page 138	• "CPUTIME threshold" on page 132 • "SQLROWSREAD threshold" on page 136 • "SQLTEMPSPACE threshold" on page 139	Not applicable

Threshold evaluation order

Thresholds are evaluated in a specific order when you define them on a database.

The following thresholds are evaluated before all others:
- TOTALMEMBERCONNECTIONS. This threshold is evaluated when a new connection is made to a database.
- CONCURRENTWORKLOADOCCURRENCES. This threshold is evaluated when a new workload occurrence is started for a workload definition that has this threshold applied to it.
- TOTALSCMEMBERCONNECTIONS. This threshold is evaluated when a connection joins a service class (either a new connection or a transfer between service classes as a result of workload reassignment).

All other thresholds are based on recognized activities resulting from an SQL statement or the execution of a utility as the load utility and are evaluated in the following order:

1. "Predictive thresholds"
2. "Reactive thresholds" on page 125

Predictive thresholds

Predictive thresholds are checked before reactive thresholds, because they affect whether a database activity can start to run.

The sequence in which predictive thresholds are evaluated is as follows. If you do not define a particular threshold, its step is skipped. Also, the steps described might be combined at run time for performance reasons.

1. Check if a CONCURRENTWORKLOADACTIVITIES threshold exists and if so, whether it has been violated. If the threshold is violated, the corresponding action is taken. If applicable, move to the next step.
2. Check if an ESTIMATEDSQLCOST threshold exists and if so, whether it has been violated. If you define this threshold in more than one domain, the threshold is resolved according to the scope resolution rules (see "Domain precedence for activity thresholds" on page 131 for more information). The result of this operation is one value of ESTIMATEDSQLCOST applicable to the activity. If the threshold is violated, the corresponding action is taken.
3. Check if a CONCURRENTDBCOORDACTIVITIES threshold exists for the workload work action set threshold domain and if so, whether it has been violated. If the threshold is violated, the corresponding action is taken.
4. Check if a CONCURRENTDBCOORDACTIVITIES threshold exists for the database work action set threshold domain and if so, whether it has been violated. If the threshold is violated, the corresponding action is taken.
5. Check if a CONCURRENTDBCOORDACTIVITIES threshold exists for the service subclass threshold domain and if so, whether it has been violated. If the threshold is violated, the corresponding action is taken.
6. Check if a CONCURRENTDBCOORDACTIVITIES threshold exists for the service superclass threshold domain and if so, whether it has been violated. If the threshold is violated, the corresponding action is taken.
7. Check if a CONCURRENTDBCOORDACTIVITIES threshold exists for the database threshold domain and if so, whether it has been violated. If the threshold is violated, the corresponding action is taken.

Concurrency threshold considerations: The evaluation order for concurrency thresholds does not follow the hierarchy used for resolving activity thresholds. An activity must pass through each defined concurrency threshold before it is permitted to execute.

For concurrency thresholds, thresholds for workload-level work action sets are checked first and database-level work action sets are checked second. Thresholds for work action sets are checked first, in order to avoid work action set thresholds on particular types of work blocking work of other types, which would affect concurrency. For example, by checking database-level work action set concurrency thresholds first, the following situation is avoided.

Assume that the following thresholds are defined:

- A database work action set containing a work action concurrency threshold for LOAD activities is defined with a value of 1.
- The service superclass S1 concurrency limit is set to `10`.

Also, assume that one LOAD activity is already running in the database (under any service superclass) and nine activities are already running in service superclass S1. A second new LOAD activity enters as the 10th activity. If the activity threshold scope resolution hierarchy were used during threshold evaluation, the incoming LOAD activity would not violate the service class threshold, increasing the concurrency to 10. The LOAD activity is then evaluated against the database-level work action threshold concurrency limit, which is violated because a LOAD activity is already running in the database and the work action threshold concurrency value is only 1. The second LOAD activity is then queued.

Any new activity arriving into service superclass S1 is now queued (because the service class concurrency limit is already reached). The work action threshold queue is affecting the service class, which is undesirable because activities trying to run in the service class do not necessarily have a relationship with the work action threshold condition (for example, an insert operation trying to run in service superclass S1 should not have to wait on a LOAD activity that is queued because of a database-level work action threshold condition). Therefore, to avoid this type of situation, the database-level work action concurrency threshold is checked before service subclass, service superclass, and database concurrency thresholds. Because the database-level work action set concurrency threshold is checked first, the 10th activity in the service class (which happens to be a LOAD activity) is blocked at the database work action threshold level before it can attempt to consume one spot in the service superclass S1.

Reactive thresholds

Reactive thresholds are evaluated in a discrete fashion when an activity is executing and no specific order is used to evaluate reactive thresholds. The following reactive thresholds are available to you:

- ACTIVITYTOTALTIME
- AGGSQLTEMPSPACE
- CONNECTIONIDLETIME
- CPUTIME
- CPUTIMEINSC
- DATATAGINSC
- SQLTEMPSPACE
- SQLROWSREAD
- SQLROWSREADINSC
- SQLROWSRETURNED
- UOWTOTALTIME

Creating a threshold

Create thresholds using the DDL statement CREATE THRESHOLD (or the CREATE WORK ACTION SET statement). You create a threshold to impose a limit on resource consumption.

Before you begin

To create a threshold, you require WLMADM or DBADM authority.

See the following topics for more information about prerequisites:

- “Workload management DDL statements” on page 18

- Naming rules

To create a threshold for a work action set, use the CREATE WORK ACTION SET statement or the ALTER WORK ACTION SET statement with the ADD WORK ACTION keywords. For more information, see CREATE WORK ACTION SET statement or ALTER WORK ACTION SET statement.

Procedure

To create a threshold:

1. Issue the CREATE THRESHOLD statement, specifying one or more of the following properties for the threshold:
   - The name of the threshold.
   - The threshold domain. The threshold domain is the database object that the threshold is both attached to and operates on. The domain that applies depends on the type of threshold, see “Threshold domain and enforcement scope” on page 122 for more information.
   - The enforcement scope for the threshold. The threshold scope is the enforcement range of the threshold in its domain. The enforcement scope that applies depends on the type of threshold, see “Threshold domain and enforcement scope” on page 122 for more information.
   - Optional: Disable the threshold when it is created. By default a threshold is created as enabled. If you create the threshold as disabled and want to enable it later, use the ALTER THRESHOLD statement.
   - The threshold predicate to specify the type of threshold and the maximum value permitted. When the maximum value is violated, the action specified for the threshold is enforced. For more information on which thresholds are available to you, see “Connection thresholds” on page 130, “Activity thresholds” on page 130, “Aggregate thresholds” on page 139, and “Unit of work thresholds” on page 146.
   - The actions to be taken if the maximum value for the threshold is exceeded. The actions consist of a mandatory action that affects the execution of the activity (STOP EXECUTION, CONTINUE, FORCE APPLICATION, or REMAP ACTIVITY TO) and an optional collect activity action (COLLECT ACTIVITY DATA). The options you specify for the collect activity action determine what information is collected for the activity that caused the threshold boundary to be violated.
2. Commit your changes. When you commit your changes, the threshold is added to the SYSCAT.THRESHOLDS view.

Altering a threshold

Alter thresholds using the ALTER THRESHOLD statement. You might alter a threshold to modify the limit imposed on a specific resource.

Before you begin

To alter a threshold, you require SQLADM, WLMADM, or DBADM authority. To specify any clause other than a COLLECT clause, the authorization ID must include WLMADM or DBADM authority.

See “Workload management DDL statements” on page 18 for more information about prerequisites.

To alter a threshold for a work action set, use the ALTER WORK ACTION SET statement with the ADD WORK ACTION keywords.

Restrictions

You cannot alter the threshold type with the ALTER THRESHOLD statement. For example: You cannot change a TOTAL MEMBERCONNECTIONS threshold into a TOTALSCMEMBERCONNECTIONS threshold, for example. If you require a different threshold type, drop the existing thresholds and then create a new threshold.

Procedure

To alter a threshold:

1. Specify one or more of the following properties for the threshold on the ALTER THRESHOLD statement. You can change the following properties:
   - The boundary for the threshold predicate.
   - The actions to be taken, if the threshold boundary is violated.
   - Whether the threshold is enabled or disabled.
2. Commit your changes. When you commit your changes, the threshold is updated in the SYSCAT.THRESHOLDS view.

Dropping a threshold

Drop a threshold that you no longer require using the DDL statement DROP THRESHOLD.

Before you begin

To drop a threshold, you require WLMADM or DBADM authority.

See "Workload management DDL statements" on page 18 for more information about prerequisites.

If you want to drop a threshold in a work action set, use the ALTER WORK ACTION SET statement. You can also drop a threshold by dropping the entire WORK ACTION SET with the DROP statement.

Procedure

To drop a threshold:

1. Do one of the following steps:
   - If the threshold is a queuing threshold, use the ALTER THRESHOLD statement to disable it.
   - If you disabled a queuing threshold by using an ALTER THRESHOLD statement, issue a COMMIT statement to commit the change.
2. Use the DROP THRESHOLD statement to drop the threshold.
3. Commit your changes. When you commit your changes the threshold is removed from the SYSCAT.THRESHOLDS view.

Example: Using thresholds

You can use thresholds for a variety of purposes. In this scenario, thresholds are used to control the number of large jobs running in order to permit different execution times for different applications, and to control the behavior of an application that is in development.

You could use a DB2 workload management solution to divide and manage the database resources for the various departments in a company. For example, assume that the sales department runs two main reports, which consist of the monthly and yearly sales. Assume also that the human resources department runs a payroll application every other week and that the development team is working on a new type of report at the request of the management team. To define different execution environments for these departments, create service classes:

```
CREATE SERVICE CLASS SALES
CREATE SERVICE CLASS HUMANRESOURCES
CREATE SERVICE CLASS DEVELOPMENT
```

In this situation, you create a workload definition for each one of these applications to map the application to its applicable service superclass:

```
CREATE WORKLOAD MONTHLYSALES APPLNAME('monthlyrpt.exe') SERVICE CLASS SALES
CREATE WORKLOAD YEARLYSALES APPLNAME('yearlyrpt.exe') SERVICE CLASS SALES
CREATE WORKLOAD PAYROLL APPLNAME('payroll.exe') SERVICE CLASS HUMANRESOURCES
CREATE WORKLOAD NEWREPORT APPLNAME('dev.exe') SERVICE CLASS DEVELOPMENT
```

The database catalog therefore contains the following workload definitions:

- MonthlySales, mapping to the service superclass Sales
- YearlySales, mapping to the service superclass Sales
- Payroll, mapping to the service superclass Human Resources
- NewReport, mapping to the service superclass Development

Threshold on the number of large jobs

Because the YearlySales report is very large, you do not want to have more than one occurrence of this application running in the database at any time. You therefore create a threshold to set the maximum number of concurrent occurrences of this workload to 1:

```
CREATE THRESHOLD SINGLEYEARLYSALESRPT FOR WORKLOAD YEARLYSALES ACTIVITIES
   ENFORCEMENT MEMBER
   WHEN CONCURRENTWORKLOADOCCURRENCES > 1
   STOP EXECUTION
```

You can achieve a similar solution by associating the YearlySales application with a service subclass YearlySalesReports (under the Sales service superclass) and setting the maximum concurrency threshold to a value of 1 for the service subclass:

```
CREATE SERVICE CLASS YEARLYSALESREPORTS UNDER SALES

ALTER WORKLOAD YEARLYSALES SERVICE CLASS YEARLYSALESREPORTS UNDER SALES

CREATE THRESHOLD SINGLEYEARLYSALESREPORT FOR SERVICE CLASS YEARLYSALESREPORTS
   UNDER SALES ACTIVITIES ENFORCEMENT DATABASE
   WHEN CONCURRENTDBCOORDACTIVITIES > 1
   STOP EXECUTION
```

In either situation, you can set the threshold action to STOP EXECUTION to prevent more than one occurrence of the workload from executing. You can also collect activity information if you want additional information about the conditions when the threshold is violated.

Threshold on activity lifetimes

Because all applications are expected to complete in an hour or less, you create a threshold with a database domain, preventing any activity from running longer than 1 hour. The only exception to this rule is the yearly report, which can take up to 5 hours to complete. Therefore, you can associate an activity total time threshold of 5 hours with the YearlySales workload. This will override the activity total time threshold applied to the yearly sales report, relaxing the time constraints. The new value of 5 hours now applies to the YearlySales workload although the global value of 1 hour applies elsewhere in the database:

```
CREATE THRESHOLD MAXDBACTIVITYTIME FOR DATABASE ACTIVITIES
   ENFORCEMENT DATABASE
   WHEN ACTIVITYTOTALTIME > 1 HOUR
   STOP EXECUTION

CREATE THRESHOLD MAXYRPTACTIVITYTIME FOR WORKLOAD YEARLYSALES
   ACTIVITIES ENFORCEMENT DATABASE
   WHEN ACTIVITYTOTALTIME > 5 HOURS
   STOP EXECUTION
```

Threshold on the number of coordinator and nested activities

The NewReport application makes heavy use of stored procedures and user-defined functions and is not fully debugged yet, so it tends to generate large numbers of activities that impact the rest of the system. After consulting with the developer, you learn that this new report is not supposed to generate more than 20 activities in total, so you define a threshold of type workload activities on the NewReport workload and set it to 20. Initially, you set the threshold action to STOP EXECUTION and COLLECT ALL to stop any unwanted side effect of the application starting large numbers of activities and to help the developer identify any problems:

```
CREATE THRESHOLD MAXDEVACTIVITIES FOR SERVICE CLASS DEVELOPMENT ACTIVITIES
   ENFORCEMENT DATABASE
   WHEN CONCURRENTDBCOORDACTIVITIES > 20
   COLLECT ACTIVITY DATA WITH DETAILS AND VALUES
   STOP EXECUTION
```

When the application becomes more stable, it enters its optimization phase. During the phase, the developer tries to reduce the number of activities generated by the application from between 15 and 20 to 15. At this time, you alter the threshold by changing its upper boundary value to 15 and the threshold action to CONTINUE. This threshold definition helps identify and address situations in which the number of generated activities exceeds 15 but the increased stability of the application does not require that its execution be stopped.

```
ALTER THRESHOLD MAXDEVACTIVITIES
   WHEN CONCURRENTDBCOORDACTIVITIES > 15
   COLLECT ACTIVITY DATA ON COORDINATOR WITH DETAILS AND VALUES
   CONTINUE
```

Threshold to limit how long a unit of work runs

The application LongUOW issues transactions that can occasionally run longer than the desired ten minutes. This results in locks being held for too long and prevents more important applications from proceeding. In this case, you want to force the application, rather than let it hold up other work. You can restrict the runtime for this application's transactions to an administrator-defined period of time using the UOWTOTALTIME threshold.

First, create a workload for the LongUOW application:

```
CREATE WORKLOAD LONG_UOW APPLNAME('LONGUOW') SERVICE CLASS SYSDEFAULTUSERCLASS
```

Then, create a threshold for this workload that forces the LongUOW application when any of the application's transactions take more than 10 minutes to finish:

```
CREATE THRESHOLD FORCELONGUOW FOR WORKLOAD LONG_UOW ACTIVITIES ENFORCEMENT DATABASE
 WHEN UOWTOTALTIME > 10 MINUTES FORCE APPLICATION
```

You can also apply this threshold at the service subclass level or database level.

Connection thresholds

A connection threshold applies controls to individual database connections. You can use connection thresholds to limit the total number of concurrent connections to the database and how long a connection can sit idle.

CONNECTIONIDLETIME threshold

The CONNECTIONIDLETIME threshold specifies a maximum amount of time that a connection can be idle (that is, not working on a user request).

Type Connection

Definition domain
Database or service superclass

Enforcement scope
Database

Tracked work
User connections

Queuing
No

Unit Time duration expressed in minutes, hours, or days

Predictive or reactive
Reactive

If a connection remains idle for longer than the duration specified by the threshold and the threshold action is STOP EXECUTION, the connection is closed.

Activity thresholds

An activity threshold applies to an individual activity. When the resource usage of an individual activity violates the upper bound of the threshold that is tracking it, the corresponding action is triggered and applied once to the activity.

After being applied once, the threshold is deactivated for the activity and not applied again.

For example: Assume that you defined a time based threshold that triggers a CONTINUE action after an elapsed time of 5 minutes. If an activity violates this threshold, the action is applied once but not reapplied every 5 minutes.

Domain precedence for activity thresholds

Activity thresholds apply to individual activities. If multiple thresholds apply to the same executing activity, a decision about which threshold to enforce must be made.

Aggregate thresholds are not affected because the same activity can contribute to multiple activity aggregates simultaneously, as occurs with concurrency thresholds, for example.

The resolution about which activity threshold to apply to an executing activity follows the rule that a value defined in a local domain overrides any value from a wider or more global domain. The hierarchy of domains is as follows, from the most local to the most global:

1. Statement
2. Work action (at workload level)
3. Workload
4. Service subclass
5. Service superclass
6. Work action (at database level)
7. Database

The following example shows how thresholds are overridden:

Examples

The following example shows how thresholds are overridden:

- A threshold that defines a maximum execution time of 1 hour for all database queries defined in the database domain is overridden by a threshold that defines a maximum execution time of 5 hours for a service superclass set up to handle large queries.
- That same service superclass threshold is overridden by a threshold for very large queries that defines the maximum execution time for a service subclass to be 10 hours.
- The maximum execution time of 1 hour defined in the database domain can be overridden by a value of 10 minutes in a second service superclass geared towards ensuring that shorter, important queries can complete quickly.
- The execution of a statement with text that matches the text that is specified for a threshold in the statement domain results in a threshold violation that overrides all other thresholds.

ACTIVITYTOTALTIME threshold

The ACTIVITYTOTALTIME threshold specifies the maximum amount of time that the data server can spend processing an activity. If the activity is queued by a queuing threshold, the total activity time includes the time spent in the queue awaiting execution.

Type Activity

Definition domain
Database, service superclass, service subclass, work action, workload and statement

Enforcement scope
Database

Tracked work
Recognized coordinator and nested activities (see “Activities” on page 15)

Queuing
No

Unit Time duration expressed in seconds, minutes, hours, or days. If the time unit specified is seconds, this value must be a multiple of 10.

Predictive or reactive
Reactive

When a cursor is opened, the activity associated with the cursor lasts until the cursor is closed.

When a time threshold is applied to a stored procedure, it also applies to work happening inside the stored procedure. Consequently, when a stored procedure time threshold expires, any work happening inside the stored procedure is stopped. Hierarchies of stored procedure invocations can lead to hierarchies of time thresholds being applied to activities executing in the innermost levels of nesting. The most restrictive time threshold in the hierarchy (that is, the time threshold with the closest deadline) is always the one that applies.

The data server considers IMPORT, EXPORT, and other CLP commands to be user logic. Activities that are invoked from within IMPORT, EXPORT, and other CLP commands are subject to thresholds.

CPUTIME threshold

The CPUTIME threshold specifies the maximum amount of combined user and system processor time that an activity can use on a particular member while the activity is running. Use this threshold to detect and control activities that are using excessive processor resources.

Type Activity

Definition domain
Database, service superclass, service subclass, work action, workload and statement

Enforcement scope
Member

Tracked work
See the information later in this topic

Queuing
No

Unit Time

Predictive or reactive
Reactive

The amount of processor time that an activity spends running is measured from the time that the activity begins running at the member, after any queuing by thresholds, until the time that the activity finishes running.

Activities tracked by this threshold are as follows:
- All DML activities.

- CALL activities. The processor time for a CALL activity does not include the processor time of any child activity. The processor time spent in fenced processes is also not counted toward the total processor time for the CALL activity.

Activities that are initiated by the database manager through a utility or procedure, with the exception of the ADMIN_CMD procedure, are not counted for this condition. The data server considers IMPORT, EXPORT, and other CLP commands to be user logic. Activities that are invoked from within IMPORT, EXPORT, and other CLP commands are subject to thresholds. Child activities of the LOAD command are not tracked by this threshold.

Example

The following example creates a CPUTIME threshold TH1 for the database domain with a member enforcement scope. This threshold stops any activity that takes longer than 30 seconds to run, which it checks for at 5-second intervals. You can use this threshold to ensure that no queries on the system use an unreasonable amount of processor time, which can negatively impact other work running on the system.

```
CREATE THRESHOLD TH1 FOR DATABASE ACTIVITIES
  ENFORCEMENT MEMBER
  WHEN CPUTIME > 30 SECONDS CHECKING EVERY 5 SECONDS
  STOP EXECUTION;
```

CPUTIMEINSC threshold

The in-service-class CPUTIMEINSC threshold specifies the maximum amount of combined user and system processor time that an activity may use on a particular member while running in a specific service subclass. Use this threshold to detect and control activities that are using excessive processor resources.

Class Activity

Definition domain
Service subclass

Enforcement scope
Member

Tracked work
See the information later in this topic

Queuing
No

Unit Time

Predictive or reactive
Reactive

The processor time that an activity spends running is measured from the time that the activity enters the current service subclass until the time that the activity leaves the service subclass or finishes running.

This threshold differs from the CPUTIME threshold in that it controls only the amount of processor time that may be used in a specific service subclass, not the total amount of processor time used during the lifetime of the activity.

Activities tracked by this threshold are as follows:

- All DML activities.

- CALL activities. Note that the processor time for a CALL activity does not include the processor time of any child activity. The processor time spent in fenced processes is also not counted towards the total processor time for the CALL activity.

Activities that are initiated by the database manager through a utility or procedure, with the exception of the ADMIN_CMD procedure, are not counted for this condition. The data server considers IMPORT, EXPORT, and other CLP commands to be user logic. Activities that are invoked from within IMPORT, EXPORT, and other CLP commands are subject to thresholds. Child activities of the LOAD command are not tracked by this threshold.

You can use the REMAP ACTIVITY action to control activities by remapping them to a service subclass with different resource assignments.

Example

The following example creates two service subclasses, A1 and A2, under a superclass A, with a single in-service-class CPUTIMEINSC threshold that remaps activities between subclasses after 1 minute of processor time has been used during query evaluation in service subclass A1. An event monitor record is logged.

```
CREATE SERVICE CLASS A;
CREATE SERVICE CLASS A1 UNDER A;
CREATE SERVICE CLASS A2 UNDER A;

CREATE THRESHOLD T1 FOR SERVICE CLASS A1 UNDER A
  ACTIVITIES ENFORCEMENT MEMBER
  WHEN CPUTIMEINSC > 1 MINUTE CHECKING EVERY 30 SECONDS
  REMAP ACTIVITY TO A2 LOG EVENT MONITOR RECORD;
```

DATATAGINSC threshold

The in-service-class DATATAGINSC threshold checks the data tag value of a table space or storage group accessed by an activity. Use this threshold to dynamically map an activity to a different DB2 service subclass based on which data is being accessed.

Type Activity

Definition domain
Service subclass

Enforcement scope
Member

Tracked work
Recognized coordinator

Queuing
No

Unit Data tag

Predictive or reactive
Reactive

Data can be tagged with a numeric value by specifying the DATA TAG attribute when creating or altering a table space or a storage group. Data tag thresholds are evaluated when a scan is first opened on a table and when an insert is performed into a table. Any new data tag thresholds picked up by the activity after a scan has been opened as a result of a remap operation is not applied to that scan.

Only the data tags for the data table spaces being accessed in a query are considered by the threshold. The data tags values for index or long table spaces are not considered during a threshold evaluation. For example, if the query `SELECT COUNT(*) FROM T1` is index-only access with the index placed in a table space with data tag 3 and the table data placed in a table space with data tag 1, when the query is executed the threshold evaluation will use data tag 1 (the data tag for the data table space). The data tag threshold behavior is independent of the access method (index or direct scan) chosen in the query access plan.

Activities tracked by this threshold are:

- Coordinator activities of type DML and corresponding subagent work (subsection execution).
- Nested DML activities that are derived from user applications. Consequently, DML activities that are issued by the database manager, such as utilities, SYSPROC procedures (with the exception of SYSPROC.ADMIN_CMD) or internal SQL statements are unaffected by this threshold.

In the following usage scenario, the user creates 3 table spaces; TBHIGH contains high priority data and has a data tag of 1, TBMED contains medium priority data and has a data tag of 4, and TBLOW contains low priority data and has a data tag of 9. The activities are initially mapped to a high priority service subclass. If any activities touch data on a table space other than that on the TBHIGH table space, the user wants the priority of those activities to drop. In the following example, a service superclass MAINSC containing three service subclasses, SCHIGH, SCMED, and SCLOW (for executing high, medium, and low priority work) have already been created.

Create a DATATAGINSC threshold on the high priority service subclass, and if any activity touches any data with a data tag of anything other than 1, map it to the medium priority service subclass.

```
CREATE THRESHOLD MAPTOMED FOR SERVICE CLASS SCHIGH UNDER MAINSC ACTIVITIES
  ENFORCEMENT MEMBER WHEN DATATAGINSC NOT IN (1) REMAP ACTIVITY TO SCMED
```

Create a SQLDATATAGINSC threshold on the medium priority service subclass, and if any activity touches any data with a data tag of 9 map it to the low priority service subclass.

```
CREATE THRESHOLD MAPTOLOW FOR SERVICE CLASS SCMED UNDER MAINSC ACTIVITIES
  ENFORCEMENT MEMBER WHEN DATATAGINSC IN (9) REMAP ACTIVITY TO SCLOW
```

If an activity touches a table space with a data tag of 9, that activity will be remapped to SCMED, and then immediately remapped again to SCLOW (due to the threshold on the SCMED service subclass). The user in this case, will see two threshold violations.

ESTIMATEDSQLCOST threshold

The ESTIMATEDSQLCOST threshold specifies the maximum estimated cost that is permitted for DML activities.

Type Activity

Definition domain
Database, service superclass, service subclass, work action, workload, and statement

Enforcement scope
Database

Tracked work
See the information later in this topic

Queuing
No

Unit Estimated SQL cost expressed in timerons

Predictive or reactive
Predictive

This threshold tracks the following activities:

- DML activities that are issued at the coordinator member.
- Nested DML activities that are invoked from a user application. Consequently, DML activities that are issued by the data server internally, such as DML activities issued from within the DB2 utilities, SYSPROC stored procedures, and internal SQL, are unaffected by this threshold unless their cost is included in the parent activity estimate. In this situation, these activities are indirectly tracked. A trigger is an example of an indirectly tracked activity. IMPORT, EXPORT, and other CLP commands are considered to be user logic. Activities that are invoked from within IMPORT, EXPORT, and other CLP commands are subject to thresholds. For information about the activities that fall under a work class with the DML work type, see “Work identification by type, cost, or data accessed with work classes” on page 48.

SQLROWSREAD threshold

The SQLROWSREAD threshold specifies the maximum number of rows that a DML activity may read on any member. Use this threshold to detect and control activities that are reading an excessive number of rows.

Class Activity

Definition domain
Database, service superclass, service subclass, work action, workload and statement

Enforcement scope
Member

Tracked work
See the information later in this topic

Queuing
No

Unit Number of rows

Predictive or reactive
Reactive

This threshold differs from the SQLROWSRETURNED threshold in that it controls the maximum number of rows read during query evaluation, not the number of rows returned to a client application from the data server.

Index accesses are not counted toward the total number of rows read. If an access plan uses only indexes during query evaluation, the SQLROWSREAD threshold will not be violated.

This threshold is evaluated at user-configurable time intervals; if the interval is greater than the amount of time it takes to exceed the number of rows read, it is possible for the number of rows read for an activity on a member to exceed the threshold boundary, before the violation is detected.

Activities tracked by this threshold are as follows:

- Coordinator activities of type DML and corresponding subagent work such as subsection execution.
- Nested DML activities that are derived from user applications. Consequently, DML activities that are issued by DB2 logic, such as utilities, SYSPROC procedures, or internal SQL statements, are unaffected by this threshold. IMPORT, EXPORT, and other CLP commands are considered to be user logic; therefore, activities that are invoked from within IMPORT, EXPORT, and other CLP commands are subject to thresholds.

Example

The following example creates an SQLROWSREAD threshold TH1 for the database domain with a member enforcement scope. This threshold stops the execution of any activity that reads more than 5 000 000 rows during query evaluation, which the threshold checks for at 10-second intervals. You can use this threshold to ensure that no queries on the system read an unreasonable number of rows, which can negatively impact other work running on the system.

```
CREATE THRESHOLD TH1 FOR DATABASE ACTIVITIES
  ENFORCEMENT MEMBER
  WHEN SQLROWSREAD > 5000000 CHECKING EVERY 10 SECONDS
  STOP EXECUTION;
```

SQLROWSREADINSC threshold

The in-service-class SQLROWSREADINSC threshold specifies the maximum number of rows that a DML activity can read on a particular member while running in a specific service subclass. Use this threshold to detect and control activities that are reading an excessive number of rows.

Class Activity

Definition domain
Service subclass

Enforcement scope
Member

Tracked work
See the information later in this topic

Queuing
No

Unit Number of rows

Predictive or reactive
Reactive

This threshold differs from the SQLROWSREAD threshold in that it controls the number of rows read only from the time that an activity enters a specific service subclass, not the total number of rows read during the lifetime of the activity. This threshold also differs from the SQLROWSRETURNED threshold in that it controls the maximum number of rows read during query evaluation in the current service subclass, not the number of rows returned to a client application from the data server.

Index accesses are not counted toward the total number of rows read. If an access plan uses only indexes during query evaluation, the SQLROWSREADINSC threshold will not be violated.

This threshold is evaluated at user-configurable time intervals; if the interval is greater than the amount of time it takes to exceed the number of rows read, it is possible for the number of rows read for an activity on a member to exceed the threshold boundary, before the violation is detected.

Activities tracked by this threshold are as follows:
- Coordinator activities of type DML and corresponding subagent work such as subsection execution.
- Nested DML activities that are derived from user applications. Consequently, DML activities that are issued by DB2 logic, such as utilities, SYSPROC procedures, or internal SQL statements, are unaffected by this threshold. IMPORT, EXPORT, and other CLP commands are considered to be user logic; therefore, activities that are invoked from within IMPORT, EXPORT, and other CLP commands are subject to thresholds.

You can use the REMAP ACTIVITY action to control activities by remapping them to a service subclass with different resource assignments.

Example

The following example creates two service subclasses, A1 and A2, under a superclass A, with a single in-service-class SQLROWSREADINSC threshold that remaps activities between subclasses after 10 000 rows have been read in service subclass A1 during query evaluation. An event monitor record is logged.

```
CREATE SERVICE CLASS A;
CREATE SERVICE CLASS A1 UNDER A;
CREATE SERVICE CLASS A2 UNDER A;

CREATE THRESHOLD T1 FOR SERVICE CLASS A1 UNDER A
  ACTIVITIES ENFORCEMENT MEMBER
  WHEN SQLROWSREADINSC > 10000 REMAP ACTIVITY TO A2
  LOG EVENT MONITOR RECORD;
```

SQLROWSRETURNED threshold

The SQLROWSRETURNED threshold specifies the maximum number of rows that can be returned by the data server to the client.

Type Activity

Definition domain
Database, service superclass, service subclass, work action, workload and statement

Enforcement scope
Database

Tracked work
See the information later in this topic

Queuing
No

Unit Number of rows

Predictive or reactive
Reactive

When multiple result sets are returned by a CALL statement, the threshold applies to each result set separately and not as an aggregate to the total number of rows returned across all result sets. For example, if you define the threshold for 20 rows and the CALL statement returns two result sets returning 15 rows and 19 rows respectively, the threshold is not triggered.

Activities tracked by this threshold are as follows:
- DML activities that are issued at the coordinator member.
- Nested DML activities that are invoked from a user application. Consequently, DML activities that are issued by the data server internally, such as DML activities issued from within the DB2 utilities, SYSPROC stored procedures, and internal SQL, are unaffected by this threshold.

SQLTEMPSPACE threshold

The SQLTEMPSPACE threshold specifies the maximum amount of system temporary table space that can be consumed by a DML activity at any member. DML activities often use temporary table space for operations such as sorting and the manipulation of intermediate result sets.

Type Activity

Definition domain
Database, service superclass, service subclass, work action, workload and statement

Enforcement scope
Member

Tracked work
See the information later in this topic

Queuing
No

Unit Amount of temporary table space expressed in kilobytes (KB), megabytes (MB), or gigabytes (GB)

Predictive or reactive
Reactive

Activities tracked by this threshold are as follows:
- DML activities that are issued at the coordinator member.
- Nested DML activities that are derived from user applications. Consequently, DML activities that are issued by DB2 logic (such as utilities, SYSPROC procedures, or internal SQL) are unaffected by this threshold.

The data server considers IMPORT, EXPORT, and other CLP commands to be user logic. Activities that are invoked from within IMPORT, EXPORT, and other CLP commands are subject to thresholds.

Aggregate thresholds

An aggregate threshold places collective control over elements of work in a database. The boundary that you define using an aggregate threshold operates as a running total, to which any work tracked by the threshold contributes.

When newly instantiated work causes the upper boundary to be violated, the corresponding action is triggered. The work that caused the upper boundary to be violated is the only one affected by the triggered action.

Activity queuing

Some thresholds have a built-in queue and permit you to enforce how many activities can execute concurrently by queuing all additional activities once the concurrency limit is reached, up until the set limit for the queue is exceeded.

When the number of activities exceeds the concurrency limit for a queuing threshold, new requests are queued automatically in a first-in, first-out fashion, until the queue reaches the size specified by the queuing boundary of the threshold definition. When the queue is full, the upper boundary is reached. The next request is considered to have violated the threshold, and the action specified for the threshold is applied to it. For example, an action of STOP EXECUTION causes the newly arrived work to be rejected.

You can also define the upper queuing boundary as unbounded, in which case there is no upper limit to the size of the queue. In this situation, when newly arriving work is added to the queue, the threshold is not considered to have been violated, regardless of how large the queue has become. If you define a hard limit for the upper boundary of the queue and define CONTINUE as the threshold violation action, all newly arriving work that exceeds the hard limit is considered to have violated the threshold; a threshold violation is created but the new work is still added to the queue.

AGGSQLTEMPSPACE threshold

The AGGSQLTEMPSPACE threshold specifies the maximum amount of system temporary table space that can be used in total across all concurrently running DML activities in a service subclass. DML activities often use temporary table space for operations such as sorting and the manipulation of intermediate result sets.

Class Aggregate

Definition domain
Service subclass

Enforcement scope
Member

Tracked work
See the information later in this topic

Queuing
No

Unit Kilobytes, megabytes, or gigabytes

Predictive or reactive
Reactive

Activities tracked by this threshold are as follows:

- DML activities that are issued at the coordinator member.
- Nested DML activities that are derived from user applications. Consequently, DML activities that are issued by DB2 logic, such as utilities, SYSPROC procedures, or internal SQL statements, are unaffected by this threshold. IMPORT, EXPORT, and other CLP commands are considered to be user logic; therefore, activities that are invoked from within IMPORT, EXPORT, and other CLP commands are subject to thresholds.

CONCURRENTDBCOORDACTIVITIES threshold

The CONCURRENTDBCOORDACTIVITIES threshold specifies the maximum number of recognized coordinator activities that can run concurrently in the specified definition domain and enforcement scope.

The use of this type of threshold is best suited for applications that do not execute more than one activity at a time. If an application starts more than one activity concurrently, such as issuing an UPDATE SQL statement while a cursor is open, then certain queue contention scenarios can sometimes occur depending on the concurrency level allowed by the threshold and the behaviors of the other applications involved. If this threshold exists in scenarios where applications can execute more than one activity concurrently or the application behavior is unknown, then it is recommended to have an ACTIVITYTOTALTIME threshold defined for those activities to help automatically resolve any potential queue contention scenarios.

Type Aggregate

Definition domain
Database, work action, service superclass, service subclass

Enforcement scope
Database in environments other than DB2 pureScale environments

Member in a DB2 pureScale environment

Tracked work
Recognized coordinator and nested activities (see "Work identification by type, cost, or data accessed with work classes" on page 48)

Queuing
Yes

Unit Number of concurrent database activities

Predictive or reactive
Predictive

This threshold is a generalization of the CONCURRENTWORKLOADACTIVITIES threshold. The CONCURRENTWORKLOADACTIVITIES applies only to activities that are running in a workload domain, but you can apply the CONCURRENTDBCOORDACTIVITIES threshold to a variety of domains, ranging from the entire database to a single work action. The CONCURRENTDBCOORDACTIVITIES threshold tracks coordinator activities for non-CALL statements and any nested activities generated by CALL statements. Unlike the CONCURRENTWORKLOADACTIVITIES threshold, the CONCURRENTDBCOORDACTIVITIES threshold is a queuing threshold.

Note: If a threshold action of CONTINUE is specified for a queuing threshold, it effectively makes the size of the queue unbounded, regardless of any hard value specified for the queue size.

When creating queuing thresholds of the CONCURRENTDBCOORDACTIVITIES type, be aware of configurations that might lead to irreconcilable queue-based contention. For example:

1. A concurrency threshold of type CONCURRENTDBCOORDACTIVITIES is created with a maximum concurrency value of 1 and a queue size greater than 1.

2. An application opens a cursor that the DB2 data server recognizes as activity A1, which consumes the unique ticket that is available for the threshold.
3. While the cursor is still open, the application issues an UPDATE statement, which the data server recognizes as activity A2, and which is also subject to the concurrency threshold. Because the A1 activity is already running, the new activity A2 is queued.

   The application is now in a queue contention state that cannot be resolved. It is waiting for A2 to execute but A2 is waiting for A1 to finish executing. This situation will not resolve itself without external intervention unless an ACTIVITYTOTALTIME threshold is also defined over these activities. If ACTIVITYTOTALTIME threshold is defined, then the situation will be resolved when A1 violates that threshold by spending more than the maximum amount of time that the data server should spend processing that activity.

This example can be generalized to multiple applications and queues. You can resolve this situation by increasing the concurrency values, or cancelling certain activities if the concurrency values are correctly set.

To reduce the chance of creating irreconcilable queue contention scenarios, the CONCURRENTDBCOORDACTIVITIES threshold affects different types of activities as follows:

- CALL statements are not controlled by the threshold, but all nested child activities are under threshold control. Note that both anonymous blocks and autonomous routines are classified as CALL statements.
- User defined functions (UDFs) are under threshold control, but child activities nested within UDFs are not controlled. If an autonomous routine is called from within a user defined function, neither the autonomous routine and nor any child activities of the autonomous routine are under threshold control.
- Trigger actions that invoke CALL statements and the child activities of these CALL statements are not under threshold control. Note that the INSERT, UPDATE, and DELETE statements themselves that can cause a trigger to activate are under threshold control.

CONCURRENTWORKLOADACTIVITIES threshold

The CONCURRENTWORKLOADACTIVITIES threshold specifies the maximum number of coordinator and nested activities that can concurrently run in a workload occurrence.

Type Aggregate

Definition domain
Workload

Enforcement scope
Workload occurrence

Tracked work
Recognized coordinator and nested activities (see “Activities” on page 15)

Queuing
No

Unit Number of concurrent workload activities

Predictive or reactive
Predictive

This threshold applies to a single workload occurrence. If you have multiple occurrences of a workload running concurrently, the threshold applies separately to each workload occurrence. The tracked activities include all recognized coordinator activities and any nested activities that are generated as a result of the execution of the coordinator activity. For example, unlike the CONCURRENTDBCOORDACTIVITIES threshold, if a stored procedure is called and that stored procedure executes some SQL, both the CALL statement (which is the coordinator activity) and the SQL statements executed by the stored procedure (which are the nested activities) count towards the threshold total.

COMMIT, ROLLBACK, and ROLLBACK to SAVEPOINT statements are unaffected by this threshold.

Nested activity considerations

The nested activities that are tracked by this threshold must satisfy the following criteria:

- They must be a recognized coordinator activity. Nested coordinator activities that are not recognized types as described in "Work identification by type, cost, or data accessed with work classes" on page 48 are not counted.
- They must be directly invoked from user logic, such as a user-written stored procedure issuing SQL or from the SYSPROC.ADMIN_CMD stored procedure. Nested coordinator activities that are started by the invocation of a DB2 utility or any other code in the SYSIBM, SYSFUN. or SYSPROC schemas are not counted towards the upper boundary specified by this threshold.

Example

In this example, the CONCURRENTWORKLOADACTIVITIES threshold maximum value is set to 5. The user logic causes the following sequence of operations to occur in a workload occurrence:

1. Issue a **`load`** command: the current number of workload activities is 1.
   - The **`load`** command internally issues some SQL. The current number of workload activities is 1. (SQL generated by a utility does not count against the CONCURRENTWORKLOADACTIVITIES threshold.)
   - The **`load`** command ends. The current number of workload activities is 0.
2. CALL the SYSPROC.SP1 stored procedure. The current number of workload activities is 1.
   - The SYSPROC.SP1 stored procedure generates some SQL. The current number of workload activities is 1. (SQL generated by a utility does not count against the CONCURRENTWORKLOADACTIVITIES threshold.)
   - The SYSPROC.SP1 stored procedure ends. The current number of workload activities is 0.
3. Open a cursor C1. The current number of workload activities is 1.
4. Issue a **`runstats`** command. The current number of workload activities is 1.
   - The **`runstats`** command generates some SQL. The current number of workload activities is 1.
   - The **`runstats`** command ends. The current number of workload activities is 1.
5. Close the cursor C1. The current number of workload activities is 0.
6. CALL the BOB.SP1 stored procedure. The current number of workload activities is 1.

- The BOB.SP1 stored procedure opens three cursors. The current number of workload activities is 4.
- The BOB.SP1 stored procedure calls the SYSPROC.SP2 stored procedure. The current number of workload activities is 5.
  - The SYSPROC.SP2 stored procedure issues some SQL. The current number of workload activities is 5.
  - The SYSPROC.SP2 stored procedure ends. The current number of workload activities is 4.
- The BOB.SP1 stored procedure calls the BOB.SP2 stored procedure. The current number of workload activities is 5.
  - The BOB.SP2 stored procedure issues some SQL. At this point, the threshold is triggered.
  - The BOB.SP2 stored procedure ends. The current number of workload activities is 4.
- The BOB.SP1 stored procedure ends. The current number of workload activities is 0.

7. Open a cursor C2. The current number of workload activities is 1.
8. CALL the BOB.SP2 stored procedure. The current number of workload activities is 2.

CONCURRENTWORKLOADOCCURRENCES threshold

The CONCURRENTWORKLOADOCCURRENCES threshold is an aggregate threshold that specifies the maximum number of workload occurrences that can run concurrently on the coordinator member.

Type Aggregate

Definition domain
Workload

Enforcement scope
Member

Tracked work
Workload occurrences

Queuing
No

Unit Number of concurrent workload occurrences

Predictive or reactive
Predictive

When a workload occurrence is started, if the work that it generates is sent to non-coordinator members, the work on these members does not count towards the concurrent threshold total on the coordinator member. For example, assume that a CONCURRENTWORKLOADOCCURRENCES threshold is defined to permit only one occurrence of workload A on a member. Then assume that an application connects to member 1, resulting in an occurrence of workload A being started, and that this workload causes work to be sent to database members 1, 2, and 3. In this situation, the total number of occurrences of workload A is one on member 1 and zero on database members 2 and 3. Therefore, if another application connects to member 1 and another occurrence of workload A is started on member 1, that workload is rejected. However, new occurrences of workload A can still be started on database members 2 and 3.

TOTALMEMBERCONNECTIONS threshold

The TOTALMEMBERCONNECTIONS threshold specifies the maximum number of concurrent database connections on a coordinator member for a database, that is, this threshold controls the maximum number of clients that can connect to the database on each of its database members.

This threshold is not enforced for users with DBADM and WLMADM authority.

Type Aggregate

Definition domain
Database

Enforcement scope
Member

Tracked work
Connections

Queuing
Yes (enforced at 0)

Unit Number of concurrent connections

Predictive or reactive
Predictive

For example, if you set the TOTALMEMBERCONNECTIONS threshold to 10 and the database has five members, each member can have up to 10 clients connected concurrently, for a total of 50 client connections across the entire database.

The TOTALMEMBERCONNECTIONS threshold controls only coordinator connections. Connections made by subagents are not counted towards the threshold.

This threshold is useful for situations in which you want to have multiple databases in the same instance. Setting a TOTALMEMBERCONNECTIONS threshold on a member ensures that client connections from one database cannot use all of the available connections on a member.

Ensure that you set the **max_connections** database manager configuration parameter high enough to support the maximum number of connections that you expect across the database. If you set a TOTALMEMBERCONNECTIONS threshold for a database, you must set **max_connections** to at least the threshold value. If you want to run multiple databases on the same instance, ensure that you set **max_connections** high enough to support the maximum number of connections for all databases. The data server does not check for this condition because it is impossible to know beforehand how many of the databases will be active concurrently.

Note: Although the queue size is typically enforced at 0 for the TOTALMEMBERCONNECTIONS threshold, if a threshold action of CONTINUE is specified for this queuing threshold, it effectively makes the size of the queue unbounded, regardless of any hard value specified for the queue size.

TOTALSCMEMBERCONNECTIONS threshold

The TOTALSCMEMBERCONNECTIONS threshold specifies the maximum number of concurrent database connections on a coordinator member for a service superclass.

Type Aggregate

Definition domain
Service superclass

Enforcement scope
Member

Tracked work
Connections

Queuing
Yes

Unit Number of concurrent connections in service class

Predictive or reactive
Predictive

When the TOTALSCMEMBERCONNECTIONS threshold in the service class is reached, subsequent coordinator connections that join the service superclass are queued until the specified queue size is reached. By default, the queue size is zero, which means that no connections can be queued. If a connection joins the queue of a TOTALSCMEMBERCONNECTIONS threshold, the connection is considered to be in a *transient* state.

Note: If a threshold action of CONTINUE is specified for a queuing threshold, it effectively makes the size of the queue unbounded, regardless of any hard value specified for the queue size.

Tracked connections include both new client connections and existing client connections that switch to the service class from another service class. Connections switch service classes by associating with a different workload definition that is mapped to a different service class. Workload reevaluation occurs only at transaction boundaries, so connections can switch service classes only at transaction boundaries; however, because resources that are associated with WITH HOLD cursors are maintained across transaction boundaries, connections with open WITH HOLD cursors cannot switch service superclasses. When the connection concentrator is on, any application that is switched leaves the service class. When the application is switched in at the subsequent statement, it must rejoin the service class and consequently pass the threshold.

When the queue size threshold is reached, the threshold action is triggered. The TOTALSCMEMBERCONNECTIONS threshold controls only coordinator connections. Connections made by subagents are not counted towards the threshold.

If you set a threshold value for TOTALMEMBERCONNECTIONS, set it large enough to accommodate the threshold that you specify for TOTALSCMEMBERCONNECTIONS. For example, if you define five service superclasses for a database and each of them has a TOTALSCMEMBERCONNECTIONS threshold value of 10, the TOTALMEMBERCONNECTIONS threshold value should be at least 50.

Unit of work thresholds

A unit of work threshold applies controls to individual units of work. When the resource usage of an individual unit of work violates the upper bound of the threshold that is tracking it, the corresponding action is triggered and applied once to either the application (in the case of force application) or the unit of work (in the case of rollback).

UOWTOTALTIME threshold

The UOWTOTALTIME threshold specifies the maximum amount of time that a unit of work may spend in the DB2 engine.

Type Unit of work

Definition domain
Database, workload, service superclass

Enforcement scope
Database

Tracked work
See the information later in this topic.

Queuing
No

Unit Labeled duration

Predictive or reactive
Reactive

The STOP EXECUTION action for a UOWTOTALTIME threshold rolls back the unit of work. The FORCE APPLICATION action forces the application to which the unit of work belongs. The COLLECT ACTIVITY DATA option can be specified for this threshold, but it is ignored.

A UOWTOTALTIME threshold defined on the workload domain overrides any UOWTOTALTIME threshold defined on the service superclass domain. A UOWTOTALTIME threshold defined on the service superclass domain overrides any UOWTOTALTIME threshold defined on the database domain.

Example

The following example creates a threshold FORCE10MINUTEUOW that issues a FORCE APPLICATION command when a unit of work has been executing for more than 10 minutes.

```
CREATE THRESHOLD FORCE10MINUTEUOW FOR DATABASE ACTIVITIES
   ENFORCEMENT DATABASE
   WHEN UOWTOTALTIME > 10 MINUTES
   FORCE APPLICATION;
```

Priority aging of ongoing work

Priority aging is an approach to workload management in which the priority of in-progress activities automatically changes over time.

The longer an activity runs, the lower its priority, and the fewer resources it will receive. You can use priority aging to control longer-running activities, so that throughput for shorter-running activities can be improved. The priority aging approach works when resource control responds to the movement of work between service classes. That is, when work that is already being processed changes service classes, the movement is actually reflected in the resources that are received by that work (as well as other work in the new service class). This approach is best implemented when using the explicit CPU controls that are provided by the CPU dispatcher or by integration with operating system workload management products.

Changing the priority of activities by remapping

System resources are allocated and controlled by using service classes. With priority aging, the priority of an activity can be changed by moving the activity from one service class to another service class. The priority increases if the new service class has more resources, and the priority decreases if the new service class has fewer resources. Activities are moved when a threshold with a REMAP ACTIVITY action is violated, based upon predetermined maximum usage of a specific resource such as processor time or rows read. After an activity is mapped to a new service class, it continues to run with the new resource constraints applied.

A simple approach that you can use to help short queries to run faster is to define a series of service classes with successively lower levels of resource priority and threshold actions that move activities between the service subclasses. Using this setup, you can decrease, or age, the priority of longer-running work over time and perhaps improve response times for shorter-running work without having detailed knowledge of the activities running on your data server.

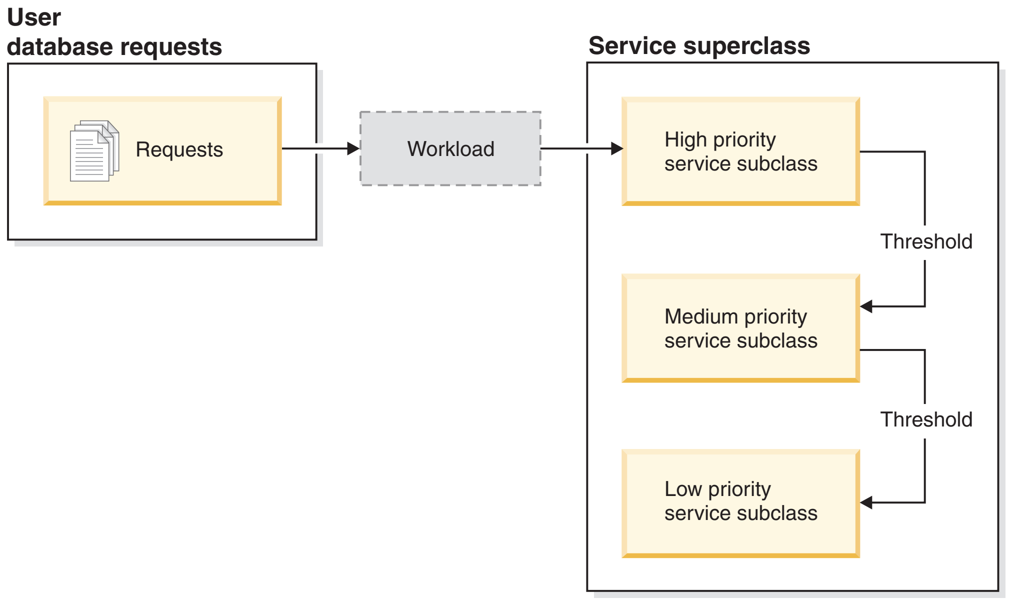


Figure 21. A simple tiered setup that shows three service classes with successively lower priority

You can create this setup by assigning a high priority for all applicable resources to one service class, medium priority to a second service class, and low priority to a third service class. As work enters the system, it is automatically placed into the first service class and begins running using the high-priority settings of this service class. If you also define thresholds for each of the service classes that limit the time or resources used during execution, work is dynamically reassigned to the next-lower service class if the threshold of the next-higher class is violated. This dynamic resource control is repeatedly applied until the work is completed or is in the lowest-priority class, where it remains until it is completed or you force it to stop running.

In-service-class thresholds

Remapping of activities is available with any of the in-service-class thresholds, which control the amount of a resource that may be used while an activity is running in a particular service subclass. Examples of resources are the amount of processor time used (CPUTIMEINSC threshold), and the number of rows read by an application (SQLROWSREADINSC threshold), per activity per member. These thresholds differ from other activity thresholds, which control resources used throughout the entire lifetime of an activity.

Because of the control that in-service-class thresholds provide over service subclasses, you can define in-service-class thresholds only on a service subclass domain. The in-service-class thresholds provide controls similar to DB2 Governor rules, which act on processor time and rows read monitor elements.

When an in-service-class threshold is associated with a REMAP ACTIVITY action, agents working for the activity periodically check whether the threshold has been violated on each member. If an agent detects a threshold violation on a member, the agent triggers the REMAP ACTIVITY action for the activity on the member and then remaps itself to the target service subclass. All other agents working for the activity on the same member remap themselves to the target service subclass when they detect that the activity has been remapped. Only one agent detects the threshold violation and remaps the activity, and the activity is considered remapped after that agent has detected the threshold violation and performed the remapping.

Two monitor elements provide information about activity remapping within service subclasses. The **act_remapped_in** monitor element provides a counter that records how many activities were remapped into a service subclass and is incremented each time for the target service subclass that an activity is remapped to. Similarly, the **act_remapped_out** monitor element counter is incremented each time for the source service subclass that an activity is remapped out of. An additional monitor element, **num_remaps**, counts the number of times in total that an activity has been remapped between service subclasses.

An activity can be remapped multiple times to different service subclasses, and an activity can return to its original service subclass after being remapped to another service subclass.

The in-service class thresholds are evaluated separately for an activity on each member, without coordination. Because there is no coordination between members, when an activity is remapped on one member, it is possible for the same activity to be in different service subclasses on different members simultaneously.

When subagent work for an activity is completed on a remote member and further work for the same activity is sent to the same member later, the activity restarts in the same service subclass as the agent that sent the request to the member. If you defined an in-service-class threshold for this service subclass, the timer or counter for the activity on the remote member restarts at zero.

Where activities are nested, parent and child activities are tracked separately. Therefore, if a child activity is using an excessive amount of resources, only this activity, not its parent or sibling activities, violates a threshold.

Using the in-service-class thresholds

On data servers where the primary resource activities have to compete for is processor time, use the CPUTIMEINSC threshold as your first measure of control. On data servers where queries reading many table rows result primarily in I/O contention, use SQLROWSREADINSC. On systems that see a combination of heavy processor and IO activity, use a combination of the CPUTIMEINSC and SQLROWSREADINSC thresholds.

You should set the agent priority of the service subclasses relative to each other, so that your data server can treat activities of different business priority differently. Note that the agent priority of the default system class should always be higher than any user defined service classes you create to avoid a negative impact on performance. The agent priority of the default maintenance class can be set lower than your user defined service classes.

How much of a given resource you permit activities to consume in a service subclass before remapping them to a different service subclass depends largely on your particular environment. To find the best value for each threshold condition, you need to monitor how activities are being processed on your data server. If the maximum amount of processor time that can be used or the maximum number of rows that can be read in a service class is set too high, activities will inappropriately start and finish in the same service subclass regardless of how much resource each activity requires. If the maximum processor time or rows read is set too low, no activity will finish in the service class it is originally mapped to and every activity will end up being remapped to the another service class regardless of business priority. In either case, your tiered configuration will not benefit the overall throughput on your data server and activities are not treated according to their business priority effectively.

In addition to determining how much of a given resource an activity can consume, some thresholds allow you to define a check interval for how often the data server checks for threshold violations. This capability is provided for thresholds where it is too expensive to check the threshold each time a unit of the resource being controlled is consumed and determines the latency with which violations of these thresholds are detected. The CPUTIME and SQLROWSREAD thresholds and their in-service class counterparts CPUTIMEINSC and SQLROWSREADINSC support check intervals. On serial database instances, the check interval equals the amount of real time that you want to elapse between checks for a threshold violation. In multimember database environments or on SMP instances, the check interval should be set to a value that is less than the amount of real time elapsed to take into account that there can be more than one agent accumulating processor time simultaneously for the activity. To calculate the approximate check interval in multimember database environments or on SMP instances, divide the amount of real time you want to elapse between checks by the degree of parallelism for the activity and use the resulting value for the CHECKING EVERY clause.

For example: In a single member database, if you want a CPUTIMEINSC threshold to trigger a REMAP ACTIVITY action after 30 seconds of processor time have been consumed, you can set the check interval to 30 seconds and be certain that the threshold action will be triggered after no more than 30 seconds of processor time have been consumed (processor time used cannot outstrip real time elapsed). In a multimember database environment, if you define a CPUTIMEINSC threshold that is set at 5 seconds with a check interval of 5 seconds, and an activity has 1 coordinator member agent and 4 subagents working on its behalf, it is possible for the activity to consume 5 seconds of CPU time in just 1 second of real time, because 5 agents simultaneously accumulate 1 second of processor time each. To prevent the activity from consuming a multiple of 5 seconds of processor time, the check interval should in this case be set to 1 second.

For additional information on how to use the thresholds, see the sample tiering scripts and priority aging scenarios.

Effect of remapping on thresholds

Which thresholds continue to apply after remapping through a REMAP ACTIVITY action depends on whether the thresholds apply only to a specific service subclass or throughout the lifetime of an activity.

When you remap an activity to a new service subclass, only the in-service-class thresholds, such as CPUTIMEINSC and SQLROWSREADINSC, change. These in-service-class thresholds no longer affect an activity after it leaves the source service subclass, and they are replaced with the corresponding thresholds for the target subclass, if you defined those thresholds. All other activity thresholds from the service subclass to which the activity was originally mapped remain unchanged, and applicable threshold timers and counters are not reset. The activity is not re-evaluated against any other thresholds that you defined for the target service subclass.

For example, assume that two service subclasses with thresholds are defined as follows:

- Service subclass A with the following thresholds:
  - An ACTIVITYTOTALTIME lifetime threshold TH1 with a STOP EXECUTION action after 30 minutes have elapsed
  - An SQLROWSREADINSC in-service-class threshold TH2 with a REMAP ACTIVITY action to service subclass B after more than 2000 rows have been read
- Service subclass B with the following thresholds:
  - An ACTIVITYTOTALTIME lifetime threshold TH3 with a STOP EXECUTION action after 5 minutes have elapsed
  - An SQLROWSREADINSC threshold TH4 with a STOP EXECUTION action after more than 1000 rows have been read

When an activity enters the system in service subclass A, both thresholds TH1 and TH2 apply to the activity. If the activity reads more than 2000 rows during query evaluation, it is dynamically remapped to service subclass B. Because of the remapping of the activity to subclass B, the applicable in-service-class thresholds change, and TH4 rather than TH2 now applies to the activity. Counters for both thresholds are reset to zero, and even though the activity has read more than 2000 rows in the original service subclass, the counter for TH4 is restarted at zero; the activity must read more than 1000 rows while running in service subclass B before threshold TH4 is violated. Threshold TH1, which applies throughout the lifetime of the activity, continues to apply, even though the activity is now running in a different subclass. Threshold TH3 does not exercise any control over the remapped activity at all, because it did not apply to the first service subclass that the activity entered when it began running.

Sample priority aging scripts

Use the provided sample scripts to quickly create a tiered service class configuration on your data server. With a tiered configuration, you can address specific performance goals by decreasing the priority of longer-running queries over time, known as priority aging. You can also modify the scripts according to your own business priorities when adapting them to your environment.

The two sample scripts `wlmtiersdefault.db2` and `wlmtierstimerons.db2` are intended to demonstrate how you might use priority aging on your data server to improve overall throughput. DB2 workload manager provides you with the controls that can help with overall throughput on your data server, but to gain the full benefit of the scripts, and of priority aging in general, you will need to run your data server for an extended period of time and monitor how this work is performed, then adjust the service class and threshold settings accordingly.

The scripts are provided in the `samples/admin_scripts` directory under your installation directory.

The `wlmtiersdefault.db2` and `wlmtierstimerons.db2` scripts create three service subclasses under a common superclass with successively lower resource settings from high to low along with CPUTIMEINSC thresholds that move or remap activities in response to the consumption of processor time. The scripts differ in how activities are mapped to a service class when they first enter your data server. A third script, `wlmtiersdrop.db2`, drops the WLM objects created by the other two sample tiering scripts.

`wlmtiersdefault.db2`
: All activities entering the data server are mapped to a high priority service subclass WLM_SHORT without differentiation between types of work. Activities will complete in the high priority service subclass whilst the highest priority is assigned to them, unless they exceed the maximum amount of processor time they are allowed to consume. Activities that consume too much processor time are first remapped by a threshold REMAP ACTIVITY action to a medium priority service subclass WLM_MEDIUM and then, if they still do not complete without exceeding the allotted processor time in that subclass, remapped to a low priority service subclass WLM_LONG, where they continue to be processed until they complete. Activities that cannot be remapped by a CPUTIMEINSC threshold are mapped directly to service subclass WLM_MEDIUM where they will remain.

`wlmtierstimerons.db2`
: DML activities entering the data server are evaluated according to their estimated cost and mapped to one of the three service subclass. DML activities estimated to be short are mapped to a high priority service subclass WLM_SHORT, DML activities estimated to be of medium length are mapped to a WLM_MEDIUM service subclass that receives medium priority, and long DML activities are mapped to a WLM_LONG service subclass that receives the lowest priority. Non-DML activities enter the highest priority service subclass. As they are processed, activities that consume more processor time than assigned to a service subclass are successively remapped by a threshold REMAP ACTIVITY action to the next lowest priority service subclass, until they are remapped to the lowest priority service subclass where they continue to be processed until they complete. Activities that cannot be remapped by a CPUTIMEINSC threshold are mapped directly to service subclass WLM_MEDIUM where they will remain.

`wlmtiersdrop.db2`
: This script drops all DB2 workload manager service classes, thresholds,

workloads, work class sets and work action sets that are created by the scripts `wlmtiersdefault.db2` and `wlmtierstimerons.db2`.

By default, the `wlmtiersdefault.db2` and `wlmtierstimerons.db2` scripts use the following service class and threshold definitions:

Table 40. Service classes with CPU shares and prefetch priority settings created by the scripts

Service class	CPU shares	Prefetch priority
WLM_SHORT (high priority)	6000	High
WLM_MEDIUM (medium priority)	3000	Medium
WLM_LONG (low priority)	1000	Low
Default system class	Default	High
Default maintenance class	Default	Low

Table 41. Thresholds created by the scripts

Threshold	Maximum amount of processor time that can be used in the service class before remapping
WLM_TIERS_REMAP_SHORT_TO_MEDIUM	30 seconds
WLM_TIERS_REMAP_MEDIUM_TO_LONG	30 seconds

The `wlmtiersdefault.db2` sample script creates the following work action set and work class set, which is used to map activities that cannot be remapped by the CPUTIMEINSC threshold directly to the WLM_MEDIUM service subclass. These activities will remain in the WLM_MEDIUM service subclass for the duration of their execution.

Table 42. Work class set created by the `wlmtiersdefault.db2` sample script

Work class	Work action
WLM_DML_WC	For DML activities, mapped to service class WLM_SHORT initially. These activities can be remapped by a CPUTIMEINSC threshold.
WLM_CALL_WC	For CALL activities, mapped to service class WLM_SHORT initially. These activities can be remapped by a CPUTIMEINSC threshold.
WLM_OTHER_WC	For activities that cannot be remapped by a CPUTIMEINSC threshold, mapped to service class WLM_MEDIUM. These activities will remain in the WLM_MEDIUM service subclass.

The `wlmtierstimerons.db2` sample script also creates the following work action set and work class set, which is used to map activities according to their estimated cost:

Table 43. Work class set created by the `wlmtierstimerons.db2` sample script

Work class	Estimated cost range in timerons and work action
WLM_SHORT_DML_WC	For DML activities with an estimated cost of 0 to 999 timerons, mapped to service class WLM_SHORT initially. These activities may get remapped by a CPUTIMEINSC threshold.
WLM_MEDIUM_DML_WC	For DML activities with an estimated cost of 1000 to 99 999 timerons, mapped to service class WLM_MEDIUM initially. These activities may get remapped by a CPUTIMEINSC threshold.
WLM_LONG_DML_WC	For DML activities with an estimated cost of 100 000 to infinity timerons, mapped to service class WLM_LONG.
WLM_CALL_WC	For CALL activities, mapped to service class WLM_SHORT initially. These activities can be remapped by a CPUTIMEINSC threshold.
WLM_OTHER_WC	For activities that cannot be remapped, mapped to service class WLM_MEDIUM

Modifying the scripts for your environment

When you modify the sample scripts to adapt them to your environment, the most important setting to consider is the maximum amount of processor time that can be used in each service class. How much processor time you permit activities to consume in each service subclass depends largely on your particular environment. To find the best values, you need to monitor how activities are being processed on your data server. By default, both the `wlmtiersdefault.db2` and `wlmtierstimerons.db2` scripts will log event monitor records to the threshold violations event monitor, if one is active, with the option to turn on and enable the activity event monitor and to collect activity data (at the cost of incurring additional overhead). For `wlmtiersdefault.db2`, if the maximum amount of processor time that can be used in each service class is set too high, most activities will always start and finish in the high priority class regardless of how much actual processor time each requires. If the maximum amount of processor time is set too low, no activity will finish in the high priority service class and every activity will end up being remapped to the medium or low priority service class regardless of business priority. In either case, the script will not benefit overall throughput on your data server and activities are not treated according to their business priority effectively. The same issue is true to a lesser extent for `wlmtierstimerons.db2` where activities are differentiated initially by being mapped to service subclasses according to estimated cost. If the maximum amount of processor time that can be used in each service class is set incorrectly, activities will fail to be remapped to a more appropriate service subclass if they consume too much processor time, or are remapped too quickly despite having higher business priority.

For more information about the specific DB2 workload manager objects created by the scripts and about how to run them, refer to the scripts.

Sample scenarios

Two examples have been included in the documentation that show you how you can adapt the sample tiering scripts on your data server to make use of priority aging.

Scenario: Controlling resource intensive business intelligence reports with priority aging

The following scenario shows how you can configure your data server to dynamically lower the priority of expensive business intelligence reports that cannot be identified before execution starts in order to maintain system performance for other queries.

The problem: There is a business intelligence report which any end user can run and which is very expensive. Anytime the report runs, it compromises the performance of the system. The front end tool used to generate the report does not set any client information that could be used to identify the report in advance which would permit you to map it to a low priority service class using a workload.

The solution: You can use the `wlmtiersdefault.db2` sample tiering scripts to configure your data server with a tiered configuration that dynamically lowers, or ages, the priority of processor intensive activities during their lifetime in order to prevent compromising data server performance for all other users. After a workload initially maps all work to a high priority service subclass, the expensive reports are detected by the CPUTIMEINSC in-service-class threshold based on the amount of processor time consumed. If an activity violates the CPUTIMEINSC threshold by using the maximum amount of allowed processor time, a REMAP ACTIVITY moves the activity to a lower priority service subclass. The activity can be remapped in response to processor time consumption again until it executes in the lowest priority service subclass where it will continue until it completes or you intervene manually. Other activities which do not exceed the thresholds continue to run in the high priority service subclass, where they receive higher agent priority.

An event monitor record is logged every time an activity is remapped, if you created a threshold violations event monitor. If you want to collect additional information about remapped activities to investigate further, you can add the COLLECT ACTIVITY DATA clause to the ALTER THRESHOLD statement in the wlmtiersdefault.db2 script. Simply rerun the script for the change to take effect.

After running the workload for a period of time, you can use the WLM_GET_SERVICE_SUBCLASS_STATS table function to see how many activities were remapped between the service subclasses:

```
SELECT substr(service_superclass_name,1,21) AS superclass,
       substr(service_subclass_name,1,21) AS subclass,
       substr(char(coord_act_completed_total),1,10) AS completed,
       substr(char(act_remapped_in),1,10) AS remapped_in,
       substr(char(act_remapped_out),1,10) AS remapped_out,
       substr(char(last_reset),1,19) AS last_reset
FROM table( WLM_GET_SERVICE_SUBCLASS_STATS(
              CAST(NULL AS VARCHAR(128)),
              CAST(NULL AS VARCHAR(128)),
              -2 )
        ) AS TF_subcls_stats@

  SELECT SUBSTR(WORKLOAD_NAME,1,19) AS WL_NAME,
         COORD_ACT_LIFETIME_AVG,
         COORD_ACT_LIFETIME_STDDEV
  FROM TABLE(WLM_GET_WORKLOAD_STATS
        (CAST(NULL AS VARCHAR(128)), -2))
         AS WLSTATS
  ORDER BY WL_NAME@

SUPERCLASS            SUBCLASS              COMPLETED  REMAPPED_IN REMAPPED_OUT LAST_RESET
```

```
-------------------- -------------------- ---------- ---------- ----------- -------------------
SYSDEFAULTSYSTEMCLASS SYSDEFAULTSUBCLASS    0          0          0           2008-10-06-20.53.47
SYSDEFAULTMAINTENANCE SYSDEFAULTSUBCLASS    3          0          0           2008-10-06-20.53.47
SYSDEFAULTUSERCLASS   SYSDEFAULTSUBCLASS    0          0          0           2008-10-06-20.53.47
WLM_TIERS             SYSDEFAULTSUBCLASS    0          0          0           2008-10-06-20.53.47
WLM_TIERS             WLM_SHORT             999        0          35          2008-10-06-20.53.47
WLM_TIERS             WLM_MEDIUM            19         35         16          2008-10-06-20.53.47
WLM_TIERS             WLM_LONG              16         16         0           2008-10-06-20.53.47

  7 record(s) selected.
```

If you notice that no or only very few activities are being remapped to the lower priority service subclasses, decrease the CPUTIMEINSC threshold value and the check interval used by the ALTER THRESHOLD statements in the script to improve the mapping of activities across service class tiers according to business priority. If most or almost all activities are being remapped to the lower priority service subclasses, increase the CPUTIMEINSC threshold value and the check interval for the ALTER THRESHOLD statements to permit more activities to complete with higher priority. After your changes are complete, rerun the wlmtiersdefault.db2 script to make them effective.

Scenario: Remapping incorrectly mapped queries through priority aging

The following scenario shows how you can configure your data server to dynamically remap, or age the priority of, activities that are consuming more processor time than originally estimated in order to maintain system performance for other queries.

The problem: You may have mapped expensive activities based on estimated SQL cost to a lower priority service subclass so that these activities do not impact the performance of less expensive, shorter activities. Such a mapping can be accomplished by defining a work action set at the service superclass level. However, if the estimated SQL cost is incorrect because of statistics that are out of date, for example, an expensive activity might be mapped incorrectly to a high priority service subclass where it begins to consume an excessive amount of resources, at the cost of all other high priority activities.

The solution: You can use the `wlmtierstimerons.db2` sample tiering script to configure your data server with a tiered configuration that evaluates incoming activities according to their estimated cost and maps them to one of three service subclasses, each with different agent priorities. If an activity consumes too much processor time, your data server dynamically lowers the priority of the activity during its lifetime by remapping it between performance tiers. This dynamic process of remapping activities to lower their priority is also referred to as priority aging.

After an activity has been mapped to its initial service class and begins executing, the CPUTIMEINSC in-service-class threshold is used by the script to control the amount of processor time an activity can consume. If the activity violates the threshold by using the maximum amount of allowed processor time, a REMAP ACTIVITY action is triggered which moves the activity to a service subclass with lower agent priority. The activity can be remapped in response to processor time consumption until it executes the lowest priority service subclass where it will continue until it completes or you intervene manually.

An event monitor record is logged every time an activity is remapped. If you want to collect additional information about remapped activities to investigate further, you can add the COLLECT ACTIVITY DATA clause to the ALTER THRESHOLD statement in the wlmtiersdefault.db2 script. Simply rerun the script for the change to take effect.

After running the workload for a period of time, you can use the WLM_GET_SERVICE_SUBCLASS_STATS table function to see how many activities were remapped between the service subclasses:

```
SELECT substr(service_superclass_name,1,21) AS superclass,
       substr(service_subclass_name,1,21) AS subclass,
       substr(char(coord_act_completed_total),1,10) AS completed,
       substr(char(act_remapped_in),1,10) AS remapped_in,
       substr(char(act_remapped_out),1,10) AS remapped_out,
       substr(char(last_reset),1,19) AS last_reset
FROM table( WLM_GET_SERVICE_SUBCLASS_STATS(
                CAST(NULL AS VARCHAR(128)),
                CAST(NULL AS VARCHAR(128)),
                -2 )
          ) AS TF_subcls_stats@

  SELECT SUBSTR(WORKLOAD_NAME,1,19) AS WL_NAME,
         COORD_ACT_LIFETIME_AVG,
         COORD_ACT_LIFETIME_STDDEV
  FROM TABLE(WLM_GET_WORKLOAD_STATS
        (CAST(NULL AS VARCHAR(128)), -2))
         AS WLSTATS
  ORDER BY WL_NAME@
```

```
SUPERCLASS            SUBCLASS              COMPLETED  REMAPPED_IN REMAPPED_OUT LAST_RESET
--------------------- --------------------- ---------- ----------- ------------ -------------------
SYSDEFAULTSYSTEMCLASS SYSDEFAULTSUBCLASS    0          0           0            2008-10-06-20.59.27
SYSDEFAULTMAINTENANCE SYSDEFAULTSUBCLASS    3          0           0            2008-10-06-20.59.27
SYSDEFAULTUSERCLASS   SYSDEFAULTSUBCLASS    0          0           0            2008-10-06-20.59.27
WLM_TIERS             SYSDEFAULTSUBCLASS    0          0           0            2008-10-06-20.59.27
WLM_TIERS             WLM_SHORT             651        0           5            2008-10-06-20.59.27
WLM_TIERS             WLM_MEDIUM            36         5           7            2008-10-06-20.59.27
WLM_TIERS             WLM_LONG              16         7           0            2008-10-06-20.59.27

  7 record(s) selected.
```

For this scenario, you should see relatively few activities being remapped between service subclasses, because activities should almost always be mapped to the appropriate service subclass initially, based on estimated cost. If you notice that activities typically are being completed only in the WLM_SHORT or the WLM_LONG service class, you can adjust the estimated cost values used by the ALTER WORK CLASS SET statement in the script to improve the mapping of activities across service class tiers, so that shorter activities are mapped to the WLM_SHORT_DML_WC work class and longer activities are mapped to the WLM_MEDIUM_DML_WC or the WLM_LONG_DML_WC work class. If you notice that most of the activities are being remapped, you can increase the threshold values used in the ALTER THRESHOLD statements to improve the initial mapping of activities to service subclasses. After your changes are complete, rerun the wlmtierstimerons.db2 script to make them effective.

Remapping activities between service subclasses

You enable remapping by specifying a REMAP ACTIVITY action with CREATE and ALTER THRESHOLD statements. The remap action, when it is triggered by a threshold violation, moves an activity from one service subclass to another service subclass under the same superclass.

Before you begin

In order to be able to remap to another service subclass, the target service subclass must exist under the same service superclass as the original service subclass of the activity. Either the target or original service subclass can be the default subclass of the superclass. The REMAP ACTIVITY action cannot be applied to service subclasses under the default system class, default maintenance class or default user class.

About this task

The REMAP ACTIVITY action will move an activity to a different service subclass within the same service superclass. Remapping is available with any of the in-service-class thresholds such as CPUTIMEINSC and SQLROWSREADINSC. You use this dynamic process of remapping activities to lower their priority over time, which is also known as priority aging. Lowering the priority of some activities over time can free up system resources, which can then be applied to other activities of higher business importance.

You can use the REMAP ACTIVITY action with the DATATAGINSC in-service-class threshold which maps an activity to a different DB2 service subclass based on the data that is estimated to be accessed.

Agents working for the activity will periodically check if a threshold has been violated on each member, without coordination between members. When any one agent detects an in-service-class threshold violation on a member, this agent triggers the REMAP ACTIVITY action for the activity on the member and then remaps itself to the target service subclass, after which the activity is considered remapped. All other agents working for the activity on the same member will remap to the target service subclass when they detect that the activity has been remapped.

Restrictions

The target service subclass cannot be the same as the original service subclass; you must remap to a different service subclass first before remapping to the original one.

If an activity is remapped to a disabled service subclass, the activity is treated as if it has been rejected by the disabled subclass and an error message -4714 is returned to the client.

Procedure

1. Identify those activities which you want to control through priority aging. A tiered setup consists of service subclasses under the same service superclass that have in-service-class thresholds with REMAP ACTIVITY threshold actions defined on them. You can refer to the basic priority aging example and to the sample scenarios as a starting point:
   a. "Priority aging of ongoing work" on page 147
   b. "Scenario: Controlling resource intensive business intelligence reports with priority aging" on page 155
   c. "Scenario: Remapping incorrectly mapped queries through priority aging" on page 156
2. Select the different service subclasses that activities will be mapped to. This includes both the the service subclass an activity is originally mapped to when activity execution starts, and any other service subclass or classes the activity will be remapped to during its lifetime. For more information on service classes, including on how to create them, see "Resource assignment with service classes" on page 67.
3. Create or alter your thresholds for controlling activities. For more information on thresholds, see "Priority aging of ongoing work" on page 147.
   a. Define your in-service-class thresholds so that they include a REMAP ACTIVITY action, which is triggered when the threshold is violated. Note

that an in-service-class threshold applies to and is affected by an activity only while the activity is mapped to the associated service subclass; affected counters and timers are reset after remapping. Consider if a threshold violation record should be logged each time an activity remaps. These records provide information about which service classes an activity spent time executing in, which you can use for performance analysis. Note that logging threshold violation records can begin consuming substantial amounts of disk space, if remapping of activities between service subclasses is a common occurrence.

   b. You can also define any thresholds that you want to apply to the lifetime of the activity, but note that only thresholds from the first service subclass that the activity is originally mapped to continue to apply throughout the lifetime of the activity. If you also define any thresholds on any of the service subclasses that an activity is later remapped to, they do not apply.

4. Commit your changes. When you commit your changes, your thresholds are added to the SYSCAT.THRESHOLDS view.
5. Allow your data server to execute the activities you are targeting with your in-service-class thresholds and monitor their progress during their lifetime. Activities will stay in the their original service subclass during execution as long as they do not violate an in-service-class threshold. As in-service-class thresholds are violated during activity execution, activities will trigger a REMAP ACTIVITY action that dynamically remaps them to different service subclasses. Once remapped, the activities continue execution and are now controlled by the resource constraints you have placed on the target service subclass.
6. If necessary, refine your approach to priority aging to reach your stated performance goals.

Example

The following example creates a simple three-tiered setup that lowers, or ages, the priority of ongoing activity over time. Three service subclasses under a single superclass A provide the execution environment in which all queries must run. Assume that the default user workload maps incoming queries to service subclass A1, which is a high-priority subclass intended to permit shorter running queries to execute quickly. A medium-priority service subclass A2 is intended to permit longer running queries to execute, although with more stringent resource controls. Service subclass A3 provides containment for any very large queries that take an excessive amount of processor time to complete.

Three thresholds provide control over the ongoing resource consumption of queries. A query is permitted to execute in the high-priority service subclass A1 only as long as it requires less than one minute of processor time to complete. After a minute of processor time has been consumed, threshold T1 automatically remaps the activity to subclass A2, where it can continue executing as long as it consumes less than 10 minutes of processor time. If the query still has not completed after 10 minutes of consuming processor time, threshold T2 remaps the activity to the lowest priority service subclass, A3. Queries in subclass A3 are permitted to continue indefinitely, although an event monitor record is logged and activity data with details is collected when the processor time used exceeds 1 hour.

```
CREATE SERVICE CLASS A
CREATE SERVICE CLASS A1 UNDER A
CREATE SERVICE CLASS A2 UNDER A
CREATE SERVICE CLASS A3 UNDER A

CREATE THRESHOLD T1 FOR SERVICE CLASS A1 UNDER A
```

```
  ACTIVITIES ENFORCEMENT MEMBER
  WHEN CPUTIMEINSC > 1 MINUTE REMAP ACTIVITY TO A2

CREATE THRESHOLD T2 FOR SERVICE CLASS A2 UNDER A
  ACTIVITIES ENFORCEMENT MEMBER
  WHEN CPUTIMEINSC > 10 MINUTES REMAP ACTIVITY TO A3

CREATE THRESHOLD T3 FOR SERVICE CLASS A3 UNDER A
  ACTIVITIES ENFORCEMENT MEMBER
  WHEN CPUTIMEINSC > 1 HOUR LOG EVENT MONITOR RECORD
  COLLECT ACTIVITY DATA WITH DETAILS
  CONTINUE
```

Workload management dispatcher overview

The DB2 workload management dispatcher is a built-in DB2 technology by which you can specifically allocate CPU resources to work that is being executed on a database server. CPU resource entitlements can be controlled by using CPU shares and CPU limit attributes on DB2 service classes.

Overview

Particularly useful under workload conditions that strain the system CPU resources, the dispatcher can effectively manage service class CPU resource entitlements with attributes such as the uncapped (almost unrestricted) soft CPU shares, and the two capped (limited) attributes: hard CPU shares and CPU limits. You can use the uncapped soft CPU shares to give high-priority-work service classes any unused CPU resources. In addition, you can enforce controls on the CPU resource entitlements by using capped hard CPU shares or CPU limits assigned to low-priority-work service classes, thereby limiting their impact on high-priority work. Under conditions where the system CPU resources are less strained, you can use one or both of the capped attributes, without the need to assign uncapped attributes, to effectively control the CPU resource entitlements between service classes running in a typical, underrun-CPU environment.

The workload management dispatcher infrastructure operates at the instance level in the DB2 database manager. The dispatcher operates by limiting the number of executing agents to be dispatched to the operating system (OS) and how long each agent is allowed to execute, at any given time. The number of executing agents that can be dispatched at the same time is referred to as the dispatch concurrency level.

The DB2 workload management dispatcher has the following benefits:

- Easy to implement, requiring less time and effort than implementing an OS WLM such as AIX WLM or Linux WLM.
- Supports flexible CPU allocation throughout the normal daily ebb and flow of system use. This flexibility is accomplished through the provisioning of both permanent allocations that are enforced all the time (hard CPU shares and CPU limits), or dynamic allocations that are enforced only when demand exceeds capacity (soft CPU shares).
- Self-contained within the DB2 database manager such that setting CPU resource entitlements provides you with workload control that is effective across all platforms due to its independence from an OS WLM such as AIX WLM or Linux WLM.
- You can continue to use the OS WLM products as a workload control mechanism, but it is not necessary if the extra implementation complexity (for example, setting up AIX WLM on each member) or if the organizational strife

(for example, system administrator reluctance to implement or permit use of OS WLM) is a barrier. Alternatively, you can use the OS WLM products for monitoring purposes while relying on the DB2 workload management dispatcher for workload control.

More information

This section provides information about essential administration concepts, tasks, and usage scenarios for the following areas:

- DB2 workload management dispatcher
- Hard CPU shares
- Soft CPU shares
- CPU limit
- Minimum CPU utilization level to have service class considered as active
- Dispatch concurrency level
- Monitoring and tuning workload management dispatcher performance

Workload management dispatcher

The workload management dispatcher manages CPU resource entitlements for workloads running within the DB2 database manager. Details about its features and functionality are provided here.

Introduction

You can use the built-in DB2 workload management dispatcher to manage DB2 workloads by configuring CPU resource entitlements without the need for third-party workload management software. The dispatcher can control DB2-specific CPU resource consumption by means of CPU shares-based settings and CPU limit settings. Soft CPU shares represent an uncapped resource allocation and can be used to allow high-priority work to consume more than its allocated share when there are unused CPU resources. Hard CPU shares and CPU limits represent a capped CPU allocation that can be used to prevent low-priority work from impacting the execution of high-priority work. CPU limits can be used to strictly control the CPU that is consumed by a particular workload in order to provide isolation for other work running on the system, whereas hard CPU shares provide the additional flexibility of allowing low-priority work to consume unused CPU resources in the absence of a high-priority workload. This scenario might occur during off-peak business hours.

The sections that follow describe the features and functionality of the workload management dispatcher in more detail. A scenarios section helps to illustrate the workload management dispatcher features and functionality with usage examples.

Features and functionality

The workload management dispatcher infrastructure operates at the instance level in the DB2 database manager. However, at the database level, you specify the CPU resource entitlements using the CPU shares and CPU limit attributes that can be placed on a service class through the CREATE SERVICE CLASS and ALTER SERVICE CLASS statements.

As mentioned, the hard and soft CPU shares attributes have different conditions under which unused CPU resources, relinquished by a service class or a number of service classes, can be claimed by the remaining competing service classes.

However, both hard and soft CPU shares attributes have the same behavior when it comes to giving back those claimed CPU resources. For example, when a service class relinquishes some or all of its full share of CPU resources, those service classes that claimed the unused CPU resources must give back the CPU resources to the service class trying to retrieve its full share when it begins to increase its demand for CPU resources. This will lead to the full restoration of the user-specified CPU resource entitlement to the retrieving service class if the demand is present. Every second, a DB2 database manager scheduler thread evaluates the CPU resource utilization by work in progress and make adjustments to ensure, over time, that the dispatcher is providing the configured CPU shares and CPU limit allocations.

The workload management dispatcher operates by limiting both the number of executing agents simultaneously dispatched to the operating system (OS) and how long each agent is allowed to execute. The number of executing agents that can be dispatched at the same time is referred to as the dispatch concurrency level which you can set using the **wlm_disp_concur** database manager configuration parameter.

By default, the workload management dispatcher is not enabled. To control DB2 database manager-specific CPU resource entitlements, you must first enable the workload management dispatcher. To enable the workload management dispatcher, you must set the **wlm_dispatcher** database manager configuration parameter to YES (by default, this configuration parameter is set to NO). For complete details about how to enable the workload management dispatcher, see: “Enabling workload management dispatcher” on page 180.

When the workload management dispatcher is enabled, all work running in the user and maintenance service classes within the DB2 database manager is under the control of the dispatcher. Work running in the system service class cannot be configured for CPU resource control because critical DB2 subsystems that run in this service class are given maximum priority and are not subject to workload management dispatcher control. By default, once turned on, the dispatcher can manage CPU resources only by way of CPU limit settings. To allow the dispatcher to manage CPU resources using both CPU shares and CPU limits, you must set the **wlm_disp_cpu_shares** database manager configuration parameter to YES.

Before or after enabling the workload management dispatcher for the first time, you will want to monitor your workloads to determine the relative CPU resources that they consume. Based on the relative priority of the workloads, this information can help in formulating your decisions concerning the creation of service classes to which the work can be assigned, the type of CPU shares (hard or soft) to assign to particular service classes, the relative quantity of CPU shares to assign to each service class, and whether to use CPU limits.

Another consideration that gives you maximum flexibility to control the behavior of the DB2 database manager is the option to set the minimum percentage of CPU resource utilization for service classes to be considered active. After setting the **wlm_disp_min_util** database manager configuration parameter, service classes utilizing CPU resources equal to or greater than that minimum percentage are considered to be active on the host or logical partition (LPAR) and the CPU shares of the active service classes are factored into CPU resource entitlement calculations.

Through the workload management dispatcher, you can control the allocation of CPU resources between service classes on your system via the service class CPU shares attribute. The shares attribute represents the relative entitlement of CPU time that each service class receives compared to other service classes on the system. By allocating more CPU shares to one service class and less to another, you can control the amount of CPU resources allocated to each service class and provide better quality of service to one service class over another.

After having made the decision that the earlier enabled workload management dispatcher can best manage your strained CPU resources by using CPU shares along with CPU limits, you must enable CPU shares by setting the **wlm_disp_cpu_shares** database manager configuration parameter to YES. The default setting for this parameter is NO. You can set and adjust CPU shares and CPU limits by using the CREATE SERVICE CLASS and ALTER SERVICE CLASS statements.

Based on the number of CPU shares assigned to a service class, the workload management dispatcher calculates the proportion of the CPU resources that each service class is entitled to use. To determine the proportion of the CPU resources to which each service superclass is entitled, you can use the following formula to convert the number of CPU shares of a particular service superclass into a percentage of CPU resources allocated by the workload management dispatcher:

```
% CPU(superclass) = (Number of superclass shares /
 Total number of shares of all active superclasses) x 100
```

To determine the proportion of the CPU resources to which each service subclass is entitled, you can use the following formula to convert the number of CPU shares of a particular service subclass into a percentage of CPU resources allocated by the workload management dispatcher:

```
% CPU(subclass) = % CPU(superclass) x (Number of subclass shares /
 Total number of shares of all active subclasses in the superclass)
```

Note: The total number of CPU shares (both hard and soft) of all active superclasses are counted across all databases and all members on the host or LPAR.
For illustrative examples of CPU proportion calculations, see the "Usage scenarios" section.

Summary of CPU resource scheduling capabilities

The following table summarizes the features of the different CPU resource control attributes available for DB2 service classes managed by the workload management dispatcher.

Table 44. Summary of workload management dispatcher CPU resource scheduling capabilities

CPU resource control attribute	Usage of idle CPU resources in the same context	CPU resource entitlement limits are relative to other active service classes in the same context	CPU resource entitlement limits are fixed based on overall system CPU capacity	Control of CPU consumption at high CPU resource utilization	Control of CPU consumption at low CPU resource utilization	Usage notes
Soft shares	Y	Y	N	Y	N	Ideal for high-priority work to exploit any spare CPU resources available on the host or LPAR to maximize workload progress
Hard shares	N	Y	N	Y	Y	Ideal for ensuring work does not interfere with higher priority work which might be running on the host or LPAR in various amounts and intensity
CPU limits	N	N	Y	Y	Y	Ideal for sandboxing and enforcing consistent fixed CPU resource allocations between service classes, or limiting service class CPU resource consumption regardless of other work on the host or LPAR

Effects of work outside of workload management dispatcher control

A workload management dispatcher exists for each DB2 instance. It can only directly detect and manage DB2 work within its own instance. Any other work running on the same host or LPAR is not under the direct control of the dispatcher. The random nature of the CPU resource demands of work running outside of the

DB2 database manager means that while the CPU limits and the relative shares of CPU resources among work executing within DB2 can be enforced, at any given instant of time, the work managed by the dispatcher still needs to compete with work running outside its own DB2 instance and outside the dispatcher's direct control. Work that is neither detected nor managed by the workload management dispatcher includes the following:

- Work performed by applications or middleware products that perform a portion of their work outside of the DB2 database manager
- Work performed by entities executing in the DB2 system service class
- Work performed by other DB2 instances
- Non-DB2 work performed in fenced mode processes such as fenced stored procedures
- Non-DB2 work performed in trusted routines. Trusted procedures and user-defined functions (UDFs) are accounted for in dispatcher CPU resource scheduling, but the dispatcher is not able to limit CPU utilization when a trusted routine executes in user code for long periods of time.

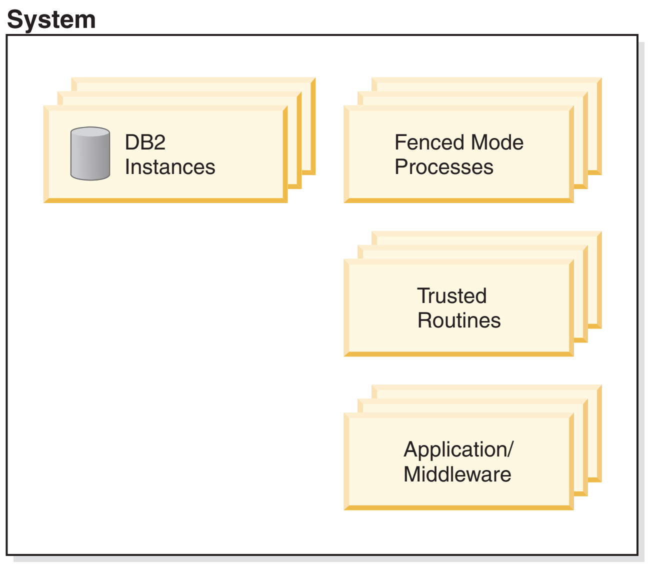


Figure 22. Example system diagram

Let's consider that you have a host or LPAR that runs only the DB2 database manager. You have created a database with service classes A and B and assigned a 50% share of the CPU resources to each service class. Assuming the overall host or LPAR makes full use of the CPU resources at all times, your measurements of total CPU utilization (%) over time looks similar to that shown in Figure 23 on page 166 panel A.

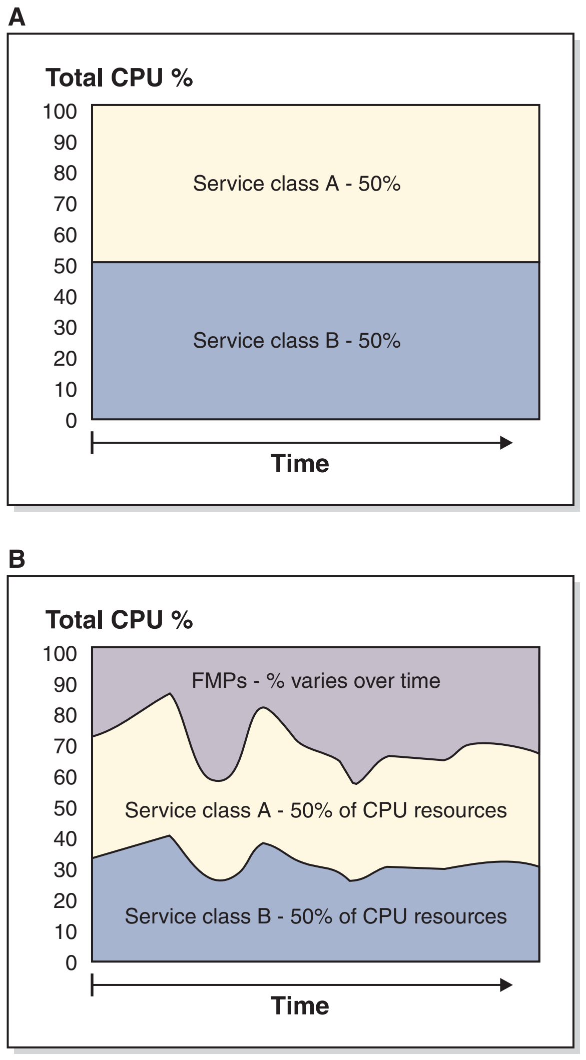


Figure 23. Total CPU utilization percentage

Now, let's consider what happens when fenced mode processes (FMPs) are executed on your host or LPAR. These processes are not under the control of the workload management dispatcher, so the amount of CPU resources they use varies randomly. However, out of the remaining CPU resources that the dispatcher can manage, service classes A and B each continue to get an equal 50% split of the leftover CPU resources, as shown in panel B.

Interactions between dispatcher and other service class settings

The following table summarizes how the workload management dispatcher settings on a service class (hard and soft CPU shares, and CPU limit) interact with other settings on the same service class.

Table 45. Interactions between dispatcher and other service class settings

Dispatcher service class setting	Other service class setting	Interaction
Hard and soft CPU shares, and CPU limit	Agent priority **Note:** Associating each DB2 service class with an agent priority, which controls the relative operating system priority of agents in the service class, has been deprecated and might be removed in a future release. Use the workload management dispatcher in place of the agent priority to control CPU consumption.	When the **`wlm_dispatcher`** database manager configuration parameter is set to `YES`, agent priority is ignored and CPU limits are activated. When the **`wlm_dispatcher`** parameter is set to `NO`, CPU limits are ignored and no longer override agent priority.
Hard and soft CPU shares, and CPU limit	Outbound correlator (OS WLM integration)	Hard and soft CPU shares, CPU limit, and OS WLM can all be active at the same time.
Hard and soft CPU shares, and CPU limit	Buffer pool priority	Hard and soft CPU shares, CPU limit, and buffer pool priority can all be active at the same time.
Hard and soft CPU shares, and CPU limit	Prefetch priority	Hard and soft CPU shares, CPU limit, and prefetch priority can all be active at the same time.

Interaction between dispatcher settings and thresholds with a REMAP action

Some workload management thresholds support a REMAP ACTIVITY action to move executing work from one service subclass to another within the same service superclass. When work moves to a service subclass with a different CPU share or CPU limit than the service subclass it moved from, the CPU share and CPU limit settings of the service subclass to which the work moves are applied.

Comparison between workload management dispatcher and workload management concurrency thresholds

Although you can control workload scheduling and resource consumption using both the workload management dispatcher and concurrency thresholds, knowing the differences in their degree of workload control and benefits will help you to decide when to apply one or both in your environment. The following table compares their abilities to control CPU resources.

Table 46. Comparison of CPU resource control abilities between workload management dispatcher and workload management concurrency thresholds

Workload management dispatcher	DB2 workload management concurrency thresholds
You can directly control CPU allocations within the DB2 database manager after an activity begins consuming CPU resources.	You can indirectly control both the consumption of CPU and other resources, such as memory, by limiting the number of connections or activities that are allowed to execute at the same time.
You can configure relative allocations of soft and hard shares of CPU resources to service classes, in addition to absolute limits of CPU consumption by a single service class.	You can impose an absolute limit on the concurrency of executing activities or open connections for a service class, but you cannot specify any kind of relative CPU allocations.

Comparison between workload management dispatcher and OS WLMs (AIX WLM and Linux WLM)

The workload management dispatcher can be used together with an OS WLM (AIX WLM or Linux WLM) in certain situations to provide even greater control. The following are some examples of circumstances in which both the workload management dispatcher and an OS WLM can work together:

- OS WLMs often have OS-level monitoring that complements the workload management dispatcher monitoring capabilities.
- OS WLMs can manage all applications on the system, including the DBMS. The workload management dispatcher can provide DB2-specific dispatching, while the OS WLM manages all the other applications on the system.
- Do not attempt to control CPU resource allocations to individual service classes with both the OS WLM and the workload management dispatcher at the same time. You can integrate an OS WLM at the service class level for monitoring purposes when the workload management dispatcher is enabled. You can also integrate an OS WLM to control external applications, or the overall CPU resources allocated to a DB2 instance, or both.

Table 47. Comparison of abilities between workload management dispatcher and OS WLM

Workload management dispatcher	OS WLM
A single solution that works across all platforms.	An OS WLM is specific to each OS. Each has its own user interface and its own limitations.
You can control CPU allocations within the DB2 database manager without the need for any OS-specific integration and/or set up – a DBA can manage these settings without requiring root access to the system.	An OS WLM often requires root privilege for configuration.
You can leverage database-specific knowledge when making CPU resource scheduling decisions that would otherwise not be possible with OS-level facilities.	An OS WLM treats the DB2 database manager as just another application and, therefore, cannot use database-specific knowledge to make CPU resource scheduling decisions.
In multiple member environments, all members can be configured with one command. However, the result is that you cannot have a different configuration at each member.	In multiple member environments, an OS WLM must be configured at every member. You can have a different configuration at each member.

Table 47. Comparison of abilities between workload management dispatcher and OS WLM (continued)

Workload management dispatcher	OS WLM
Controls the use of CPU resources by only DB2 work running in the user and maintenance service classes within the scope of a single DB2 instance. The dispatcher cannot control the use of CPU resources by applications executing external to the DB2 instance.	An OS WLM can fully control CPU resources on the entire system.
CPU resource control is accomplished through both soft and hard CPU shares.	OS WLM solutions on AIX and Linux do not currently provide an equivalent of the DB2 hard CPU shares.

Comparison between workload management dispatcher and agent priority

Workload control using agent priority can be used. The ability of agent priority to control CPU resources is compared with that of the workload management dispatcher in the following table.

Table 48. Comparison of CPU resource control abilities between workload management dispatcher and agent priority

Workload management dispatcher	Agent priority
A method for consistently and accurately allocating or imposing limits on the use of CPU resources between service classes.	Agent priority cannot impose limits on the use of CPU resources by a service class. Agent priority can only give a service class priority over another without any granular control over CPU resource entitlements.

Note: Associating each DB2 service class with an agent priority, which controls the relative operating system priority of agents in the service class, has been deprecated and might be removed in a future release. Use the workload management dispatcher in place of the agent priority to control CPU consumption.

Usage scenarios

Scenario 1: CPU entitlement calculations

Figure 24 on page 170 shows the data server configured as illustrated. For illustration purposes to help describe the basic concepts, assume that there is negligible work running in the default user, maintenance, and system service classes. At the start of the scenario, consider that there is enough work executing in the user service superclasses A, B, and C to use the full CPU resource entitlements for those service classes. For the following scenario, there is only one DB2 instance with one database and only one logical member on this host or LPAR.

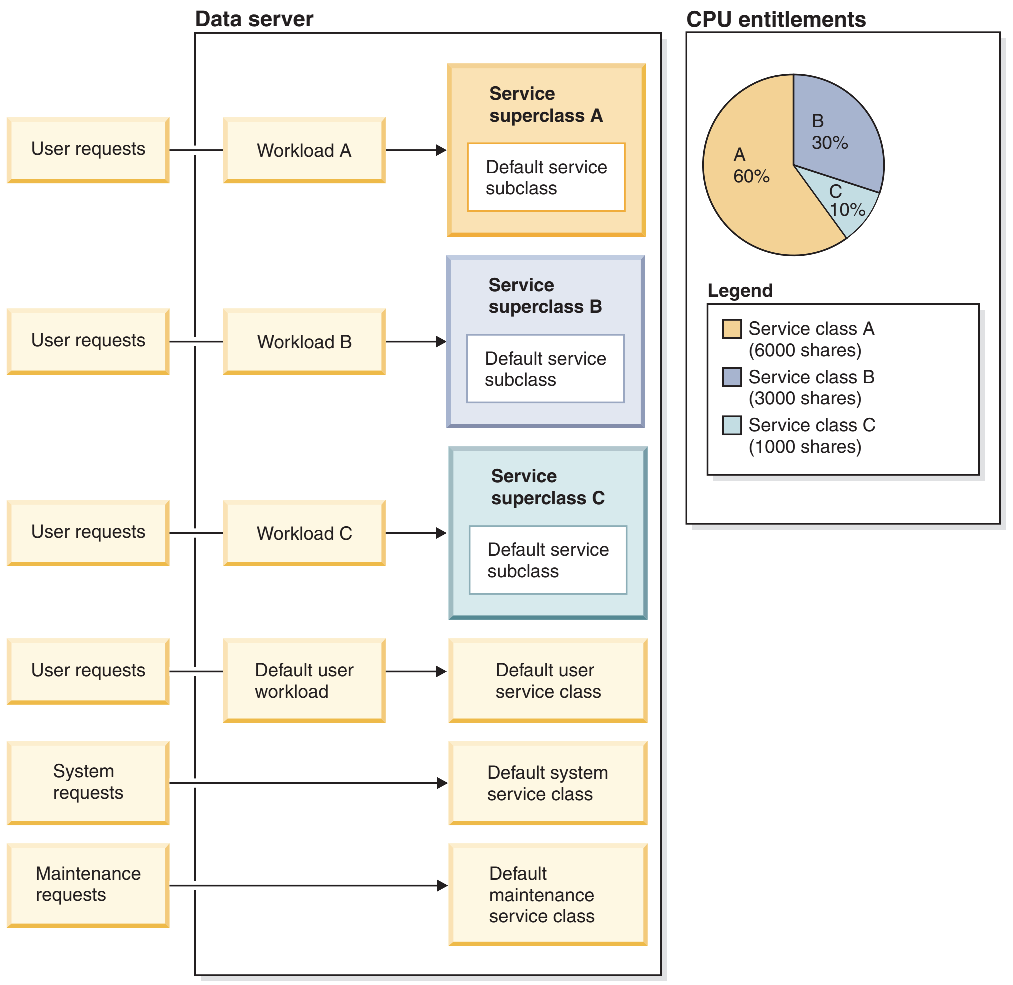


Figure 24. Data server configuration

As shown in Figure 24, the CPU entitlement percentage for each of the service superclasses is calculated as follows:

- Service superclass A has 60%

  `(6000 / (6000 + 3000 + 1000)) x 100`
- Service superclass B has 30%

  `(3000 / (6000 + 3000 + 1000)) x 100`
- Service superclass C has 10%

  `(1000 / (6000 + 3000 + 1000)) x 100`

CPU shares can be assigned at both the service superclass and service subclass levels. If you do not specify CPU shares when creating a service superclass or service subclass, the DB2 database manager assigns a default of 1000 hard CPU shares to such service classes. At the superclass level, the CPU shares value represents how the system CPU resources are divided among DB2 service superclasses. At the subclass level, the CPU shares value represents the division of the CPU resources available to a particular superclass among its active subclasses.

Scenario 2: Workload management dispatcher operates at instance level; service classes operate at database level

The workload management dispatcher operates at the instance level, but the configurations (CPU shares and CPU limits) that the dispatcher uses to allocate CPU resources are placed on individual service superclasses and service subclasses within individual databases. When multiple databases exist within the same instance, the sum of the CPU share values within service superclasses on each database determines the relative allocation of the CPU resources that each database receives. For example, there are two databases in the same instance, database A and database B, each database has two service superclasses (SC1 and SC2), as shown in Figure 25 on page 172 panel A.

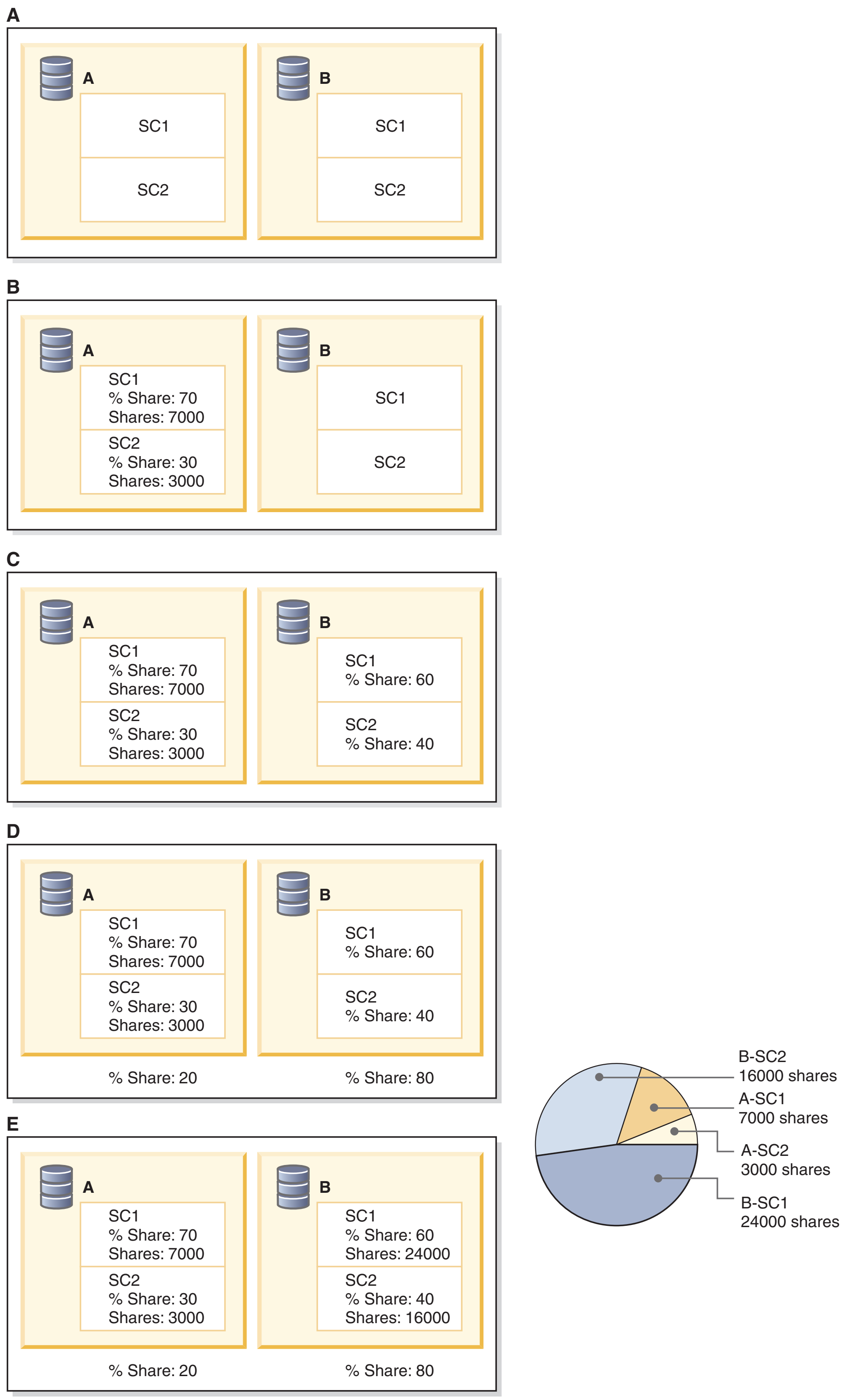


Figure 25. CPU shares allocations to service classes for two databases in one instance

In this example scenario, we want a 70/30 percentage split of CPU resources in database A which is configured using soft CPU shares of 7000 and 3000 for SC1 and SC2, respectively, as shown in panel B. In database B, we want a 60/40 percentage split of CPU resources for SC1 and SC2, respectively, as shown in panel C.

Before deciding on how this 60/40 percentage split translates into CPU shares in the two service superclasses for database B, we must decide what are the required relative CPU resource entitlements between databases A and B. The work running in database B is much more important than that running in database A. Therefore, we want database B to have a CPU entitlement of 80% and database A to have 20%.

The sum of the CPU shares on database A is 10,000. These 10,000 CPU shares represent 20% of the total CPU shares across the two databases, we require 50,000 CPU shares in total to represent 100% of the total CPU resources. Therefore, database B must be assigned 80% of those 50,000 CPU shares, resulting in 40,000 CPU shares. To obtain the 60/40 percentage split between the two superclasses of database B, service superclass SC1 receives 60% of the 40,000 total CPU shares assigned in database B, resulting in 24,000 CPU shares. Service superclass SC2 receives 40% of the 40,000 total CPU shares assigned in database B, resulting in 16,000 CPU shares.

The pie chart shows the CPU shares assignments that achieved the percentage CPU resource allocations that we wanted.

Scenario 3: Favor one workload over another at high CPU utilization and protect favored workload at low CPU utilization

In this example usage scenario, the aim is to manage the quality of service for multiple workloads while simultaneously maximizing the CPU utilization on the system. However, in addition to experiencing contention for the CPU resources, the workloads in this scenario experience contention for other resources. Allocating unused CPU resources to some workloads when competing workloads, not consuming their full CPU entitlement, are still present, can cause a degradation in performance due to CPU cache contention, I/O contention, or other secondary effects.

In this scenario, there is a need to protect the favored workload from unfavored workloads, despite the possibility that the CPU resources are not fully utilized. The under-utilized CPU resources can result when unfavored workloads are limited and the favored workload is active, but not using its full CPU entitlement. We can accomplish protecting the favored workload by assigning hard CPU shares on the unfavored workloads and assigning soft CPU shares on the favored workload.

Again, let's use two workloads: 'Favored' and 'Other'. The 'Favored' workload is to have 70% of the CPU resources when running at the same time as the 'Other' workload and 100% when the 'Other' workload is not present. The 'Other' workload is to have 30% of the CPU resources when running at the same time as the 'Favored' workload and 100% when the 'Favored' workload is not present. This is similar to Scenario 3, except that the overall CPU utilization drops below 100% on occasion.

The following steps show how to configure DB2 workload management to achieve the goals listed previously:

1. Create the 'Favored' and 'Other' service superclasses and assign CPU shares so that the 70/30 CPU entitlement proportion is met. CPU shares can be specified as 7 and 3, 14 and 6, or any other combination that achieves the 70%/30% CPU

entitlement ratio. In the following example, 7000 soft CPU shares are assigned to the 'Favored' service class and 3000 hard CPU shares are assigned to the 'Other' service class:

```
create service class favored soft cpu shares 7000
create service class other hard cpu shares 3000
```

2. Create the 'Favored' and 'Other' workloads as shown in the following example:

```
create workload favored appl_name('favoredapp') service class favored
create workload other appl_name('otherapp') service class other
```

As a result, the system looks like the following:

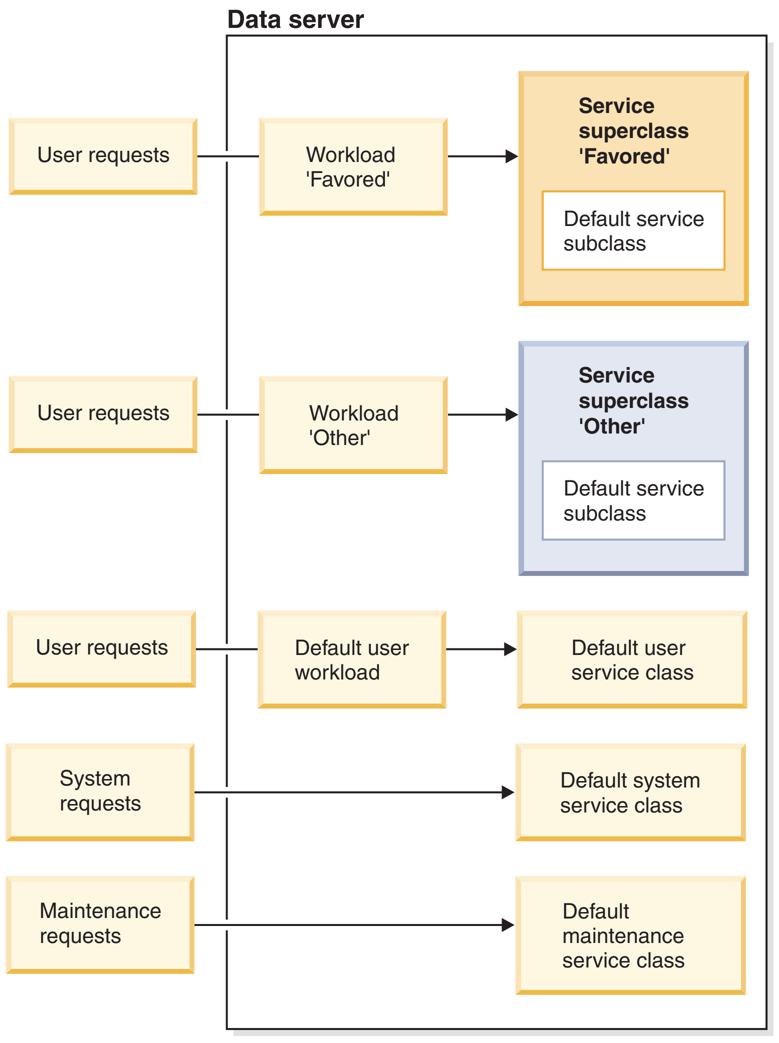


Figure 26. Data server configuration

For simplicity, assume only a negligible amount of work is running in the service classes other than 'Favored' and 'Other'.

3. Measure whether the desired CPU share goals are being achieved. The system can be in one of several states in terms of its workload:
   a. 100% CPU utilization
      1) Work is executing in both the 'Favored' workload and the 'Other' workload

The measured CPU utilization is 70% for the 'Favored' service class and 30% for the 'Other' service class.

2) Work is executing in only the 'Favored' workload

   The measured CPU utilization is 100% for the 'Favored' service class and 0% for the 'Other' service class.

3) Work is executing in only the 'Other' workload

   The measured CPU utilization is 0% for the 'Favored' service class and 100% for the 'Other' service class.

b. A service class uses less than its CPU entitlement

   1) Work is executing in both the 'Favored' workload and the 'Other' workload. The 'Favored' workload is using 50% instead of the full 70% that comes from its CPU entitlement.

      The measured CPU utilization of the 'Favored' workload is 50%. The 'Other' workload continues to use 30% because its CPU shares are hard. The total CPU utilization is 80%.

   2) Work is executing in both the 'Favored' workload and the 'Other' workload. The 'Other' workload is using 10% instead of the full 30% that comes from its CPU entitlement.

      Due to its CPU shares being soft, the measured CPU utilization of the 'Favored' service class increases from 70% to 90%, claiming the unused 20% relinquished by the 'Other' service class. The CPU utilization of the 'Other' service class is 10%. The total CPU utilization is 100%.

   3) Work is executing in only the 'Favored' workload and it uses all of its CPU entitlement

      Due to the absence of work running in the 'Other' service class, the 'Favored' service class can use both its own CPU entitlement of 70% and the unused 30% of CPU resources relinquished by the 'Other' service class. The total CPU utilization is 100%.

   4) Work is executing in only the 'Other' workload and it uses all of its CPU entitlement

      Due to the absence of work running in the 'Favored' service class, the 'Other' service class can use both its own CPU entitlement of 30% and the unused 70% of CPU resources relinquished by the 'Favored' service class. The total CPU utilization is 100%.

Scenario 4: Create a sandbox to achieve consistency, even at the expense of some CPU resources becoming idle

In this example usage scenario, a favored workload never consumes more than its fixed proportion of CPU resources, regardless of the availability of unused CPU resources.

Let's use two workloads: 'Favored' and 'Other'. The 'Favored' workload is to have a maximum of 70% of the CPU resources at any time, regardless of the availability of unused CPU resources. The 'Other' workload is to have a maximum of 30% of the CPU resources at any time, regardless of the availability of unused CPU resources.

The following steps show how to configure DB2 workload management to achieve the goals listed previously:

1. Create the 'Favored' and 'Other' service classes and assign each with a CPU limit so that the maximum 70% and 30% of CPU resources is enforced for the 'Favored' and the 'Other' workloads, respectively. In the following example,

CPU limits must be specified as a number between 1 and 100, which represents the maximum percentage of CPU utilization for that service class:

```
create service class favored cpu limit 7000
create service class other cpu limit 3000
```

2. Create the 'Favored' and 'Other' workloads as shown in the following example:

   ```
   create workload favored appl_name('favoredapp') service class favored
   create workload other appl_name('otherapp') service class other
   ```

   As a result, the system looks like that in Figure 26 on page 174.

   For simplicity, assume only a negligible amount of work is running in the service classes other than 'Favored' and 'Other'.
3. Measure whether the desired CPU limits are successfully being enforced. The system can be in one of several states in terms of its workload:
   a. 100% CPU utilization
      1) Work is executing in both the 'Favored' workload and the 'Other' workload

         The measured CPU utilization is 70% for the 'Favored' service class and 30% for the 'Other' service class.
   b. One or more service classes uses less than its CPU limit
      1) Work is executing in both the 'Favored' workload and the 'Other' workload. The 'Favored' workload is using 50% instead of the full 70% that comes from its CPU limit entitlement.

         The measured CPU utilization of the 'Favored' workload is 50%. The 'Other' workload continues to use 30% because that is the maximum CPU limit entitlement. The total CPU utilization is 80%.
      2) Work is executing in both the 'Favored' workload and the 'Other' workload. The 'Other' workload is using 10% instead of the full 30% that comes from its CPU limit entitlement.

         Due to its CPU limit that stipulates a maximum of 70% CPU utilization, the measured CPU utilization of the 'Favored' service class remains at 70%. The unused 20% of CPU resources relinquished by the 'Other' service class remains unclaimed. The CPU utilization of the 'Other' service class is 10%. The total CPU utilization is 80%.
      3) Work is executing in only the 'Favored' workload and it is using the maximum amount of CPU resources as stipulated by its CPU limit

         Due to its CPU limit that stipulates a maximum of 70% CPU utilization, the measured CPU utilization of the 'Favored' service class remains at 70%. The unused 30% of CPU resources relinquished by the 'Other' service class remains unclaimed. The CPU utilization of the 'Other' service class is 0%. The total CPU utilization is 70%.
      4) Work is executing in only the 'Other' workload and it is using the maximum amount of CPU resources as stipulated by its CPU limit

         Due to its CPU limit that stipulates a maximum of 30% CPU utilization, the measured CPU utilization of the 'Other' service class remains at 30%. The unused 70% of CPU resources relinquished by the 'Favored' service class remains unclaimed. The CPU utilization of the 'Favored' service class is 0%. The total CPU utilization is 30%.

Scenario 5: Needing to divide workloads by user and still favor one type of work over another for a given user

In the preceding scenarios, service classes were used to control the allocation of CPU resources between different workloads based on business priorities. In some cases, it might be desirable to both control the share of resources among workloads based on business priorities, and prioritize short-running work over long-running work to improve overall throughput or response times.

In this example usage scenario, a CEO and all of the one thousand other employees access a database through one application named mybizapp. Our aim is to give the CEO alone a full 10% share of the CPU resources and the remaining 90% of the CPU resources is used by the one thousand other users that access the database. To accomplish this goal, create a service superclass for the CEO (ceo_sc). Then, define a workload to map the CEO to her service superclass, as shown in the following examples:

```
create service class ceo_sc soft cpu shares 1000
create workload ceo_wl
  applname('mybizapp')
  session_user('ceo')
  service class ceo_sc
```

Create a service superclass for all of the other users (mybizapp_sc). Then, define a workload (mybizapp_wl) to map all of the other users of the mybizapp application to the newly created service superclass mybizapp_sc, as shown in the following example:

```
create service class mybizapp_sc hard cpu shares 9000
create workload mybizapp_wl
  applname('mybizapp')
  service class mybizapp_sc
```

Within the workload of the mybizapp application, there are both high-cost and low-cost queries. The business organization has determined that low-cost queries, costing less than 10,000 timerons, are generally higher in priority than high-cost queries, costing more than 10,000 timerons. Therefore, low-cost queries are to be given a greater share of the CPU resources than high-cost queries, specifically by a 2:1 ratio. To accomplish this goal, create two service subclasses (lowcost_ssc and highcost_ssc) within the mybizapp_sc service superclass and assign soft CPU shares in a ratio of 2:1, as shown in the following example:

```
create service class lowcost_ssc under mybizapp_sc soft cpu shares 2000
create service class highcost_ssc under mybizapp_sc soft cpu shares 1000
```

The 2:1 ratio of soft CPU shares determines how much of the 90% of the CPU resources assigned to the mybizapp_sc service superclass is allocated to low-cost queries and how much is allocated to high-cost queries.

Create a work class set (splitbycost_wcs) and work action set (mybizapp_was) to route low-cost queries to the lowcost_ssc service subclass and high-cost queries to the highcost_ssc service subclass, as shown in the following examples:

```
create work class set splitbycost_wcs
 (work class lowcost_wc work type dml for timeroncost from 0 to 10000,
 work class highcost_wc work type dml for timeroncost from 10001)
```

```
create work action set mybizapp_was for service class mybizapp_sc
 using work class set splitbycost_wcs
 (work action maplowcost_wa on work class lowcost_wc map activity
 to lowcost_ssc, work action maphighcost_wa on work class highcost_wc
 map activity to highcost_ssc)
```

When work is executing in each of the service classes and consuming its full CPU resource entitlement, the previous configurations result in a division of the CPU resources, as shown in the following figure:

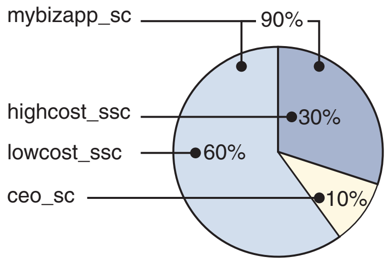


Figure 27. CPU resource entitlements

The `ceo_sc` service superclass has 1000 CPU shares out of 10,000, resulting in a CPU resource entitlement of 10%. The `mybizapp_sc` service superclass has 9000 CPU shares out of 10,000, resulting in a CPU resource entitlement of 90%. Within the 90% of the `mybizapp_sc` service superclass CPU resource entitlement, its `lowcost_ssc` service subclass has 2 shares out of 3, resulting in a CPU resource entitlement of 66.7% of the CPU resources of its service superclass, or 60% of the total CPU resources. The `highcost_ssc` service subclass has 1 share out of 3, resulting in a CPU resource entitlement of 33.3% of the CPU resources of its superclass, or 30% of the total CPU resources.

More information

Complete details are provided about the following subjects:
- Hard CPU shares, see: "Hard CPU shares" on page 181.
- Soft CPU shares, see: "Soft CPU shares" on page 190.
- CPU limit, see: "CPU limit" on page 194.
- Minimum CPU utilization level for a service class to be considered active, see: "Minimum CPU resource utilization for service class to be considered active" on page 210.
- Dispatch concurrency level, see: "Dispatch concurrency level" on page 213.
- Monitoring and tuning workload management dispatcher performance, see: "Monitoring and tuning workload management dispatcher performance" on page 215.

Workload management dispatcher behavior in multimember environments

When the workload management dispatcher is enabled on multimember DB2 instances, CPU resource scheduling operates across all of the members on a given host. Note that the workload management dispatcher also supports shared LPAR (micropartition) environments on AIX.

Multimember database environments

On multimember DB2 instances, the dispatcher behaves in the following ways:
- The relative quantity of CPU shares are evaluated and CPU resources are allocated across all members in the instance based on the work that is active in that instance on that host or LPAR as a whole. For example, let's consider a two member database with work being executed in two service classes, A and B. Service class A is assigned 3500 soft CPU shares and service class B is assigned 6500 soft CPU shares. The CPU utilization for the entire host or LPAR is 35% for service class A and 65% for service class B despite the possibility that relatively

more work is being executed on one member than the other. The workload management dispatcher looks across both members when making its decisions regarding which service class should be getting more CPU resources at any given moment.

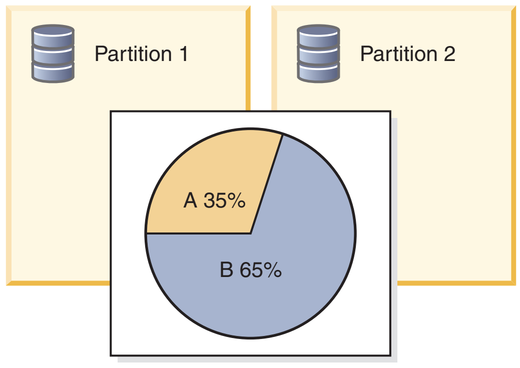


Figure 28. Multimember database environments: Soft CPU shares allocations pie chart across 2 database members

- The value of the **wlm_disp_concur** database manager configuration parameter applies to each host or LPAR. In multimember databases, the dispatch concurrency level specified by the **wlm_disp_concur** configuration parameter is applied across all of the members.
- For multimember databases, CPU limits are enforced on a per host or LPAR basis – when multiple members are used, each partition is allowed to use all of a specified CPU limit as long as the sum across all members is less than or equal to the CPU limit. If the CPU limit on the single service class A is 35% and there are 2 members, then member 1 can use up to 35% if the sum of the CPU utilization across member 1 and 2 does not exceed 35%.

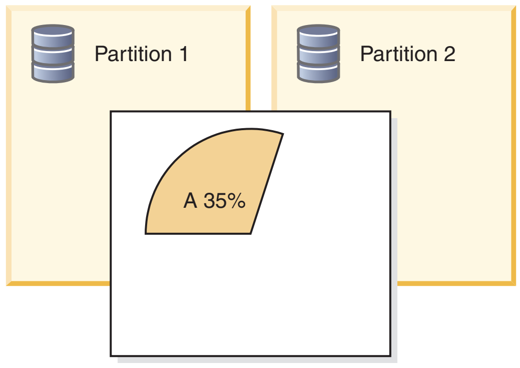


Figure 29. Multimember database environments: CPU limit pie chart across two database members

Micropartition (shared LPAR) environments

The workload management dispatcher supports micropartition environments in AIX. In micropartition environments, the percentage CPU utilization for both controls and monitoring in the workload management dispatcher is computed relative to the CPU resources allocated to the LPAR by the operating system or hypervisor over the most recent dispatcher CPU resource scheduling cycle, using the entitled (guaranteed) CPU resources for the LPAR as a baseline level. In cases when the CPU resource allocated to the LPAR is greater than the entitled CPU resources, the dispatcher computes the CPU utilization relative to the greater amount, and when the CPU resource allocation is less than the entitled CPU resources, the dispatcher computes the CPU utilization relative to the entitled CPU resources.

Note: The workload management dispatcher behavior is consistent with the way AIX WLM performs its calculations. For dedicated LPARs on AIX, and for all non-AIX environments, the CPU utilization is calculated relative to the full CPU capacity of the physical cores available to the DB2 database manager.

Enabling workload management dispatcher

To enable the DB2 workload management dispatcher, set the value of the **wlm_dispatcher** database manager configuration parameter to YES. The workload management dispatcher manages CPU resources allocated to DB2 user and maintenance service classes.

Procedure

To enable workload management dispatcher by using the command line processor (CLP):

1. Attach to your DB2 instance.
   ```
   ATTACH TO instance-name
   ```
2. Issue the **UPDATE DATABASE MANAGER CONFIGURATION** (or **UPDATE DBM CFG**) command. Set the value of the **wlm_dispatcher** database manager configuration parameter to YES.
   ```
   UPDATE DBM CFG USING wlm_dispatcher yes
   ```
3. Optional: Detach from your DB2 instance.
   ```
   DETACH
   ```

Results

The workload management dispatcher is enabled. You can now specify CPU limit allocations of CPU resources to DB2 service classes.

What to do next

After having enabled the workload management dispatcher to manage CPU resources, you must consider completing the following tasks:

- Create or alter a service class and configure the CPU limit by using the CREATE SERVICE CLASS or ALTER SERVICE CLASS statement. See: “Setting a CPU limit” on page 209.
- Enable hard and soft CPU shares by configuring the **wlm_disp_cpu_shares** database manager configuration parameter. See step 1 in: “Enabling and setting soft CPU shares” on page 193.
- Create or alter a service class and configure a hard CPU share by using the CREATE SERVICE CLASS or ALTER SERVICE CLASS statement. See: “Enabling and setting hard CPU shares” on page 188.
- Create or alter a service class and configure a soft CPU share by using the CREATE SERVICE CLASS or ALTER SERVICE CLASS statement. See: “Enabling and setting soft CPU shares” on page 193.
- Set the minimum CPU utilization percentage for workload management dispatcher to consider service classes to be active by configuring the

wlm_disp_min_util database manager configuration parameter. See: "Setting minimum CPU resource utilization for service class to be considered active" on page 212.

- Set the dispatch concurrency level by configuring the **wlm_disp_concur** database manager configuration parameter. See: "Setting dispatch concurrency level" on page 214.

Ensuring maximum DB2 workload management dispatcher scheduling accuracy

To ensure maximum scheduling accuracy for the workload management dispatcher, the DB2 database manager attempts to assign realtime priorities to the **db2wlmt** timer thread and the **db2wlmtm** scheduling threads. For assignment of such priorities to succeed, certain permissions need to be granted to the DB2 database manager, depending on the operating system.

Procedure

Without the ability to assign realtime priorities to the timer and scheduling threads, the DB2 workload management dispatcher is still able to prioritize work, but not as accurately or optimally as it would otherwise. The following tasks, to ensure maximum scheduling accuracy for the workload management dispatcher, are listed according to operating system. Select the operating system that pertains to you and then follow the given instructions.

- On AIX operating systems, the instance owner must have CAP_NUMA_ATTACH and CAP_PROPAGATE capabilities to set a higher relative priority for agents in a service class using AGENT PRIORITY. To grant these capabilities, logon as `root` and run the following command:

  ```
  chuser capabilities=CAP_NUMA_ATTACH,CAP_PROPAGATE
  ```

- On Solaris 10 or higher, the instance owner must have the `proc_priocntl` privilege to set a higher relative priority for agents in a service class using AGENT PRIORITY. To grant this privilege, logon as `root` and run the following command:

  ```
  usermod -K defaultpriv=basic,proc_priocntl db2user
  ```

  In this example, `proc_priocntl` is added to the default privilege set of user `db2user`.

  Moreover, when the DB2 database manager is running in a non-global zone of Solaris, the `proc_priocntl` privilege must be added to the limit privilege set of the zone. To grant this privilege to the zone, logon as `root` and run the following command:

  ```
  global# zonecfg -z db2zone
  zonecfg:db2zone> set limitpriv="default,proc_priocntl"
  ```

  In this example, `proc_priocntl` is added to the limit privilege set of the zone `db2zone`.

- On Solaris 9, there is no facility for the DB2 database manager to raise the relative priority of threads. Upgrade to Solaris 10 or higher to take advantage of this feature.

Hard CPU shares

The DB2 workload management dispatcher can manage CPU resources using shares-based entitlements that are assigned to service classes. Hard CPU shares, when assigned to a service class containing work viewed by the administrator as high impact or lower priority, prevents that service class from consuming more than its share of CPU resources whenever there is work in other service classes running on the system.

Introduction

Hard CPU shares can be assigned to any user and maintenance service class, but not to the system service class. After enabling the workload management dispatcher, monitoring your existing workloads to determine the extent of CPU resource consumption, and enabling the CPU shares attribute for service classes, you can assign hard CPU shares to the service classes that you consider to be running lower-priority or high-impact work. Using hard CPU shares ensures that these service classes will have their CPU consumption limited in the presence of other workloads, both limiting their impacts on the system, and ensuring that the remaining CPU is reserved for other higher priority work.

The sections that follow describe the features and functionality of the hard CPU shares in more detail. A usage scenarios section helps to illustrate the hard CPU shares features and functionality with usage examples.

Features and functionality

When the host or logical partition (LPAR) is running at 100% CPU utilization, the allocation of CPU resources between service classes simply reflects their relative share percentages. On the other hand, when the host or LPAR begins to run below full CPU utilization, the reallocation of CPU resources is complex and dependent on whether the CPU shares attribute on each active service class is set to soft or hard CPU shares.

A service class with hard CPU shares assigned cannot exceed its CPU resource entitlement, indicated by its CPU shares configuration, to consume any unused CPU resources that become available on the host or LPAR. The workload management dispatcher always respects the CPU resource entitlement, determined by the relative amount of hard CPU shares that were assigned, when work is still running in competing service superclasses or running in competing service subclasses within the same service superclass. If competing workloads are not present or a competing workload temporarily becomes totally idle, service classes with hard CPU shares are able to claim unused CPU resources.

The hard CPU shares setting is most effective when used in cases where you want to strictly enforce the CPU resource entitlement on a service class to prevent work running in this service class from interrupting more important work running on the host or LPAR. Assign hard CPU shares to service classes that run complex or intensive queries that might otherwise degrade the performance of higher priority work due to contention on resources such as I/O, bufferpool, or CPU caches.

To enable the CPU shares attribute, you must set the value of the **wlm_disp_cpu_shares** database manager configuration parameter to YES. The default setting for this parameter is NO. After this parameter has been enabled, all existing and newly created service classes are assigned 1000 hard CPU shares by default to initially ensure an equal distribution of CPU resources. You can assign and adjust hard CPU shares by using the CREATE SERVICE CLASS and ALTER SERVICE CLASS statements. For complete details about how to enable and set hard CPU shares, see: “Enabling and setting hard CPU shares” on page 188.

Based on the number of CPU shares assigned to a service class, the workload management dispatcher calculates the proportion of the CPU resources that each service class is entitled to use. To determine the proportion of the CPU resources to which each service superclass is entitled, you can use the following formula to convert the number of CPU shares of a particular service superclass into a percentage of CPU resources allocated by the workload management dispatcher:

```
% CPU(superclass) = (Number of superclass shares /
  Total number of shares of all active superclasses) x 100
```

To determine the proportion of the CPU resources to which each service subclass is entitled, you can use the following formula to convert the number of CPU shares of a particular service subclass into a percentage of CPU resources allocated by the workload management dispatcher:

```
% CPU(subclass) = % CPU(superclass) x (Number of subclass shares /
  Total number of shares of all active subclasses in the superclass)
```

Note: The total number of CPU shares (both hard and soft) of all active superclasses are counted across all databases and all members on the host or LPAR.

Usage scenarios

Scenario 1

In Figure 30 on page 184 panel A, service class B has been assigned hard CPU shares and service classes A and C have been assigned soft CPU shares, the amounts of which are described in the figure legend. The pie chart represents the proportion of allocated CPU resources to which each of these active service classes are entitled and each service class is using their complete share of the CPU resources, therefore summing to 100% CPU utilization in this example. In panel B, service class A does not have enough work to fully use its CPU entitlement, dropping from 60% to 50% CPU utilization. The unused 10% of the CPU resources, temporarily relinquished by service class A, can be claimed by only the competing service class C based on its soft CPU shares assignment. Service class B cannot exceed its CPU resource allocation of 30% in this example because it has hard CPU shares assigned and there is enough work running in service classes A and C for those service classes to be considered active by the dispatcher. Panel C shows the total reallocation of CPU resources to service class C, increasing from 10% to 20% of the total available CPU resources.

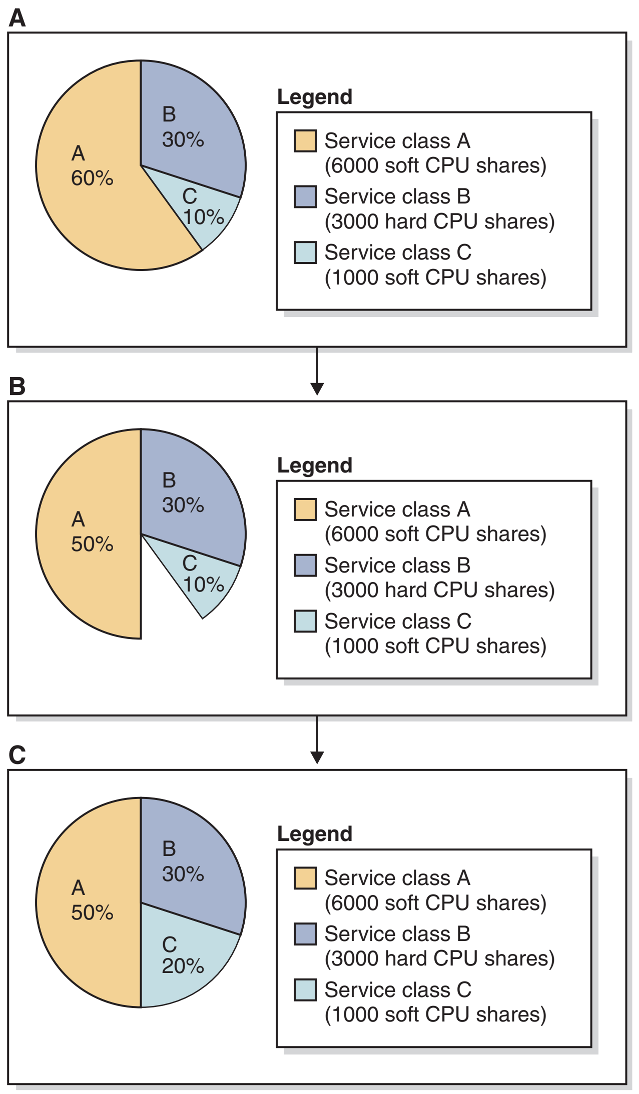


Figure 30. Hard and soft CPU shares pie charts: Scenario 1

If service class A experiences an increase in its workload, it effectively increases its demand on CPU resources. In this circumstance, service class C immediately relinquishes to service class A all of the claimed CPU resources, thereby restoring the state of CPU resource allocations to that which is depicted by the pie chart in panel A.

Note: When service classes compete to consume CPU resources, individual service class requests for CPU resources is handled by the workload management dispatcher in a first-come-first-served fashion. Due to typically frequent and short-lived requests for CPU resources on a busy host or LPAR, the reallocation of unused CPU resources over time results in a smooth redistribution of CPU resources which is in proportion to the relative CPU shares assignments.

Scenario 2

The use of hard shares can result in some portion of the CPU resources to remain under-utilized on the database server. Under-used CPU resources can occur in cases where the other service classes were not running a large enough workload to fully use their CPU resource allocations. Under-used CPU resources are desirable in cases where the hard shares are being used to limit an intensive workload that might otherwise interfere with the progress of other service classes, even when the CPU resources are below full utilization. This circumstance generally occurs due to contention on resources such as I/O or the CPU cache.

In Figure 31 on page 186 panel A, service classes B and C have been assigned hard CPU shares and service class A has been assigned soft CPU shares, the amounts of which are described in the figure legend. The pie chart represents the proportion of allocated CPU resources to which each of these active service classes are entitled and each service class is using their complete share of the CPU resources, therefore summing to 100% CPU utilization in this example. In panel B, service class A does not have enough work to fully use its CPU entitlement, dropping from 60% to 50% CPU utilization. The unused 10% of the CPU resources, temporarily relinquished by service class A, cannot be claimed by the competing service classes B and C based on their hard CPU shares assignment. Service classes B and C cannot exceed their CPU resource allocations of 30% and 10%, respectively, in this example because they both have hard CPU shares assigned and there is enough work running in service class A for it to be considered active by the dispatcher (CPU utilization falls below the level configured for the **wlm_disp_min_util** database manager configuration parameter; default is 5%). Panel C shows that the unused CPU resources are not reallocated and the CPU resources remain under-utilized in this scenario.

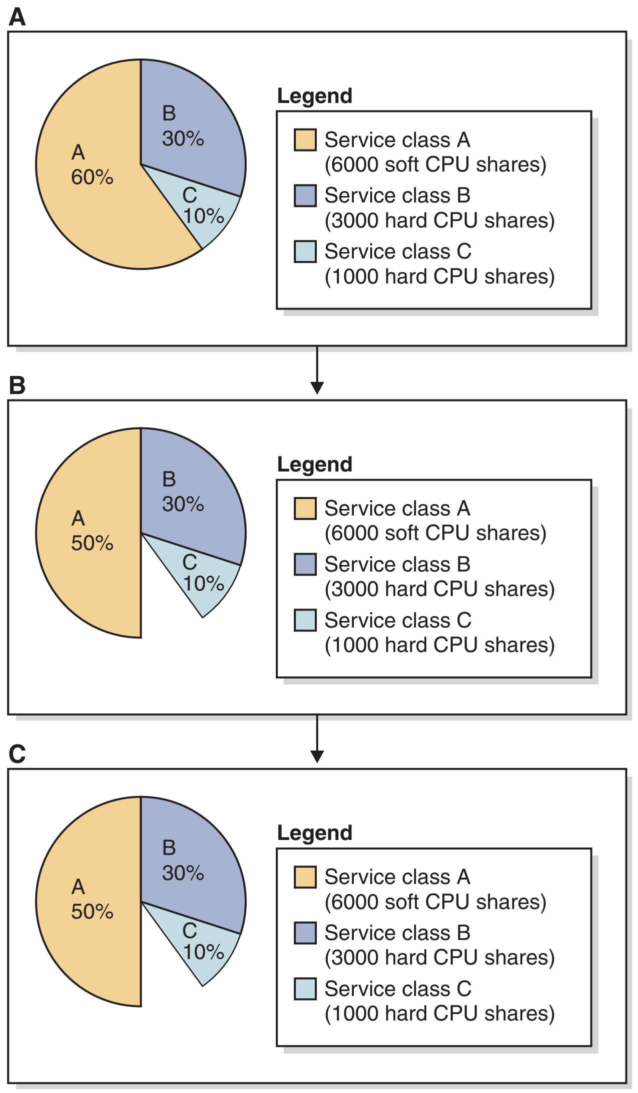


Figure 31. Hard and soft CPU shares pie charts: Scenario 2

This scenario shows that you can protect the progress of work running in a high-priority service class from interruptions by work running in low-priority service classes.

Scenario 3

Hard CPU shares offer benefits over traditional fixed percentage CPU limits. In the absence of other workloads, the service class with hard CPU shares has the flexibility to claim unused CPU resources. Therefore, a service class with a hard CPU shares assignment is not artificially limited when other work is not present on the host or LPAR as that which occurs for a service class with fixed CPU limits.

In Figure 32 on page 187 panel A, service classes B and C have been assigned hard CPU shares and service class A has been assigned soft CPU shares, the amounts of which are described in the figure legend. The pie chart represents the proportion of allocated CPU resources to which each of these active service classes are entitled and each service class is using their complete share of the CPU resources, therefore summing to 100% CPU utilization in this example. In panel B, service class A does not have any work to fully use its CPU entitlement, dropping from 60% to 0%

CPU utilization. The dispatcher considers service class A as being inactive. The unused 60% of the CPU resources, temporarily relinquished by service class A, can now be claimed by the competing service classes B and C based on their hard CPU shares assignment and an inactive service class. Service classes B and C, in this circumstance, can exceed their CPU resource allocations of 30% and 10%, respectively, because they both have hard CPU shares assigned and there is not enough work running in service class A for it to be considered active by the dispatcher (CPU utilization falls below the level configured for the **`wlm_disp_min_util`** database manager configuration parameter; default is 1%). Panel C shows that service class B is allocated 75% ((3000 / (3000 + 1000)) x 100) of the CPU resources and service class C is allocated 25% ((1000 / (3000 + 1000)) x 100).

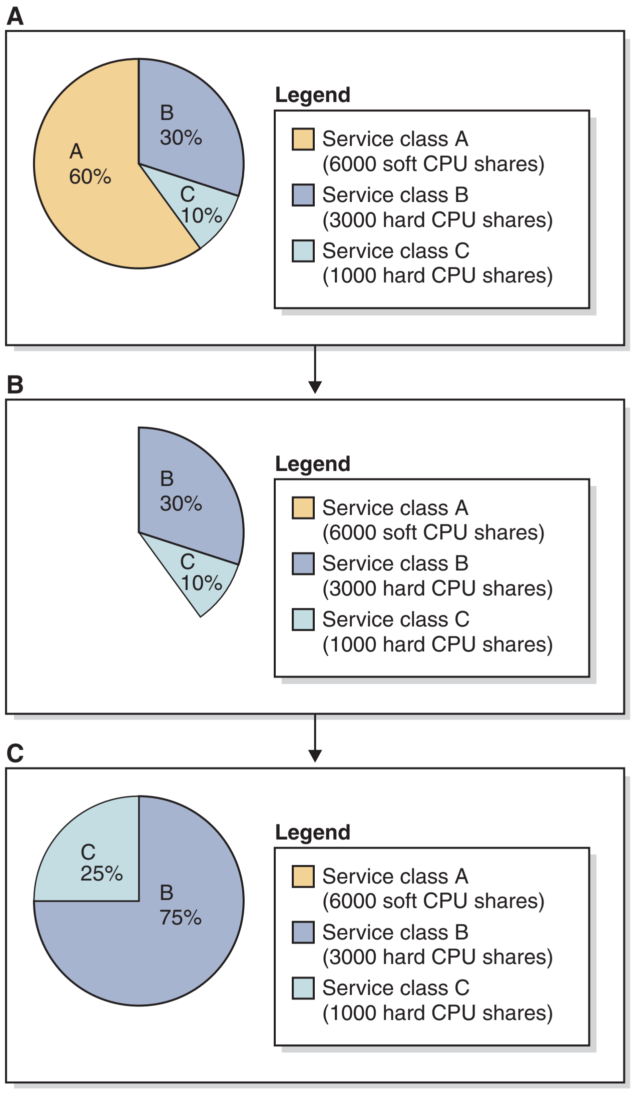


Figure 32. Hard and soft CPU shares pie charts: Scenario 3

If service class A experiences an increase in its workload, it effectively increases its demand on CPU resources. In this circumstance, service classes B and C immediately relinquish to service class A all of the claimed CPU resources, thereby restoring the state of CPU resource allocations to that which is depicted by the pie chart in panel A.

This scenario shows that although you can protect the progress of work running in high-priority service classes from interruptions by work running in low-priority service classes, when high-priority work is no longer present (such as during off-peak business hours), low-priority service classes with hard CPU shares still have the flexibility to claim the unused CPU resources.

Note: If either service class B or C does not use its full CPU resource allocation and is still considered by the dispatcher to be actively running work, the other service class with hard CPU shares cannot take advantage of it and use more than its allocation.

More information

Complete details are provided about the following workload management dispatcher subjects:

- Workload management dispatcher, see: "Workload management dispatcher" on page 161.
- Soft CPU shares, see: "Soft CPU shares" on page 190.
- CPU limit, see: "CPU limit" on page 194.
- Minimum CPU utilization level for a service class to be considered active, see: "Minimum CPU resource utilization for service class to be considered active" on page 210.
- Dispatch concurrency level, see: "Dispatch concurrency level" on page 213.
- Monitoring and tuning workload management dispatcher performance, see: "Monitoring and tuning workload management dispatcher performance" on page 215

Enabling and setting hard CPU shares

Enable the CPU shares attributes by setting the value of the **`wlm_disp_cpu_shares`** database manager configuration parameter to `YES`. Set the hard CPU shares attribute using the CREATE SERVICE CLASS or ALTER SERVICE CLASS statements. You will generally want to set hard CPU shares on service classes running low-priority or high-impact work.

Before you begin

Note: For the hard CPU shares setting to be effective, you must enable the workload management dispatcher by configuring the **`wlm_dispatcher`** database manager configuration parameter. This can be done either before or after you have enabled and set the hard CPU shares. See: "Enabling workload management dispatcher" on page 180.

About this task

The CPU shares attributes are enabled in this task using the command line processor method.

The hard CPU shares attribute is set for a service class in this task using the CREATE SERVICE CLASS or ALTER SERVICE CLASS statement using the command line processor.

Restrictions

You can assign soft CPU shares only to service classes that the workload management dispatcher can control, which are user and maintenance service classes. The CPU resource allocations for system service classes cannot be controlled by the workload management dispatcher.

Procedure

Skip to step 2 if the CPU shares attributes have already been enabled
To enable the CPU shares attributes:

1. Using the command line processor (CLP), issue the **UPDATE DATABASE MANAGER CONFIGURATION** (or **UPDATE DBM CFG**) command and set the value of the **wlm_disp_cpu_shares** database manager configuration parameter to YES; the parameter value is updated immediately by first attaching to your DB2 instance:
   ```
   attach to instance-name
   update dbm cfg using wlm_disp_cpu_shares yes
   detach
   ```

Skip to step 3 if an existing service class hard CPU shares setting is to be altered

To create a new service class and set the hard CPU shares attribute:

2. Issue the CREATE SERVICE CLASS statement to create a new service class and set the hard CPU shares value to 5000 in this example:
   ```
   create service class service-class-name hard cpu shares 5000
   ```

To alter the hard CPU shares setting for an existing service class:

3. Issue the ALTER SERVICE CLASS statement to alter the hard CPU shares value to 15000 in this example:
   ```
   alter service class service-class-name hard cpu shares 15000
   ```

Results

The CPU shares attributes have been enabled and you have set or altered the hard CPU shares setting for the specified service class. Service classes assigned hard CPU shares can, under restricted conditions, claim CPU resources that other service classes have relinquished due to their lessened workload demand.

What to do next

After having enabled the workload management dispatcher to manage CPU resources, and having enabled CPU shares attributes and set the hard CPU shares attribute, consider completing the following tasks:

- For the hard CPU shares setting to be effective, you must enable the workload management dispatcher by configuring the **wlm_dispatcher** database manager configuration parameter. See: "Enabling workload management dispatcher" on page 180.
- Set the dispatch concurrency level by configuring the **wlm_disp_concur** database manager configuration parameter. See: "Setting dispatch concurrency level" on page 214.
- Create or alter a service class and configure a soft CPU share by using the CREATE SERVICE CLASS or ALTER SERVICE CLASS statement. See: "Enabling and setting soft CPU shares" on page 193.
- Create or alter a service class and configure the CPU limit by using the CREATE SERVICE CLASS or ALTER SERVICE CLASS statement. See: "Setting a CPU limit" on page 209.

- Set the minimum CPU utilization percentage for the workload management dispatcher to consider service classes to be active by configuring the **wlm_disp_min_util** database manager configuration parameter. See: "Setting minimum CPU resource utilization for service class to be considered active" on page 212.

Soft CPU shares

The DB2 workload management dispatcher can manage CPU resources using shares-based entitlements that are assigned to service classes. Soft CPU shares, when assigned to a service class by the administrator, give that service class the ability to consume more than its share of CPU resources if they are unused. When used in conjunction with other service classes bounded by hard CPU shares, this provides preferential treatment for that service class with regards to CPU resources.

Introduction

Soft CPU shares can be assigned to any user and maintenance service class, but not to the system service class. After enabling the workload management dispatcher and monitoring your existing workloads to determine the extent of CPU resource consumption, you can assign soft CPU shares to the service classes that are deemed high priority. Soft CPU shares are most effective when used on high priority workloads, because they allow a workload to consume more than its specified entitlement if there are any idle CPU resources on the system. Use of soft CPU shares is not recommended when you want to constrain the CPU consumption of lower priority or high-impact work; in this case, use hard CPU shares instead.

The sections that follow describe the features and functionality of the soft CPU shares in more detail. A usage scenario section helps to illustrate the soft CPU shares features and functionality with a usage example.

Features and functionality

When the host or logical partition (LPAR) is running at 100% CPU utilization, the allocation of CPU resources between service classes simply reflects their relative share percentages. On the other hand, when the host or LPAR begins to run below full CPU utilization, the reallocation of CPU resources is complex and dependent on whether the CPU shares attribute on each active service class is set to soft or hard CPU shares.

A service class with soft CPU shares assigned can exceed its CPU resource entitlement, indicated by its CPU shares configuration, to consume any unused CPU resources that become available on the host or LPAR. When two or more service classes have soft shares and unused CPU resources become available with enough CPU resource demand from each service class to consume the spare capacity, allocation of the CPU resources to the competing service classes is done proportionally according to the relative share of each active service class. The soft CPU shares setting is most effective for high-priority work that you want to be able to temporarily claim any spare CPU resources that become available. In addition, the soft CPU shares setting is most effective for workloads consisting of short queries that are expected to have a relatively modest impact on database resources, outside of their immediate CPU consumption.

To enable the CPU shares attribute, you must set the value of the **wlm_disp_cpu_shares** database manager configuration parameter to YES. The default setting for this parameter is NO. You can assign and adjust soft CPU shares by using the CREATE SERVICE CLASS and ALTER SERVICE CLASS statements. For complete details about how to enable and set soft CPU shares, see: "Enabling and setting soft CPU shares" on page 193.

Based on the number of CPU shares assigned to a service class, the workload management dispatcher calculates the proportion of the CPU resources that each service class is entitled to use. To determine the proportion of the CPU resources to which each service superclass is entitled, you can use the following formula to convert the number of CPU shares of a particular service superclass into a percentage of CPU resources allocated by the workload management dispatcher:

```
% CPU(superclass) = (Number of superclass shares /
  Total number of shares of all active superclasses) x 100
```

To determine the proportion of the CPU resources to which each service subclass is entitled, you can use the following formula to convert the number of CPU shares of a particular service subclass into a percentage of CPU resources allocated by the workload management dispatcher:

```
% CPU(subclass) = % CPU(superclass) x (Number of subclass shares /
  Total number of shares of all active subclasses in the superclass)
```

Note: The total number of CPU shares (both hard and soft) of all active superclasses are counted across all databases and all members on the host or LPAR.

Usage scenario

In Figure 33 on page 192 panel A, service classes A, B, and C have been assigned soft CPU shares, the amounts of which are described in the figure legend. The pie chart represents the proportion of allocated CPU resources to which each of these active service classes are entitled and each service class is using their complete share of the CPU resources, therefore summing to 100% CPU utilization in this example. In panel B, service class A does not have enough work to fully use its CPU entitlement, dropping from 60% to 50% CPU utilization. The unused 10% of the CPU resources, temporarily relinquished by service class A, can be proportionally claimed by the competing service classes B and C based on their relative soft CPU shares assignments. Panel C depicts the proportional reallocation of CPU resources between service classes B and C, with service class B getting 7.5% (10% x (3000/4000)) and service class C getting 2.5% (10% x (1000/4000)) of the unused 10% relinquished by service class A.

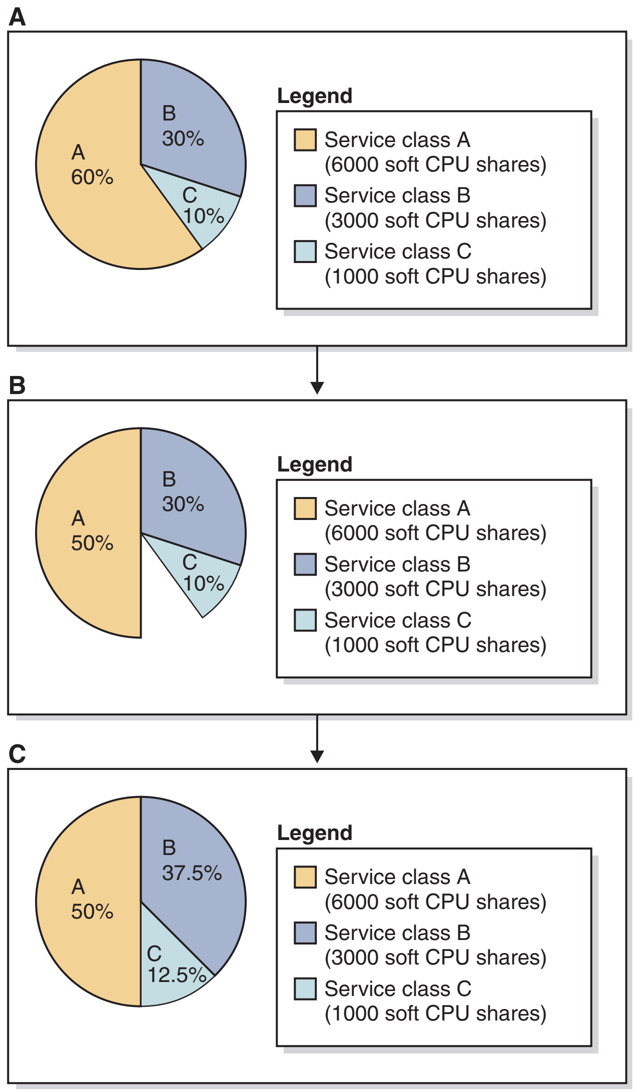


Figure 33. Soft CPU shares pie charts

If service class A experiences an increase in its workload, it effectively increases its demand on CPU resources. In this circumstance, service classes B and C immediately relinquish to service class A all of the claimed CPU resources, thereby restoring the state of CPU resource allocations to that which is depicted by the pie chart in panel A.

Note: When service classes compete to consume CPU resources, individual service class requests for CPU resources is handled by the workload management dispatcher in a first-come-first-served fashion. Due to typically frequent and short-lived requests for CPU resources on a busy host or LPAR, the reallocation of unused CPU resources over time results in a smooth redistribution of CPU resources which is in proportion to the relative CPU shares assignments.

More information

Complete details are provided about the following workload management dispatcher subjects:

- Workload management dispatcher, see: "Workload management dispatcher" on page 161.

- Hard CPU shares, see: "Hard CPU shares" on page 181.
- CPU limit, see: "CPU limit" on page 194.
- Minimum CPU utilization level for a service class to be considered active, see: "Minimum CPU resource utilization for service class to be considered active" on page 210.
- Dispatch concurrency level, see: "Dispatch concurrency level" on page 213.
- Monitoring and tuning workload management dispatcher performance, see: "Monitoring and tuning workload management dispatcher performance" on page 215

Enabling and setting soft CPU shares

Enable the CPU shares attributes by setting the value of the **`wlm_disp_cpu_shares`** database manager configuration parameter to `YES`. Set the soft CPU shares attribute using the CREATE SERVICE CLASS or ALTER SERVICE CLASS statements. You set the soft CPU shares on high-priority service classes when CPU resources are strained.

Before you begin

Note: For the soft CPU shares setting to be effective, you must enable the workload management dispatcher by configuring the **`wlm_dispatcher`** database manager configuration parameter. This can be done either before or after you have enabled and set the soft CPU shares. See: "Enabling workload management dispatcher" on page 180.

About this task

The CPU shares attributes are enabled in this task using the command line processor method.

The soft CPU shares attribute is set for a service class in this task using the CREATE SERVICE CLASS or ALTER SERVICE CLASS statement using the command line processor.

Restrictions

You can assign soft CPU shares only to service classes that the workload management dispatcher can control, which are user and maintenance service classes. The CPU resource allocations for system service classes cannot be controlled by the workload management dispatcher.

Procedure

Skip to step 2 if the CPU shares attributes have already been enabled
To enable the CPU shares attributes:

1. Using the command line processor (CLP), issue the **`UPDATE DATABASE MANAGER CONFIGURATION`** (or **`UPDATE DBM CFG`**) command and set the value of the **`wlm_disp_cpu_shares`** database manager configuration parameter to `YES`; the parameter value is updated immediately by first attaching to your DB2 instance:

   ```
   attach to instance-name
   update dbm cfg using wlm_disp_cpu_shares yes
   detach
   ```

Skip to step 3 if an existing service class soft CPU shares setting is to be altered

To create a new service class and set the soft CPU shares attribute:

2. Issue the CREATE SERVICE CLASS statement to create a new service class and set the soft CPU shares value to 5000 in this example:

   ```
   create service class service-class-name soft cpu shares 5000
   ```

To alter the soft CPU shares setting for an existing service class:

3. Issue the ALTER SERVICE CLASS statement to alter the soft CPU shares value to 15000 in this example:

   ```
   alter service class service-class-name soft cpu shares 15000
   ```

Results

The CPU shares attributes have been enabled and you have set or altered the soft CPU shares setting for the specified service class. Service classes assigned soft CPU shares can claim CPU resources that other service classes have relinquished due to their lessened workload demand.

Note: Soft CPU shares are most effective when assigned to high-priority service classes, and the high-priority service classes are protected from interruption by low-priority service classes that have hard CPU shares assigned.

What to do next

After having enabled the CPU shares attributes and set the soft CPU shares attribute, consider completing the following tasks:

- For the soft CPU shares setting to be effective, you must enable the workload management dispatcher by configuring the **`wlm_dispatcher`** database manager configuration parameter. See: "Enabling workload management dispatcher" on page 180.
- Set the dispatch concurrency level by configuring the **`wlm_disp_concur`** database manager configuration parameter. See: "Setting dispatch concurrency level" on page 214.
- Create or alter a service class and configure a hard CPU share by using the CREATE SERVICE CLASS or ALTER SERVICE CLASS statement. See: "Enabling and setting hard CPU shares" on page 188.
- Create or alter a service class and configure the CPU limit by using the CREATE SERVICE CLASS or ALTER SERVICE CLASS statement. See: "Setting a CPU limit" on page 209.
- Set the minimum CPU utilization percentage for workload management dispatcher to consider service classes to be active by configuring the **`wlm_disp_min_util`** database manager configuration parameter. See: "Setting minimum CPU resource utilization for service class to be considered active" on page 212.

CPU limit

The DB2 workload management dispatcher can enforce fixed CPU limit entitlements that can be assigned to service superclasses and subclasses. By applying a CPU limit, you can limit the CPU that is consumed by a service class to a fixed amount on the system, regardless of any other work running in the DB2 database manager. This leaves the remaining portion of CPU resources available for other consumers to use. When CPU limits are used in conjunction with CPU shares, the most limiting or restrictive condition is always honored.

Introduction

A CPU limit can be assigned to any user and maintenance service class, but not to the system service class. After having enabled the workload management dispatcher and having monitored your existing workloads to determine the extent of CPU resource consumption, you can then assign CPU limits to the service classes that you want to be strictly limited in their CPU consumption.

CPU shares provide you with the ability to control the CPU resource entitlement of individual workloads when the overall workload of the host or LPAR is heavy and yet not waste CPU resources when the overall workload is light. However, there are workloads for which you always want to limit their CPU resource entitlement despite the light overall workload of the host or LPAR. For example, if multiple departments share the cost of purchasing a database server, each department might want to ensure that the other departments are not taking more than their allocated CPU resource entitlements, despite the possibility that the selected configuration can result in under-utilizing the CPU resources of the host or LPAR. CPU shares do not give you this level of control, whereas a CPU limit does.

The sections that follow describe the features and functionality of the CPU limit in more detail. A usage scenario section helps to illustrate the CPU limit features and functionality with usage examples.

Features and functionality

The CPU limit gives you the ability to place a fixed limit on the CPU resource entitlement by work in a service class. If a CPU limit is set on all service classes, you can reserve a portion of the CPU resources to perform work regardless of any other work running in the DB2 database manager. Configuring a CPU limit on a service class effectively provides a strictly-enforced sandbox for your workloads in which you can achieve fairness in CPU resource consumption between workloads, but at the expense of occasionally not achieving full utilization of the CPU resources.

The CPU limit is also useful when you have multiple DB2 instances on your host or LPAR. With the workload management dispatcher operating at the instance level, the CPU resource allocation of any service class is computed from the shares of that service class relative to the shares of all other service classes within the instance. A CPU limit, however, is expressed as a percentage of the CPU resources of the host or LPAR, regardless of how many DB2 instances exist on such a host or LPAR. By applying CPU limits to your superclasses and shares to your subclasses, you can use the CPU limit to control the absolute CPU resource entitlement of each superclass, and by extension the instance, and then use shares to control the relative CPU resource entitlements of service subclasses running within those superclasses.

A CPU limit can be configured both at the service superclass level, where it represents a percentage limit of CPU resource entitlement on the host or LPAR by all subclasses in that superclass, or at the subclass level, where it represents a percentage limit of CPU resource entitlement on the host or LPAR by that particular subclass.

To enable the CPU limit attribute, you must enable the workload management dispatcher by setting the value of the **wlm_dispatcher** database manager configuration parameter to ON. The default setting for this parameter is OFF. By enabling the workload management dispatcher, CPU resource control using the

CPU limit attribute becomes available by default. You can assign and adjust CPU limits by using the CREATE SERVICE CLASS and ALTER SERVICE CLASS statements. For complete details about how to set CPU limits, see: “Setting a CPU limit” on page 209.

The workload management dispatcher always respects the most restrictive CPU limit or CPU shares assignments when allocating CPU resources to service classes. For example, when a CPU limit is set at both the superclass and subclass levels, the more restrictive CPU limit is honored. Likewise, if a service class reaches its CPU limit before it has fully utilized its shares-based CPU resource entitlement, the dispatcher respects the CPU limit.

Usage scenarios

CPU limit and multiple superclasses

This set of usage examples addresses CPU limit behavior in a multiple superclass environment.

Figure 34 on page 197 shows a host or LPAR configured with two superclasses, A and B. For illustration purposes to help describe the basic concepts, assume that there is negligible work running in the default user, maintenance, and system service classes. For the following scenarios, there is only one DB2 instance with one database and only one member on this host or LPAR.

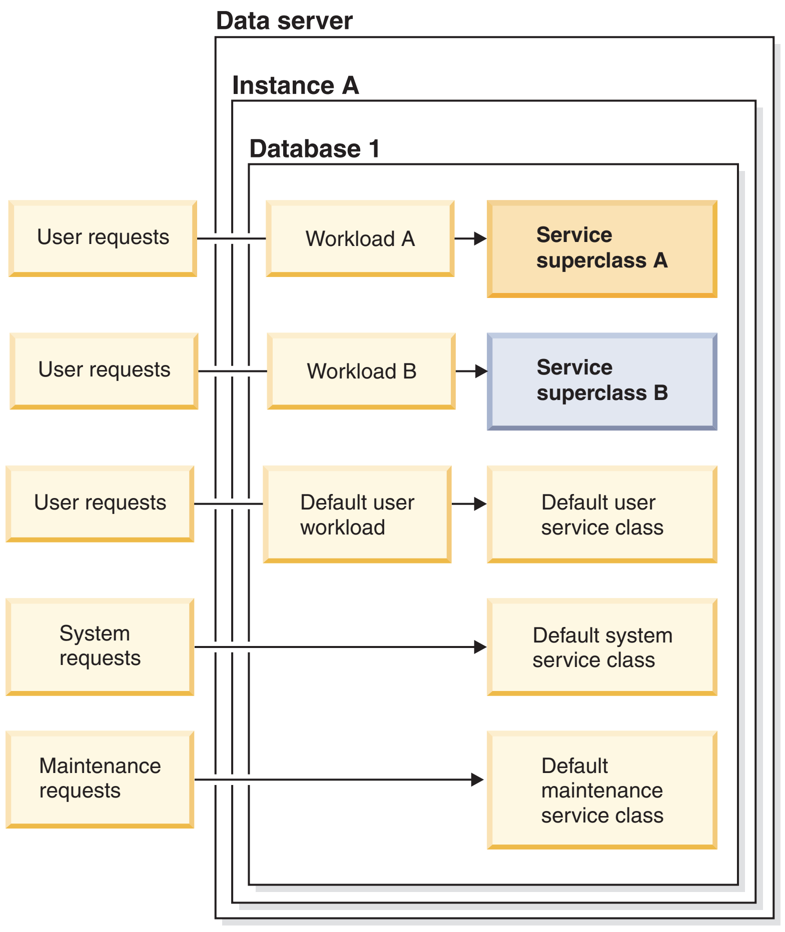


Figure 34. Data server configuration: Multiple superclasses

CPU limit and multiple superclasses: Scenario 1

In this example, Figure 35 on page 198 panel A shows that service class A has a CPU limit of 30% and service class B has no CPU limit. At the start of this scenario, service class A has at least enough work to drive its CPU resource utilization to 30% and service class B has at least enough work to drive its CPU resource utilization to 70%. Service classes A and B both have 1000 soft CPU shares.

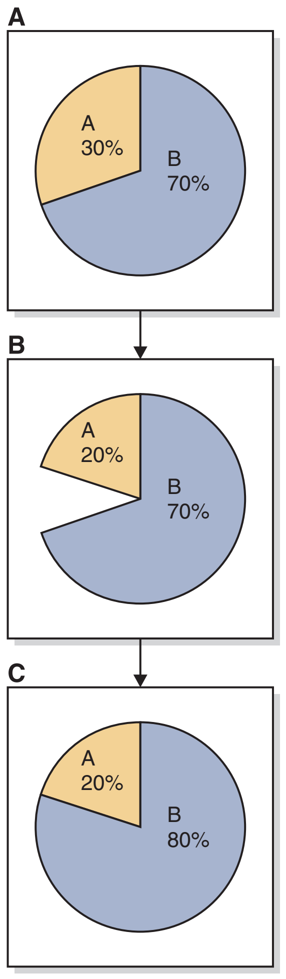


Figure 35. CPU limit and multiple superclasses: Scenario 1

Panel B shows that service class A has a reduction in CPU resource demand from 30% to 20%. Service class B has more than enough CPU resource demand to claim the CPU resources temporarily relinquished by service class A, as shown in panel C.

CPU limit and multiple superclasses: Scenario 2

In this example, Figure 36 on page 199 panel A again shows that service class A has a CPU limit of 30% and service class B has no CPU limit. At the start of this scenario, service class A has at least enough work to drive its CPU resource utilization to 30% and service class B has at least enough work to drive its CPU resource utilization to 70%. Service classes A and B both have 1000 soft CPU shares.

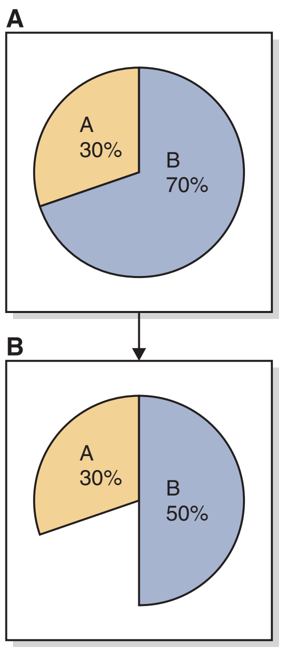


Figure 36. CPU limit and multiple superclasses: Scenario 2

Panel B shows that service class B has a reduction in CPU resource demand from 70% to 50%. Due to its CPU limit, service class A cannot consume the 20% of the CPU resources that service class B temporarily relinquished. The total CPU utilization for the host or LPAR remains at 80%.

CPU limit and multiple superclasses: Scenario 3

In this example, Figure 37 on page 200 panel A again shows that service class A has a CPU limit of 30% and service class B has no CPU limit. At the start of this scenario, service class A has at least enough work to drive its CPU resource utilization to 30% and service class B has at least enough work to drive its CPU resource utilization to 70%. Service classes A and B both have 1000 soft CPU shares.

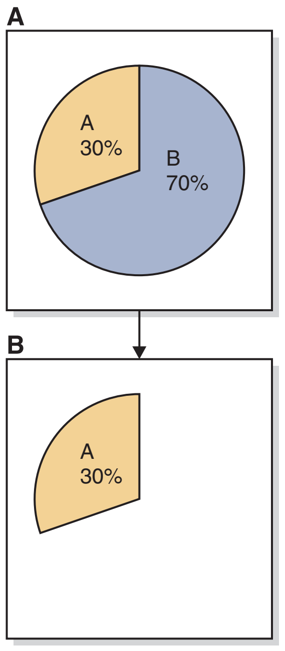


Figure 37. CPU limit and multiple superclasses: Scenario 3

Panel B shows that service class B has a reduction in CPU resource demand from 70% to 0%. Due to its CPU limit, service class A cannot consume the 70% of the CPU resources that service class B temporarily relinquished. The total CPU utilization for the host or LPAR remains at 30%.

CPU limit and multiple subclasses

This next set of usage examples addresses CPU limit behavior in a multiple subclass environment.

Figure 38 on page 201 shows a host or LPAR configured with two superclasses, A and B. Inside service superclass A are service subclasses A1 and A2. For illustration purposes to help describe the basic concepts, assume that there is negligible work running in the default user, maintenance, and system service classes. For the following scenarios, there is only one DB2 instance with one database and only one logical partition on this host or LPAR.

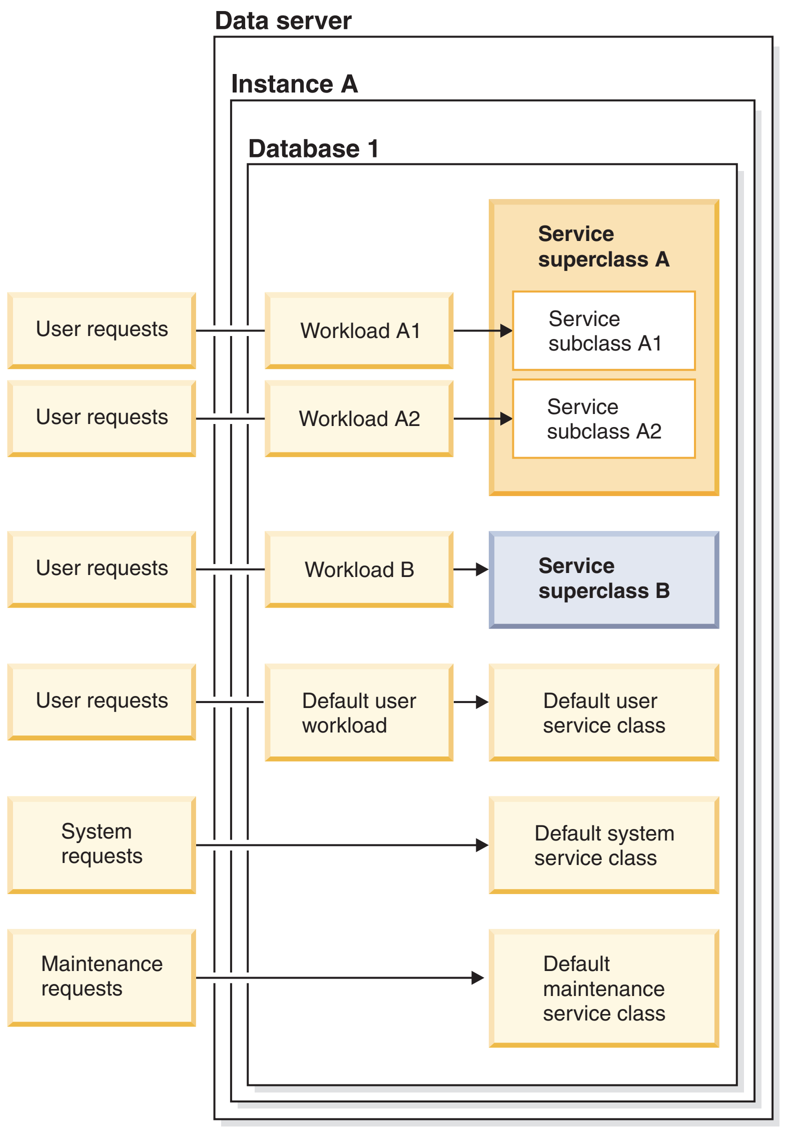


Figure 38. Data server configuration: Multiple subclasses

CPU limit and multiple subclasses: Scenario 1

In this example, Figure 39 on page 202 panel A shows that service superclass class A has a CPU limit of 50% and service subclass A1 has a CPU limit of 20%. Service superclass B has no CPU limit. At the start of this scenario, service subclass A1 has at least enough work to drive its CPU resource utilization to 20% and service subclass A2 has at least enough work to drive its CPU resource utilization to 30%, giving service superclass A a total CPU resource utilization of 50%. Service superclass B has at least enough work to drive its CPU resource utilization to 50%. Service superclasses A and B both have 1000 soft CPU shares.

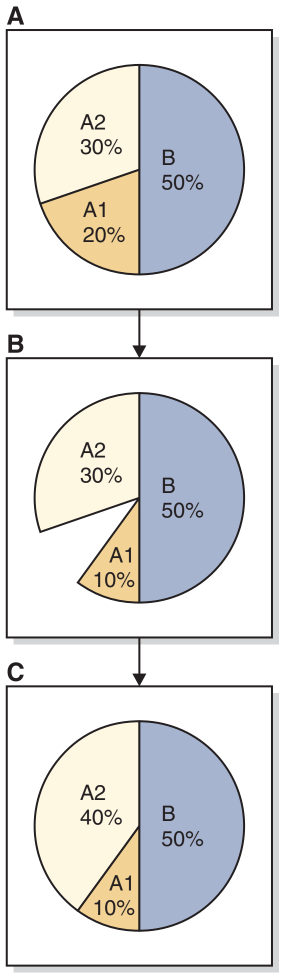


Figure 39. CPU limit and multiple subclasses: Scenario 1

Panel B shows that service subclass A1 has a reduction in CPU resource demand from 20% to 10%. Service subclass A2 and service superclass B each have more than enough CPU demand to claim the entire amount of unused CPU resources that service class A1 has temporarily relinquished. However, service subclass A2 is allocated all of the relinquished CPU resource and increases its CPU utilization from 30% to 40%, as depicted in panel C. This CPU resource allocation result is due to the service superclasses A and B already sharing the total CPU resources with a 50%/50% equal split resulting from the 1000 soft CPU shares assigned to each of the superclasses.

CPU limit and multiple subclasses: Scenario 2

In this example, Figure 40 on page 203 panel A again shows that service superclass class A has a CPU limit of 50% and service subclass A1 has a CPU limit of 20%. Service superclass B has no CPU limit. At the start of this scenario, service subclass A1 has at least enough work to drive its CPU resource utilization to 20% and service subclass A2 has at least enough work to drive its CPU resource utilization to 30%, giving service superclass A a total CPU resource utilization of 50%. Service superclass B has at least enough work to drive its CPU resource utilization to 50%. Service superclasses A and B both have 1000 soft CPU shares.

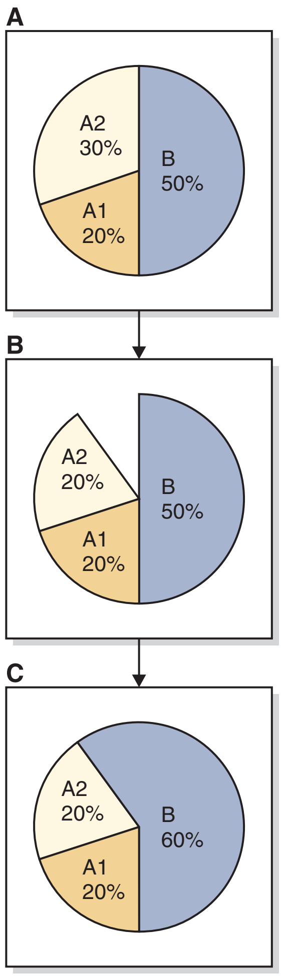


Figure 40. CPU limit and multiple subclasses: Scenario 2

Panel B shows that service subclass A2 has a reduction in CPU resource demand from 30% to 20%. Due to service subclass A1 having a CPU limit of 20%, service subclass A1 cannot exceed its current 20% CPU utilization. Service superclass A drops its CPU utilization to a total of 40%. Service superclass B has enough CPU resource demand to claim the CPU resource that was temporarily relinquished by service subclass A2, increasing the CPU utilization of service superclass B from 50% to 60%, as shown in panel C.

CPU limit and multiple DB2 instances

This next set of usage examples addresses CPU limit behavior in a multiple DB2 instance environment.

Figure 41 on page 204 shows a host or LPAR configured with two DB2 instances, instance A and instance B. Each instance contains one database, database 1 and database 2. Each database contains one service superclass, service superclass A and B. Inside service superclass A are service subclasses A1 and A2. Inside service superclass B are service subclasses B1 and B2. To keep the scenario simple, user requests for each database are routed to only the two service subclasses and no work is routed to the default service subclass. In addition, to help describe the basic concepts, assume that there is negligible work running in the default user, maintenance, and system service classes. For the following scenarios, there are two DB2 instances with one database in each instance and only one member on this host or LPAR.

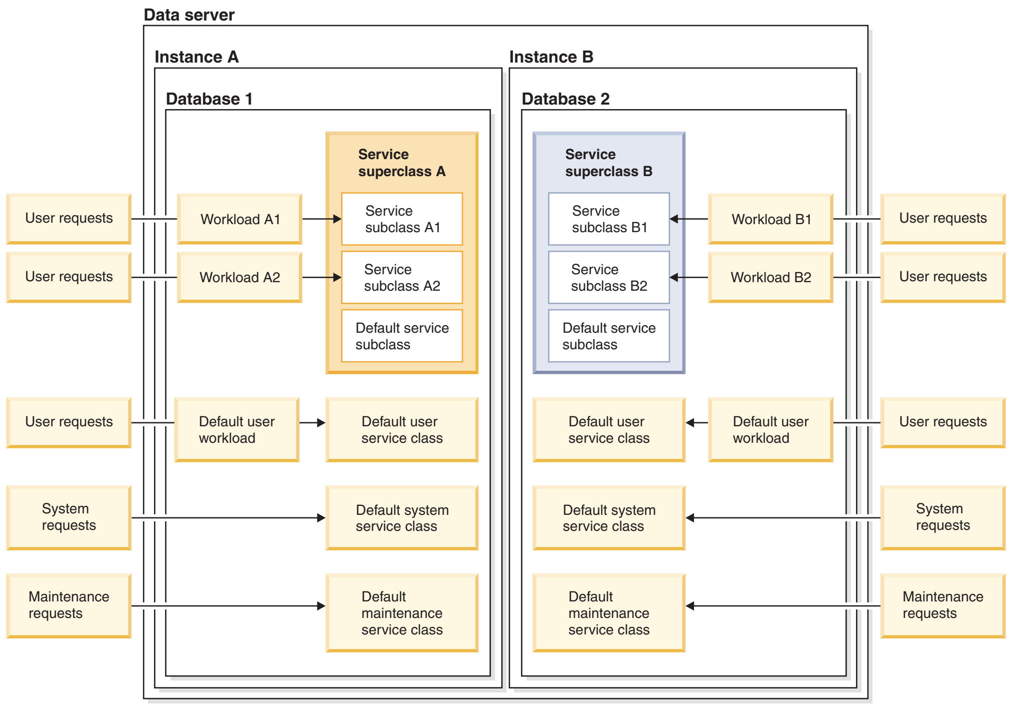


Figure 41. Data server configuration: Multiple DB2 instances

CPU limit and multiple DB2 instances: Scenario 1

In this example, instance A is to receive no more than 50% of the total CPU resources of the host or LPAR and instance B is to receive no more than 50% of the total CPU resources of the host or LPAR. Within instance A, 80% of the instance CPU resources are to be allocated to service subclass A1 and 20% to service subclass A2 by assigning 8000 soft CPU shares to A1 and 2000 soft CPU shares to A2. When service subclass A1 does not consume its full 80%, we want service subclass A2 to claim any unused CPU resources, and vice versa, to maximize CPU utilization within instance A. Within instance B, 60% of the instance CPU resources are to be allocated to service subclass B1 and 40% to service subclass B2 by assigning 6000 soft CPU shares to B1 and 4000 soft CPU shares to B2. As with service subclasses A1 and A2, we want to maximize CPU utilization within instance B by having service subclass B1 claim any unused CPU resources when service subclass B2 does not use its full CPU resource entitlement, and vice versa.

To configure the appropriate conditions for this scenario as described in the preceding paragraph, limit the CPU resources for each instance by creating a CPU limit of 50% on service superclass A, in database 1, in instance A, and creating a CPU limit of 50% on service superclass B, in database 2, in instance B. When both instances are using all of their CPU resource entitlements, the host or LPAR as a whole is considered to have 100% CPU utilization. If either instance does not use its full CPU entitlement, the other instance cannot claim the unused CPU resources.

For each service superclass on each instance, the workload management dispatcher divides the available CPU resources among the subclasses using their relative soft CPU shares assignments. By using soft CPU shares assigned to the service subclasses, the only circumstance in which an instance does not make full use of their CPU resource entitlement occurs when every subclass in the instance does not have enough work running within it to achieve full CPU utilization of its entitlement.

Figure 42 on page 206 panel A shows that service superclass class A has a CPU limit of 50% and service superclass B has a CPU limit of 50%. Service subclass A1 has 80% of the instance A CPU resources (40% of the host or LPAR CPU resources); service subclass A2 has the remaining 20% (10% of the host or LPAR CPU resources). Service subclass B1 has 60% of the instance B CPU resources (30% of the host or LPAR CPU resources); service subclass B2 has the remaining 40% (20% of the host or LPAR CPU resources). At the start of this scenario, service subclass A1 has at least enough work to drive its host or LPAR CPU resource utilization to 40% and service subclass A2 has at least enough work to drive its host or LPAR CPU resource utilization to 10%, giving service superclass A a total CPU resource utilization of 50%. Service subclass B1 has at least enough work to drive its host or LPAR CPU resource utilization to 30% and service subclass B2 has at least enough work to drive its host or LPAR CPU resource utilization to 20%, giving service superclass B a total CPU resource utilization of 50%.

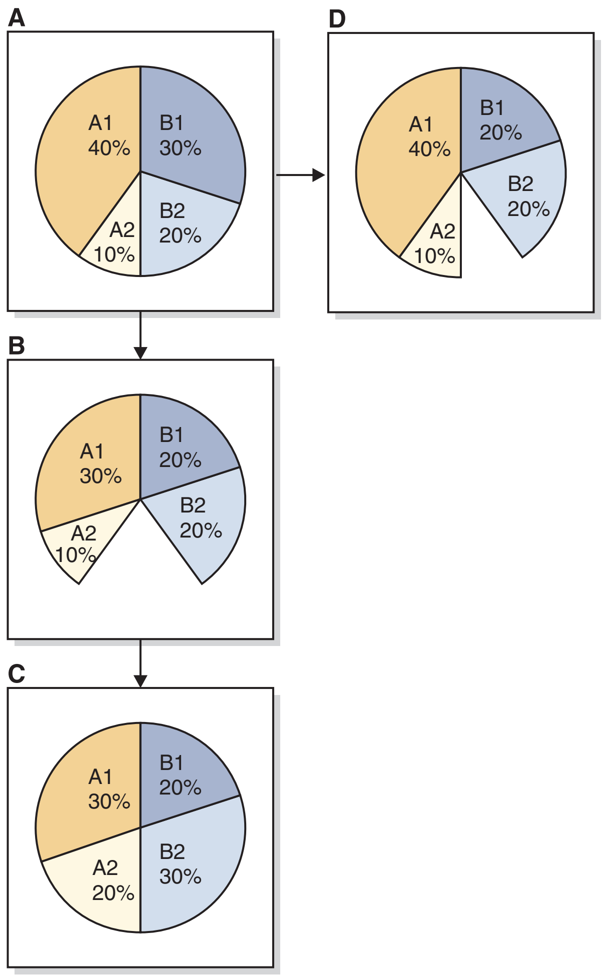


Figure 42. CPU limit and multiple DB2 instances: Scenario 1

Panel B shows that service subclass A1 has a reduction in CPU resource demand from 40% to 30% and service subclass B1 has a reduction in CPU resource demand from 30% to 20%. Assuming service subclass A2 has enough work executing within it to claim any unused CPU resources that become available, A2 increases its CPU utilization from 10% to 20% because A2 has soft CPU shares assigned to it, as shown in panel C. The same applies to service subclass B2 which increases its CPU utilization from 20% to 30%, as shown in panel C.

Let's now consider the original start condition as described in panel A for a different example. If service subclass B1 reduces its CPU demand from 30% to 20% and service subclass B2 does not have enough work running within it to exceed a CPU demand of 20%, then service superclass B in instance B does not use its full CPU entitlement of 50% and remains at a CPU utilization of 40%, as shown in panel D. The result is that the host or LPAR has a CPU utilization of only 90% of the total CPU resources.

CPU limit and multiple DB2 instances: Scenario 2

This scenario example illustrates what happens when the sum of the CPU limits of the service subclasses does not exceed the CPU limit of the parent service superclass.

Using similar initial conditions as in "CPU limit and multiple DB2 instances: Scenario 1", let's just change the soft CPU shares assigned to service subclasses A1 and A2 into CPU limits of 40% and 10%, respectively, of the total CPU resources for the host or LPAR, as shown in Figure 43 panel A. When both service subclasses use the CPU resources up to their assigned CPU limits, the total CPU utilization is 50% for service superclass A, making redundant the additional constraint of a 50% CPU limit on service superclass A.

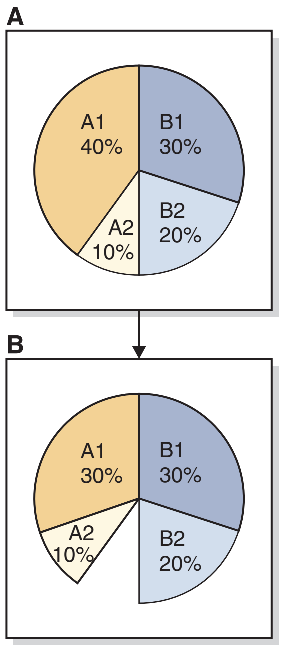


Figure 43. CPU limit and multiple DB2 instances: Scenario 2

Panel B shows that service subclass A1 has a reduction in CPU resource demand from 40% to 30% due to a decrease in the amount of work running in the service subclass. In this circumstance, the dispatcher cannot allocate the unused CPU resource, temporarily relinquished by service subclass A1, to service subclass A2. Service subclass A2 continues running workloads on its CPU limit of 10% of the CPU resources of the host or LPAR. This situation makes instance A unable to use its full CPU resource entitlement of 50%.

CPU limit and multiple DB2 instances: Scenario 3

This scenario example illustrates what happens when the sum of the CPU limits of the service subclasses exceed the CPU limit of the parent service superclass.

Using similar initial conditions as in "CPU limit and multiple DB2 instances: Scenario 1", let's just change the soft CPU shares assigned to service subclasses A1 and A2 into CPU limits of 40% and 40%, respectively, of the total CPU resources for the host or LPAR. In this example, the total of the assigned CPU limits for service subclasses A1 and A2 is 80% which exceeds the 50% CPU limit assigned to service superclass A. The workload management dispatcher prevents service superclass A from exceeding its 50% CPU limit. The amount of CPU resources that is allocated to each service subclass in superclass A is determined by the CPU shares that have been assigned to the subclasses. CPU shares were not explicitly assigned for service subclasses A1 and A2, but each of these subclasses has the 1000 soft CPU shares that were assigned when the subclasses were created, giving each subclass an equal CPU entitlement. The dispatcher allocates an equal division of the 50% of the total host or LPAR CPU resources entitled to service superclass A. The result is that 25% is allocated to service subclass A1 and 25% is allocated to service subclass A2, as shown in Figure 44 panel A.

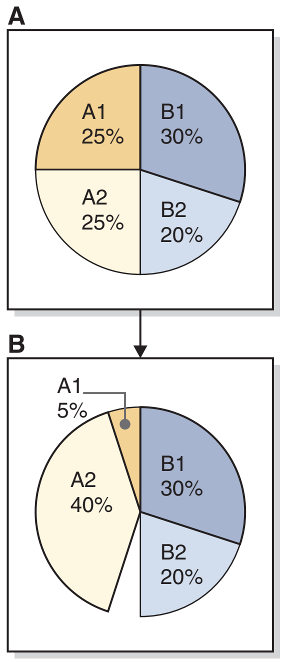


Figure 44. CPU limit and multiple DB2 instances: Scenario 3

Panel B shows that service subclass A1 has a reduction in CPU resource demand from 25% to 5% due to a decrease in the amount of work running in the service subclass. Due to the soft CPU shares assignment, the dispatcher can allocate the unused CPU resource, temporarily relinquished by service subclass A1, to the point of 40% claimed by service subclass A2. Service subclass A2 is unable to exceed its CPU limit of 40% of the CPU resources of the host or LPAR. This situation makes instance A unable to use its full CPU resource entitlement of 50%.

Note: The limitations of this approach to managing work in multiple instances on the same host or LPAR is that it limits you to one service superclass in each instance. For operating systems that have a workload manager into which DB2 workload management can be integrated, an alternative is to map the DB2 service classes of each instance to a service class in an operating system (OS) WLM (such as AIX WLM and Linux WLM) and assign the hard limits of the OS WLM on each OS service class to put upper bounds on the CPU resource utilization of each instance.

More information

Complete details are provided about the following workload management dispatcher subjects:

- Workload management dispatcher, see: “Workload management dispatcher” on page 161.
- Dispatch concurrency level, see: “Dispatch concurrency level” on page 213.

- Minimum CPU utilization level for a service class to be considered active, see: "Minimum CPU resource utilization for service class to be considered active" on page 210.
- Hard CPU shares, see: "Hard CPU shares" on page 181.
- Soft CPU shares, see: "Soft CPU shares" on page 190.
- Monitoring and tuning workload management dispatcher performance, see: "Monitoring and tuning workload management dispatcher performance" on page 215

Setting a CPU limit

Set the CPU limit attribute using the CREATE SERVICE CLASS statement to create a new service class and CPU limit, and use the ALTER SERVICE CLASS statement to alter the CPU limit setting for an existing service class. You set the CPU limit to cap CPU utilization by a service class under all circumstances during workload management dispatcher control.

Before you begin

You must enable the workload management dispatcher by configuring the **wlm_dispatcher** database manager configuration parameter, if not already done. By enabling the workload management dispatcher, CPU resource control using the CPU limit attribute becomes available by default. See: "Enabling workload management dispatcher" on page 180.

About this task

The CPU limit is set for a service class in this task using the CREATE SERVICE CLASS or ALTER SERVICE CLASS statement using the command line processor.

Restrictions

You can assign CPU limits only to service classes that the workload management dispatcher can control, which are user and maintenance service classes. The CPU resource allocations for system service classes cannot be controlled by the workload management dispatcher.

Procedure

To create a new service class and set the CPU limit (skip to step 2 if an existing service class CPU limit setting is to be altered):

1. Issue the CREATE SERVICE CLASS statement to create a new service class and set the CPU limit to 25% in this example:
   ```
   create service class service-class-name cpu limit 25
   ```

To alter the CPU limit setting for an existing service class:

2. Issue the ALTER SERVICE CLASS statement to alter the CPU limit to 50% in this example:
   ```
   alter service class service-class-name cpu limit 50
   ```

Results

You have set or altered the CPU limit setting for the specified service class. The workload management dispatcher cannot allocate CPU resources to this service class beyond the set limit.

What to do next

After having enabled the workload management dispatcher to manage CPU resources and having set the CPU limit, consider completing the following tasks:

- Set the dispatch concurrency level by configuring the **`wlm_disp_concur`** database manager configuration parameter. See: "Setting dispatch concurrency level" on page 214.
- Enable hard and soft CPU shares by configuring the **`wlm_disp_cpu_shares`** database manager configuration parameter. See step 1 in: "Enabling and setting soft CPU shares" on page 193.
- Create or alter a service class and configure a hard CPU share by using the CREATE SERVICE CLASS or ALTER SERVICE CLASS statement. See: "Enabling and setting hard CPU shares" on page 188.
- Create or alter a service class and configure a soft CPU share by using the CREATE SERVICE CLASS or ALTER SERVICE CLASS statement. See: "Enabling and setting soft CPU shares" on page 193.
- Set the minimum CPU utilization percentage for the workload management dispatcher to consider service classes to be active by configuring the **`wlm_disp_min_util`** database manager configuration parameter. See: "Setting minimum CPU resource utilization for service class to be considered active" on page 212.

Minimum CPU resource utilization for service class to be considered active

By setting the **`wlm_disp_min_util`** database manager configuration parameter, you are able to control the minimum level of CPU resource utilization at which the workload management dispatcher considers the service class actively engaged in executing work. The CPU shares of only the active service classes are factored into CPU resource allocation scheduling that is performed by the dispatcher.

When managing shares-based CPU resource allocations, the workload management dispatcher considers a service class to be active and factors its entire CPU shares assignment in the overall CPU resource scheduling allocation if any amount of the CPU resource is being used by database requests executing in that service class. In certain instances, it is desirable to have some control over how much service-class-generated CPU activity is needed for the workload management dispatcher to include the CPU shares of the service class during CPU resource scheduling.

In the example scenario depicted in Figure 45 on page 211 panel A, service class A contains a high-priority transactional workload that runs only during the business day, while service class B and C contain ongoing day and night, low-priority batch jobs. Service class A is protected from interruption by assigning hard CPU shares to service classes B and C. At night when the transactional workload on service class A is not present (as shown in panel B), service classes B and C are able to make full use of the CPU resources and make much faster progress (as shown in panel C).

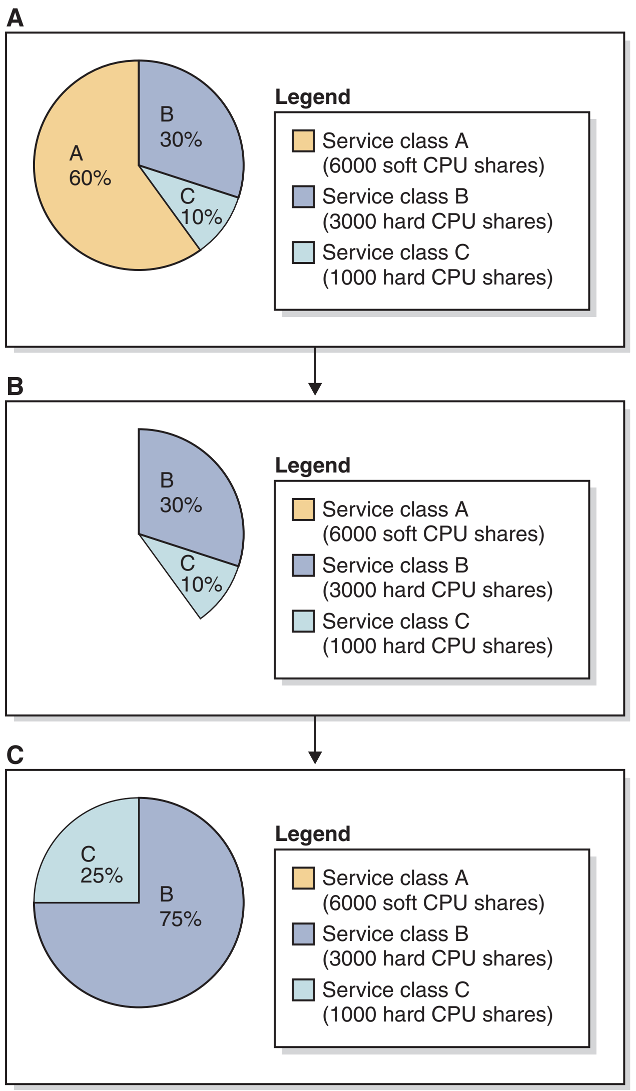


Figure 45. Minimum CPU utilization example: Hard and soft CPU shares

Let's now consider what happens if a small trickle of transactional work continues to occur at night on service class A. In this case, service class A is considered to be active by the workload management dispatcher, and the unused CPU resources temporarily relinquished by service class A are not available to service classes B and C. The CPU resource entitlements for service classes B and C are as shown in panel B with a small sliver of the CPU utilization pie representing the activity of service class A (not shown in the panel B pie chart). Much slower overnight progress is the result for service classes B and C than that made in the original scenario as shown in panel C.

Maximum user flexibility to manage their DB2 workloads is provided by the option to set a percentage of CPU utilization at or above which a service class is considered to be active on the host or LPAR. When a service class is considered to be inactive, its CPU shares assignment is not factored into CPU resource entitlement calculations, thereby allowing service classes, particularly those with assigned hard CPU shares, to claim the unused CPU resources. This minimum percentage of CPU utilization is specified by configuring the percentage value of the **`wlm_disp_min_util`** database manager configuration parameter. This configuration parameter can be set to a percentage value between 0 and 100, with a default value of 5. For this configuration parameter setting to be effective, the workload management dispatcher must be enabled by setting the value of the **wlm_dispatcher** database manager configuration parameter to YES.

Let's reconsider the small trickle scenario described earlier. With the percentage value of the **wlm_disp_min_util** database manager configuration parameter now set to a value slightly higher than the small sliver of overnight CPU utilization for service class A, we can be more confident that the progress of the overnight batch jobs of service classes B and C is much improved, similar to that of the original scenario in which the CPU utilization was as that shown in panel C.

More information

Complete details are provided about the following workload management dispatcher subjects:

- Workload management dispatcher, see: "Workload management dispatcher" on page 161.
- Dispatch concurrency level, see: "Dispatch concurrency level" on page 213.
- Hard CPU shares, see: "Hard CPU shares" on page 181.
- Soft CPU shares, see: "Soft CPU shares" on page 190.
- CPU limit, see: "CPU limit" on page 194.
- Monitoring and tuning workload management dispatcher performance, see: "Monitoring and tuning workload management dispatcher performance" on page 215

Setting minimum CPU resource utilization for service class to be considered active

Set the minimum CPU utilization for a service class by setting the value of the **wlm_disp_min_util** database manager configuration parameter to a percentage. Service classes utilizing CPU resources equal to or greater than that percentage are considered active on the host or logical partition (LPAR) and the CPU shares of the active service classes are factored into CPU allocation calculations.

Procedure

To set the minimum CPU utilization percentage for service classes to be considered active:

Using the command line processor (CLP), issue the **UPDATE DATABASE MANAGER CONFIGURATION** (or **UPDATE DBM CFG**) command and set the value of the **wlm_disp_min_util** database manager configuration parameter to 6%; the parameter value is updated immediately by first attaching to your DB2 instance:

```
attach to instance-name
update dbm cfg using wlm_disp_min_util 6
detach
```

Results

The minimum CPU utilization percentage for service classes to be considered active has been set. Service classes that have a CPU utilization percentage that is less than this minimum are considered to be idle and their CPU allocations can then be proportionally reallocated to service classes that can claim spare CPU resources.

What to do next

After having set the minimum CPU utilization percentage for service classes to be considered active by the workload management dispatcher, consider completing the following tasks:

- For the minimum CPU utilization setting to be effective, you must enable the workload management dispatcher by configuring the **wlm_dispatcher** database manager configuration parameter. See: "Enabling workload management dispatcher" on page 180.
- Set the dispatch concurrency level by configuring the **wlm_disp_concur** database manager configuration parameter. See: "Setting dispatch concurrency level" on page 214.
- Create or alter a service class and configure the CPU limit by using the CREATE SERVICE CLASS or ALTER SERVICE CLASS statement. See: "Setting a CPU limit" on page 209.
- Enable hard and soft CPU shares by configuring the **wlm_disp_cpu_shares** database manager configuration parameter. See step 1 in: "Enabling and setting soft CPU shares" on page 193.
- Create or alter a service class and configure a hard CPU share by using the CREATE SERVICE CLASS or ALTER SERVICE CLASS statement. See: "Enabling and setting hard CPU shares" on page 188.
- Create or alter a service class and configure a soft CPU share by using the CREATE SERVICE CLASS or ALTER SERVICE CLASS statement. See: "Enabling and setting soft CPU shares" on page 193.

Dispatch concurrency level

The workload management dispatcher controls the number of threads that the database manager will allow to be simultaneously dispatched to the operating system (OS). This number is referred to as the dispatch concurrency level. You can set the dispatch concurrency level using the **wlm_disp_concur** database manager configuration parameter. Details are provided here.

Features and functionality

The number of simultaneously executing agents managed by the workload management dispatcher should generally be a low multiple of the number of CPUs on the system. The goal is to establish a concurrency level just large enough to ensure that the CPU resources on the host or LPAR are fully utilized and no larger, while accounting for OS scheduling latencies as threads switch from being active to inactive and vice versa. This optimal value ensures maximum efficiency and gives the workload management dispatcher maximum control over CPU resource allocation. If the configured concurrency value is too small, there will not be enough work to fully utilize the available CPU resources. If the configured concurrency value is too large, the dispatcher will have less control over the work running on the system, which might add to resource contention.

By setting the **wlm_disp_concur** database manager configuration parameter, you can either specify how the DB2 database manager itself sets the concurrency level (`COMPUTED`), or you can manually set the concurrency level to a fixed value.

As a general guideline, the optimal dispatch concurrency level is four times the number of CPUs available on the server hardware. This guideline is typically sufficient for most platforms and is the level you get as the default (COMPUTED is the default setting for the configuration parameter). For complete details about how to set the dispatch concurrency level, see: “Setting dispatch concurrency level.”

The specified value of the **wlm_disp_concur** database configuration parameter applies to each host or LPAR. In multimember database environments, the specified concurrency level is shared between the members.

Tuning

After the workload management dispatcher has been enabled, monitor your system for a drop in throughput and CPU utilization. If a drop does occur in either metric, increase the value of the configuration parameter in increments of the number of available processors.

More information

Complete details are provided about the following subjects:
- Workload management dispatcher, see: “Workload management dispatcher” on page 161.
- Soft CPU shares, see: “Soft CPU shares” on page 190.
- Hard CPU shares, see: “Hard CPU shares” on page 181.
- CPU limit, see: “CPU limit” on page 194.
- Minimum CPU utilization level for a service class to be considered active, see: “Minimum CPU resource utilization for service class to be considered active” on page 210.
- Monitoring and tuning workload management dispatcher performance, see: “Monitoring and tuning workload management dispatcher performance” on page 215

Setting dispatch concurrency level

Set the dispatch concurrency level by setting the value of the **wlm_disp_concur** database manager configuration parameter to COMPUTED or a manually-set value. You set the dispatch concurrency level to an optimal value that ensures maximum efficiency and that gives the workload management dispatcher maximum control over CPU resource allocations.

Procedure

To set the dispatch concurrency level:

Using the command line processor (CLP), issue the **UPDATE DATABASE MANAGER CONFIGURATION** (or **UPDATE DBM CFG**) command and set the value of the **wlm_disp_concur** database manager configuration parameter to one of the following possibilities:
- COMPUTED (default)
- *manually_set_value*

The following example manually sets the dispatch concurrency level to 16, which is 4 times the 4 CPUs available on the system, and is updated immediately by first attaching to your DB2 instance:

```
attach to instance-name
update dbm cfg using wlm_disp_concur 16
detach
```

Results

The dispatch concurrency level has been set. If set to COMPUTED, the concurrency level is determined by the DB2 database manager. If manually set, you might need to tune the concurrency level to an optimal value that ensures maximum efficiency and that gives the workload management dispatcher maximum control over CPU resource allocations.

What to do next

After having set the dispatch concurrency level, consider completing the following tasks:

- For the dispatch concurrency level setting to be effective, you must enable the workload management dispatcher by configuring the **`wlm_dispatcher`** database manager configuration parameter. See: "Enabling workload management dispatcher" on page 180.
- Create or alter a service class and configure the CPU limit by using the CREATE SERVICE CLASS or ALTER SERVICE CLASS statement. See: "Setting a CPU limit" on page 209.
- Enable hard and soft CPU shares by configuring the **`wlm_disp_cpu_shares`** database manager configuration parameter. See step 1 in: "Enabling and setting soft CPU shares" on page 193.
- Create or alter a service class and configure a hard CPU share by using the CREATE SERVICE CLASS or ALTER SERVICE CLASS statement. See: "Enabling and setting hard CPU shares" on page 188.
- Create or alter a service class and configure a soft CPU share by using the CREATE SERVICE CLASS or ALTER SERVICE CLASS statement. See: "Enabling and setting soft CPU shares" on page 193.
- Set the minimum CPU utilization percentage for the workload management dispatcher to consider service classes to be active by configuring the **`wlm_disp_min_util`** database manager configuration parameter. See: "Setting minimum CPU resource utilization for service class to be considered active" on page 212.

After the workload management dispatcher has been enabled and the dispatch concurrency level has been set, monitor your system for a drop in throughput and CPU utilization. If a drop in either metric does occur, increase the value of the **`wlm_disp_concur`** configuration parameter in increments of the number of available processors. For more information about monitoring and tuning workload management dispatcher performance, see: "Monitoring and tuning workload management dispatcher performance"

Monitoring and tuning workload management dispatcher performance

The monitoring and tuning of workload management dispatcher performance can be achieved with the table functions and monitoring elements provided with the DB2 database manager. Details are provided here.

Introduction

To monitor and tune the performance of the workload management dispatcher and achieve the best results, you require the proper tools. Table functions and monitoring elements are provided that can help you monitor the performance of the dispatcher. After analyzing the collected monitoring data as described here, you can adjust the dispatcher concurrency level or redistribute CPU entitlements by adjusting service class CPU shares and CPU limits to tune the dispatcher performance.

The following sections describe the types of workloads to consider, because they differ in how they are best monitored to deliver the appropriate data for you to analyze, and the performance measures which are the most suitable for the particular type of workload under consideration.

Types of workloads

From the perspective of measuring performance for the purpose of tuning your dispatcher configuration to obtain the best possible workload performance from your system, there are two types of workloads to consider: batch and transactional. Each type of workload has characteristic measures of performance that are best suited to determining how well your system is performing under that type of workload. Use the performance measures that best characterize the workload type your system is experiencing.

Batch

A batch workload has one or more applications connecting to the database and each application submits activity after activity or transaction after transaction without any pause. The most important measure of the performance of this workload is how quickly the entire set of activities or transactions is completed. The processing speed of the database manager is the main determinant of how quickly the entire set of activities or transactions is completed.

Transactional

A transactional workload has a user at a terminal that submits an activity or transaction to the database, then waits for a response, analyzes the response, and decides whether or not to submit a follow-up activity or transaction. For this type of workload, the most important measure of its performance is how quickly the user gets back an individual result. The processing speed of the database manager to process a single activity or transaction for each individual user on the system is the main determinant of how quickly the average user can get back an individual result. How quickly the database manager can process all the activities or transactions from a user over a given period of time is not the relevant metric because it is more dependent on user behavior than on the performance of the database manager.

Performance measures

You can use the following performance measures to ascertain how well your system is performing under a particular type of workload.

Average throughput

Average throughput is the average number of service completions per unit time. If the service is a transaction or unit of work (UOW), then the average UOW throughput is the number of unit of work completions per unit time. It is usually presented as transactions per second or transactions per minute. Average throughput is a useful measure of system performance when the type of work being measured is a batch workload.

Average activity throughput is the average number of activity completions per unit time. On a system with mostly long-running units of work containing many individual activities, it is easier to measure the progress of the activities within the workload by measuring activity throughput rather than measure the progress of the workload by measuring UOW throughput.

Average response time

Average response time is the average amount of time it takes to get a single service completion from the time the service was requested. If the service is a transaction or unit of work (UOW), then the average UOW response time is the amount of time it takes for a UOW to complete from the time it was requested. Average response time is a useful measure of system performance when the type of work being measured is a transactional workload. The closest approximation to average UOW response time is the **`uow_lifetime_avg`** statistic available from the MON_SAMPLE_SERVICE_CLASS_METRICS and MON_SAMPLE_WORKLOAD_METRICS table functions, the WLM_GET_SERVICE_SUBCLASS_STATS and WLM_GET_WORKLOAD_STATS table functions, and the event_scstats and event_wlstats event monitor logical data groups reported in the WLM statistics event monitor. A more sophisticated form of UOW lifetime information is available in the UowLifetime histogram, also available in the event monitor.

Average activity response time is the average amount of time it takes to get a single activity to return its result from the time the activity was started. The closest approximation to average activity response time is the **`coord_act_lifetime_avg`** statistic available from the WLM_GET_SERVICE_SUBCLASS_STATS and WLM_GET_WORKLOAD_STATS table functions, and the event_scstats and event_wlstats event monitor logical data groups. This number is measured at each member and is reset when a member is deactivated or the WLM_COLLECT_STATS procedure is called. The reason it can be an approximation is that for one type of activity, a cursor activity, the activity can return some results before it finishes and relies on the user to finish reading the result set and close the cursor before the activity is considered complete. A more sophisticated form of activity lifetime is available in the CoordActLifetime histogram, also available in the event monitor.

CPU utilization

Another metric that is useful when tuning workload management dispatcher, regardless of the type of workload, is the CPU utilization. CPU utilization is the fraction of the time that the CPU resources are busy on the host or LPAR. CPU utilization is the metric that the workload management dispatcher uses to allocate the CPU resources to any one service class. CPU utilization is also the metric that you can use to verify that your workload management dispatcher configuration is working the way you intended. You can measure the CPU utilization over the same intervals as the **`uow_throughput`**, **`uow_lifetime_avg`**, and **`act_throughput`** monitor elements by using the MON_SAMPLE_SERVICE_CLASS_METRICS and MON_SAMPLE_WORKLOAD_METRICS table functions, the WLM_GET_SERVICE_SUBCLASS_STATS and WLM_GET_WORKLOAD_STATS table functions, and the event_scstats and event_wlstats event monitor logical data groups collected and reported by the WLM statistics event monitor.

Note: If CPU utilization measurements are not as expected for your created service classes, check for the presence of workloads that are running under the default user and maintenance service classes because these workloads were not explicitly assigned to service classes that you created. Forgetting to include workloads running under these default service classes, which each have 1000 hard CPU shares assigned by default when CPU shares were first enabled, can account for CPU utilization measurements that are not as you expected.

The CPU utilization reported through the table functions and event monitors is the CPU resources that are consumed by work executing in only the user and maintenance service classes. Work that is not handled by the dispatcher is not counted towards CPU utilization.

Work that is not handled by the workload management dispatcher includes:
- Work performed by applications or middleware products, other than the DB2 database manager, that perform a portion of their work outside of the DB2 database manager
- Work performed by entities executing in the DB2 system service class
- Work performed by other DB2 instances
- Non-DB2 database manager work performed in fenced mode processes (FMPs) such as fenced stored procedures
- Non-DB2 database manager work performed in trusted routines

To obtain the CPU utilization for these other consumers of CPU resources, one must use operating-system-level (OS-level) monitoring such as that provided with OS workload managers.

CPU velocity

CPU velocity is a statistic that determines whether there is contention for a resource and the degree of such contention. When all access to a resource is mutually exclusive and there are multiple requestors of that resource wanting to access it at the same time, there must be some form of queuing for access, or requestors must be turned away. When a queue is allowed to form, the time taken for a requestor to obtain and then finish using a resource can exceed the time spent simply using the resource. The velocity is the ratio of the time spent simply using the resource to the total time spent both waiting for and using the resource. It is measured on a scale of zero to 100%. When there is a high amount of contention for a resource, velocity sinks towards zero. When there is no contention for a resource, then there is no queue time; CPU velocity reaches its maximum value of 100%.

When the workload management dispatcher is enabled, you can measure CPU velocity using the MON_SAMPLE_SERVICE_CLASS_METRICS and MON_SAMPLE_WORKLOAD_METRICS table functions, the WLM_GET_WORKLOAD_STATS and WLM_GET_SERVICE_SUBCLASS_STATS table functions, and the event_scstats and event_wlstats event monitor logical data groups collected and reported by the WLM statistics event monitor. A low CPU velocity value indicates that contention exists for the CPU resources of the host or LPAR and indicates that the workload management dispatcher can be effective in shifting CPU resources towards high-priority service classes and away from low-priority service classes. A high CPU velocity indicates that the workload management dispatcher will have a limited effect on improving workload performance, since every request for CPU resources is already being serviced without any delay.

Canceling activities

If an activity is consuming too many resources, or is running too long, you can cancel it. Canceling an activity is gentler than forcing the application that submitted the activity. A canceled activity returns SQL4725N to the user, but does not end the connection or affect any other user activity. Forcing the application ends both the connection and user activities.

About this task

You can only explicitly cancel an activity if a coordinator activity is currently working on a request for the activity. If you cancel an activity in the IDLE state (that is, no requests are being processed), the activity is placed in the CANCEL_PENDING state and is canceled on the next request that is received. For example, if you attempt to cancel a CURSOR activity between fetches, the SQL4725N error is not returned to the user until the next fetch after the cancel.

All user activities are cancelable, including the load utility and stored procedures.

Procedure

1. Identify the activity that you want to cancel. You can use the WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES table function to identify the activities running in an application. You can also use the MON_GET_ACTIVITY_DETAILS_COMPLETE table function to view additional details about a particular activity if the information in WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES is not sufficient to identify the work that the activities are performing.
2. Cancel the activity using the WLM_CANCEL_ACTIVITY stored procedure. The stored procedure takes the following arguments: *application_handle*, *uow_id*, and *activity_id*. For an example of how to use this stored procedure, see “Scenario: Identifying activities that are taking too long to complete” on page 346.

Chapter 4. Monitoring and intervention

The third domain of workload management is monitoring, which must be performed on an ongoing basis.

The primary purpose of monitoring is to validate the health and efficiency of your system and the individual workloads running on it. Using table functions, you can access real-time operational data such as a list of running workload occurrences and the activities running in a service class or average response times. Using event monitors you can capture detailed activity information and aggregate activity statistics for historical analysis.

Looking at aggregate information should usually be the first step when you build a monitoring strategy. Aggregates give a good picture of overall data server activity and are also cheaper because you do not have to collect information on every activity in which you might be interested. You can collect more detailed information as you understand the scope of your monitoring needs.

Typical monitoring tasks you can perform are:

- Analyzing the workload on your system to help design your initial DB2 workload management configuration.
- Tracking and investigating the behavior of your system by obtaining types of operational information that permit you to:
  - Analyze system performance degradation
  - Diagnose activities that are taking too long to complete
  - Investigate agent contention
  - Isolate poorly performing queries

  Information is available for activities, service classes, workloads, work classes, threshold queues, and threshold violations.
- Exercising control over the execution environment by canceling queued activities that you expect will cause problems or cancel running activities that you have diagnosed as negatively impacting the system.

Real-time monitoring with table functions

Real-time monitoring data includes information about work currently running on the system, statistics, and metrics for work that has been performed on the system that can help you to determine usage patterns and resource allocation and identify problem areas. You use DB2 table functions to obtain this operational information.

Table functions with names that begin with *WLM_* are DB2 workload management table functions. These table functions provide access to a set of data relevant to managing your workload, such as workload management statistics, as a virtual DB2 table against which you can issue a SELECT statement. This enables you to write applications to query data and analyze it as if it were in a physical table on the data server. The DB2 workload management table functions are qualified with the SYSPROC schema name.

Table functions with names that begin with *MON_* are monitoring metrics functions. Monitoring metrics provide monitoring data about the health of and query performance on your DB2 data server, which can then be used as input to a

3rd party tool or in conjunction with additional scripting you provide to analyze the metrics returned. Only those monitoring metrics functions that are relevant for DB2 workload management are included here. The monitor metrics table functions are similar to the workload management statistics table functions. Both return elements describing work that has taken place on the system. The key differences between these monitoring metrics table functions and the DB2 workload management table functions are:

- The DB2 workload management table functions provide data that is more statistical in nature, such as computed values like averages, high watermarks, standard deviations, etc. In contrast, the monitoring metrics table functions provide a much more complete set of raw monitoring data.
- The data reported by the DB2 statistics functions is reset when data is sent to a statistics event monitor. This resetting of data is necessary to make values such as high watermarks meaningful over a specific collection interval. Data reported by the monitoring metrics functions is also captured by a statistics event monitor, but is never reset. The data reported by monitoring interfaces accumulates from the time a database is activated until the time it is deactivated.

Some table functions return sets of information about the work that is currently running on a system:

Table 49. Table functions that show you the work currently running on the system

Objects for which information is collected	**Functions and information returned**
Workload occurrences	The WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES table function returns a list of workload occurrences, across database members, that are assigned to a service class. For each occurrence, there is information about the current state and the connection attributes used to assign the workload to the service class and activity statistics indicating activity volume and success rates. For an example of how to use this table function, see “Example: Investigating agent usage by service class” on page 92. The deprecated WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES_V97 table function is also available.
Workload occurrence activities	The WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES table function returns a list of current activities associated with a workload occurrence. For each activity, information is available about the current state of the activity (for example, executing or queued), the type of activity (for example, LOAD, READ, or DDL), and the time at which the activity started. For examples of how to use this table function, see “Example: Aggregating data using DB2 workload management table functions” on page 231 and “Scenario: Identifying activities that are taking too long to complete” on page 346. The deprecated WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES_V97 table function is also available.

Table 49. Table functions that show you the work currently running on the system (continued)

Objects for which information is collected	Functions and information returned
Service class agents	The WLM_GET_SERVICE_CLASS_AGENTS table function returns a list of database agents associated with a service class or an application handle. Information returned also shows the current state of the agent, the action that the agent is performing, and the status of that action. For an example of how to use this table function, see "Example: Investigating agent usage by service class" on page 92. The deprecated WLM_GET_SERVICE_CLASS_AGENTS_V97 table function is also available.
Activities	The MON_GET_ACTIVITY_DETAILS table function returns metrics and other detailed information as an XML document about a specific activity identified by its application handle, unit of work ID, and activity ID. One detail returned is the activity type; depending on that type, a set of additional data is returned. For example, for SQL activities, cost estimates and information about the statement text, package data, and rows returned or modified are provided. Details about the isolation level and processor resource are also available, amongst others. The deprecated WLM_GET_ACTIVITY_DETAILS table function is also available. For an example that shows you how to use this table function, see "Example: Monitoring current system behavior at different levels using DB2 workload management table functions" on page 227.

Some table functions return monitoring data for all requests executed on the system aggregated by service subclass and workload objects:

Table 50. Table functions that show you monitoring data aggregated by DB2 workload management objects

Objects for which data is aggregated	Functions and information returned
Workloads	Both the MON_GET_WORKLOAD table function and the MON_GET_WORKLOAD_DETAILS table function return metrics for one or more workloads. The metrics returned by this function represent the accumulation of all metrics of all workload occurrences that use the same workload definition. The MON_GET_WORKLOAD table function returns the most commonly used metrics in a column-based format and is an efficient method of retrieving base metrics. The MON_GET_WORKLOAD_DETAILS table function returns the entire set of available metrics in an XML document format, which provides maximum flexibility for formatting output. The XML based output can be parsed directly by an XML parser, or it can be converted to relational format by the XMLTABLE function.

Table 50. Table functions that show you monitoring data aggregated by DB2 workload management objects (continued)

Objects for which data is aggregated	Functions and information returned
Service subclasses	Both the MON_GET_SERVICE_SUBCLASS table function and the MON_GET_SERVICE_SUBCLASS_DETAILS table function return metrics for one or more service subclasses. The metrics returned by the table functions represent the accumulation of all metrics for requests that have executed under the indicated service subclass. The MON_GET_SERVICE_SUBCLASS table function returns the most commonly used metrics in a column based format and is an efficient method of retrieving base metrics. The MON_GET_SERVICE_SUBCLASS_DETAILS table function returns the entire set of available metrics in an XML document format, which provides maximum flexibility for formatting output. The XML-based output can be parsed directly by an XML parser, or it can be converted to relational format by the XMLTABLE function.
Connections	The MON_GET_CONNECTION table function returns data that is aggregated across user connections to the system.
Units of work	The MON_GET_UNIT_OF_WORK table function returns data that is aggregated for the current unit of work within a user connection.

Statistical information

General statistical information is also available for a number of different objects. You can use this statistical information for a number of different purposes, such as for verifying that changes to your DB2 workload management configuration have had the expected effect. If you create a new work class to classify READ activities, for example, you can verify that READ activities are being classified under the new work class correctly. You can also use table functions to quickly recognize certain problems with the system. For example, you can use table functions to determine an acceptable value for the average activity lifetime and recognize when this value exceeds its usual range, possibly indicating a problem that requires further investigation.

The following table lists the statistics that you can obtain by using table functions. All statistics table functions return the statistics that accumulated since the last time that you reset the statistics.

Table 51. Table functions that show you statistical information

Objects for which statistics are returned	Functions and statistics returned
Service superclasses	The WLM_GET_SERVICE_SUPERCLASS_STATS table function shows summary statistics across database members at the service superclass level: namely, high-water marks for concurrent connections, which are useful when determining peak workload activity.

Table 51. Table functions that show you statistical information (continued)

Objects for which statistics are returned	**Functions and statistics returned**
Service subclasses	The WLM_GET_SERVICE_SUBCLASS_STATS table function shows summary statistics across database members at the service subclass level (all activities run in service subclasses). Statistics include numbers of completed activities and average execution times. This information is useful when you are looking at general system health and distribution of activities across service classes and database members. For examples of how to use this table function, see "Example: Obtaining point-in-time statistics from service classes" on page 230, "Example: Aggregating data using DB2 workload management table functions" on page 231, "Example: Analyzing a service class–related system slowdown" on page 91, and "Scenario: Investigating a workload-related system slowdown" on page 342. The deprecated WLM_GET_SERVICE_SUBCLASS_STATS_V97 table function is also available.
Workloads	The WLM_GET_WORKLOAD_STATS table function shows summary statistics across database members at the workload level. These include high-water marks for concurrent workload occurrences and numbers of completed activities. This information is useful when you are monitoring general system health or drilling down to identify problem areas. For an example of how to use this table function, see "Scenario: Investigating a workload-related system slowdown" on page 342. The deprecated WLM_GET_WORKLOAD_STATS_V97 table function is also available.
Work action sets	The WLM_GET_WORK_ACTION_SET_STATS table function shows summary statistics across database members at the work action set level: namely, the number of activities in each work class that had the corresponding work actions applied to them. This information is useful for understanding the effectiveness of a work action set and understanding the types of activities running on the system. For an example of how to use this table function, see "Example: Analyzing workloads by activity type" on page 61.
Threshold queues	The WLM_GET_QUEUE_STATS table function shows summary statistics across database members for the queues used for thresholds. Statistics include the current and total numbers of queued activities and total time spent in a queue. This informations is useful when you are querying current queued activity or validating that you defined a threshold correctly. Excessive queuing might indicate that a threshold is too restrictive, and very little queuing might indicate that a threshold is not restrictive enough or not needed.

Statistics are useful only if the time period during which they are collected is meaningful. Collecting statistics over a very long time, and for any length of time using the WLM_COLLECT_STATS stored procedure, might be less useful if it becomes difficult to identify changes to trends or problem areas because there is too much old data. Thus, you can reset statistics at any time.

Because of the default workload and default user service classes, monitoring capabilities exist from the moment that you install the DB2 data server. These can help you to start identifying sources of activities that you can use to create workloads and the service classes to which you can assign them.

Example: Using DB2 workload management table functions

A large amount of data is available through DB2 workload management real-time monitoring. The example in this topic shows how you might start using the information.

In this situation, only the default workload and service class are in place. Use this example to understand how you can use the table functions to understand what, exactly, is running on the data server. Follow these steps:

1. Use the Service Superclass Statistics table function to show all of the service superclasses. After you install or upgrade to DB2 9.5 or later, three default superclasses are defined: one for maintenance activities, one for system activities, and one for user activities. SYSDEFAULTUSERCLASS is the service class of interest.

```
SELECT VARCHAR(SERVICE_SUPERCLASS_NAME,30) AS SUPERCLASS
   FROM TABLE(WLM_GET_SERVICE_SUPERCLASS_STATS('',-1)) AS T

SUPERCLASS
------------------------------
SYSDEFAULTSYSTEMCLASS
SYSDEFAULTMAINTENANCECLASS
SYSDEFAULTUSERCLASS

  3 record(s) selected.
```

2. Use the Service Subclass Statistics table function to show statistics for all the service subclasses of the SYSDEFAULTUSERCLASS superclass. For each service subclass you can see the current volume of requests that are being processed, the number of activities that have completed execution, and the overall distribution of activities across members (possibly indicating a problem if the distribution is uneven). You can optionally obtain additional statistics including the average lifetime for activities, the average amount of time activities spend queued, and so on. You can obtain optional statistics for a service subclass by specifying the COLLECT AGGREGATE ACTIVITY DATA keyword on the ALTER SERVICE CLASS statement to enable aggregate activity statistics collection.

```
SELECT VARCHAR(SERVICE_SUPERCLASS_NAME, 20) AS SUPERCLASS,
   VARCHAR(SERVICE_SUBCLASS_NAME, 20) AS SUBCLASS,
   COORD_ACT_COMPLETED_TOTAL,
   COORD_ACT_ABORTED_TOTAL,
   COORD_ACT_REJECTED_TOTAL,
   CONCURRENT_ACT_TOP
FROM TABLE(WLM_GET_SERVICE_SUBCLASS_STATS(
   'SYSDEFAULTUSERCLASS', 'SYSDEFAULTSUBCLASS', -1))
   AS T
```

```
SUPERCLASS           SUBCLASS             COORD_ACT_COMPLETED_TOTAL COORD_ACT_ABORTED_TOTAL COORD_ACT_REJECTED_TOTAL CONCURRENT_ACT_TOP
-------------------- -------------------- ------------------------- ----------------------- ------------------------ ------------------
SYSDEFAULTUSERCLASS  SYSDEFAULTSUBCLASS                           2                       0                        0                  1

  1 record(s) selected.
```

3. For a given service subclass, use the Workload Occurrence Information table function to list the occurrences of a workload that are mapped to the service subclass. The table function displays all of the connection attributes, which you can use to identify the source of the activities. This information can be quite useful in determining custom workload definitions in the future. For example, perhaps a specific workload occurrence listed here has a large volume of work from an application as shown by the activities completed counter.

```
SELECT APPLICATION_HANDLE,
   VARCHAR(WORKLOAD_NAME, 30) AS WORKLOAD,
   VARCHAR(SESSION_AUTH_ID, 20) AS SESSION_AUTH_ID,
   VARCHAR(APPLICATION_NAME, 20) AS APPL_NAME
FROM TABLE(WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES(
   'SYSDEFAULTUSERCLASS', 'SYSDEFAULTSUBCLASS', -1))
   AS T

APPLICATION_HANDLE   WORKLOAD                       SESSION_AUTH_ID      APPL_NAME
-------------------- ------------------------------ -------------------- --------------------
                 431 SYSDEFAULTUSERWORKLOAD         SWALKTY              db2bp

  1 record(s) selected.
```

a. For that application, use the Workload Occurrence Activities Information table function to show the current activities across database members that were created from the application's connection. You can use this information for a number of purposes, including identifying activities that might be causing problems on the data server.

```
SELECT APPLICATION_HANDLE,
   LOCAL_START_TIME,
   UOW_ID,
   ACTIVITY_ID,
   ACTIVITY_TYPE
FROM TABLE(WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES(431,-1)) AS T

APPLICATION_HANDLE   LOCAL_START_TIME           UOW_ID      ACTIVITY_ID ACTIVITY_TYPE
-------------------- -------------------------- ----------- ----------- --------------------------------
                 431 2008-06-17-12.49.46.854259          11           1 READ_DML

  1 record(s) selected
```

b. For each activity, retrieve more detailed information by using the Activity Details table function. The data might show that some SQL statements are returning huge numbers of rows, that some activities have been idle for a long time, or that some queries are running that have an extremely large estimated cost. In situations such as these, it might make sense to define some thresholds to identify and prevent potentially damaging behavior in the future.

```
SELECT VARCHAR(NAME, 20) AS NAME,
   VARCHAR(VALUE, 40) AS VALUE
FROM TABLE(WLM_GET_ACTIVITY_DETAILS(431,11,1,-1))
   AS T WHERE NAME IN ('UOW_ID', 'ACTIVITY_ID', 'STMT_TEXT')

NAME                 VALUE
-------------------- ----------------------------------------
UOW_ID               1
ACTIVITY_ID          1
STMT_TEXT            select * from syscat.tables

  3 record(s) selected.
```

Example: Monitoring current system behavior at different levels using DB2 workload management table functions

DB2 workload management provides a number of table functions that you can use to obtain data about your workload management configuration.

Installing DB2 Version 9.5 or later creates a set of default workloads and service classes. Before deciding how to implement your own DB2 workload management solution, you can use the table functions to observe work being performed in the system in terms of the default workload occurrences, service classes, and activities.

You can start by obtaining the list of workload occurrences in a service class. To do this, use the WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES table function. In the following example, an empty string is passed for *service_superclass_name* and *service_subclass_name*, and -2 (a wildcard character) is passed for *member*:

```
SELECT SUBSTR(SERVICE_SUPERCLASS_NAME,1,19) AS SUPERCLASS_NAME,
       SUBSTR(SERVICE_SUBCLASS_NAME,1,18) AS SUBCLASS_NAME,
       SUBSTR(CHAR(MEMBER),1,4) AS MEMB,
       SUBSTR(CHAR(COORD_MEMBER),1,4) AS COORDMEMB,
       SUBSTR(CHAR(APPLICATION_HANDLE),1,7) AS APPHNDL,
       SUBSTR(CHAR(WORKLOAD_NAME),1,22) AS WORKLOAD_NAME,
       SUBSTR(CHAR(WORKLOAD_OCCURRENCE_ID),1,6) AS WLO_ID
FROM TABLE(WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES('', '', -2)) AS SCINFO
ORDER BY SUPERCLASS_NAME, SUBCLASS_NAME, MEMB, APPHNDL, WORKLOAD_NAME, WLO_ID
```

Assume that the system has four database members and that there are two applications performing activities on the database when you issue the query. The results would resemble the following ones:

```
SUPERCLASS_NAME     SUBCLASS_NAME      MEMB COORDMEMB APPHNDL WORKLOAD_NAME          WLO_ID
------------------- ------------------ ---- --------- ------- -----------------------------
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 0    0         1       SYSDEFAULTUSERWORKLOAD 1
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 0    0         2       SYSDEFAULTUSERWORKLOAD 2
```

The results indicate that both workload occurrences were assigned to the SYSDEFAULTUSERWORKLOAD workload. The results also show that both workload occurrences were assigned to the SYSDEFAULTSUBCLASS service subclass in the SYSDEFAULTUSERCLASS service superclass and that both workload occurrences are from the same coordinator member (member 0).

Next, you can also use the WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES table function again to determine the connection attributes of the two workload occurrences:

```
SELECT SUBSTR(CHAR(APPLICATION_HANDLE),1,7) AS APPHNDL,
       SUBSTR(CHAR(WORKLOAD_NAME),1,22) AS WORKLOAD_NAME,
       SUBSTR(CHAR(WORKLOAD_OCCURRENCE_ID),1,6) AS WLO_ID,
       SUBSTR(CHAR(SYSTEM_AUTH_ID),1,9) AS SYSAUTHID,
       SUBSTR(CHAR(APPLICATION_NAME),1,15) AS APPLNAME
FROM TABLE(WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES('', '', 0)) AS SCINFO
ORDER BY APPHNDL, WORKLOAD_NAME, WLO_ID

APPHNDL WORKLOAD_NAME          WLO_ID SYSAUTHID APPLNAME
------- ---------------------- ------ --------- ---------------
1       SYSDEFAULTUSERWORKLOAD 1      LYNN      accountspay
2       SYSDEFAULTUSERWORKLOAD 2      KATE      businessobjects
```

Then, you can use the WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES table function to show the current activities of one of the workload occurrences:

```
SELECT SUBSTR(CHAR(COORD_MEMBER),1,5) AS COORD,
       SUBSTR(CHAR(MEMBER),1,4) AS MEMB,
       SUBSTR(CHAR(UOW_ID),1,5) AS UOWID,
       SUBSTR(CHAR(ACTIVITY_ID),1,5) AS ACTID,
       SUBSTR(CHAR(PARENT_UOW_ID),1,8) AS PARUOWID,
       SUBSTR(CHAR(PARENT_ACTIVITY_ID),1,8) AS PARACTID,
       SUBSTR(ACTIVITY_TYPE,1,9) AS ACTTYPE,
       SUBSTR(CHAR(NESTING_LEVEL),1,7) AS NESTING
FROM TABLE(WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES(1, -2)) AS WLOACTS
ORDER BY MEMB, UOWID, ACTID

COORD MEMB UOWID ACTID PARUOWID PARACTID ACTTYPE  NESTING
----- ---- ----- ----- -------- -------- -------- -------
0     0    1     3     -        -        CALL     0
0     0    1     5     1        3        READ_DML 1
```

```
0     1    1     5     -        -        READ_DML 1
0     2    1     5     -        -        READ_DML 1
0     3    1     5     -        -        READ_DML 1
```

The query results show that workload occurrence 1 is running two activities. One activity is a stored procedure (indicated by the activity type of CALL), and the other activity is a DML activity that performs a read (for example, a SELECT statement). The DML activity is nested in the stored procedure call. You can tell that the DML activity is nested because the parent unit of work identifier and parent activity identifier of the DML activity match the unit of work identifier and the activity identifier of the CALL activity. You can also tell that the DML activity is executing on database members 0, 1, 2, and 3. The parent identifier information is available only on the coordinator member.

You can obtain more information about an individual activity that is currently running by using the MON_GET_ACTIVITY_DETAILS table function. This table function returns an XML document where the elements in the document describe the activity. In this example, the XMLTABLE function is used to return a result table from the XML output.

```
SELECT D.APP_HANDLE,
       D.MEMBER,
       D.COORD_MEMBER,
       D.LOCAL_START_TIME,
       D.UOW_ID,
       D.ACTIVITY_ID,
       D.PARENT_UOW_ID,
       D.PARENT_ACTIVITY_ID,
       D.ACTIVITY_TYPE,
       D.NESTING_LEVEL,
       D.INVOCATION_ID,
       D.ROUTINE_ID
FROM TABLE(MON_GET_ACTIVITY_DETAILS(65592, 1, 1, -2)) AS ACTDETAILS,
XMLTABLE (XMLNAMESPACES( DEFAULT 'http://www.ibm.com/xmlns/prod/db2/mon'),
          '$details/db2_activity_details' PASSING XMLPARSE(DOCUMENT
    ACTDETAILS.DETAILS) as "details"
COLUMNS "APP_HANDLE"         BIGINT    PATH 'application_handle',
        "MEMBER"             BIGINT    PATH 'member',
        "COORD_MEMBER"       BIGINT    PATH 'coord_member',
        "LOCAL_START_TIME"   VARCHAR(26) PATH 'local_start_time',
        "UOW_ID"             BIGINT    PATH 'uow_id',
        "ACTIVITY_ID"        BIGINT    PATH 'activity_id',
        "PARENT_UOW_ID"      BIGINT    PATH 'parent_uow_id',
        "PARENT_ACTIVITY_ID" BIGINT    PATH 'parent_activity_id',
        "ACTIVITY_TYPE"      VARCHAR(10) PATH 'activity_type',
        "NESTING_LEVEL"      BIGINT    PATH 'nesting_level',
        "INVOCATION_ID"      BIGINT    PATH 'invocation_id',
        "ROUTINE_ID"         BIGINT    PATH 'routine_id'
) AS D;
```

```
APP_HANDLE           MEMBER               COORD_MEMBER         LOCAL_START_TIME
UOW_ID               ACTIVITY_ID          PARENT_UOW_ID
PARENT_ACTIVITY_ID   ACTIVITY_TYPE NESTING_LEVEL        INVOCATION_ID
ROUTINE_ID
-------------------- -------------------- --------------------
------------------------- -------------------- --------------------
-------------------- -------------------- ------------- --------------------
-------------------- --------------------
               65592                    1                    1
        2009-04-07-18.39.42.549197                    1
        1                    -                    - READ_DML                         0                    0                    0
               65592                    0                    1
        2009-04-07-18.39.42.552763                    1
        1                    -                    - READ_DML                         0                    0                    0

  2 record(s) selected.
```

The table functions mentioned previously provide a high-level description of work that is running in the system. The information that these table functions provide regarding the status of the work is limited to an activity state such as

EXECUTING. If you want to probe further to discover what exactly is occurring in a service class at a point in time, you can run the WLM_GET_SERVICE_CLASS_AGENTS table function.

In the following example, WLM_GET_SERVICE_CLASS_AGENTS is called by passing 1 for *application_handle* and -2 (a wildcard character) for *member*:

```
SELECT SUBSTR(CHAR(APPLICATION_HANDLE),1,7) AS APPHANDLE,
       SUBSTR(CHAR(MEMBER),1,4) AS MEMB,
       SUBSTR(CHAR(AGENT_TID),1,9) AS AGENT_TID,
       SUBSTR(AGENT_TYPE,1,11) AS AGENTTYPE,
       SUBSTR(AGENT_STATE,1,10) AS AGENTSTATE,
       SUBSTR(REQUEST_TYPE,1,14) AS REQTYPE,
       SUBSTR(CHAR(UOW_ID),1,6) AS UOW_ID,
       SUBSTR(CHAR(ACTIVITY_ID),1,6) AS ACT_ID
FROM TABLE(WLM_GET_SERVICE_CLASS_AGENTS('', '', 1, -2)) AS SCDETAILS
ORDER BY APPHANDLE, MEMB, AGENT_TID

APPHANDLE MEMB AGENT_TID AGENTTYPE   AGENTSTATE REQTYPE      UOW_ID ACT_ID
--------- ---- --------- ----------- ---------- --------------------------
1         0    3         COORDINATOR ACTIVE     FETCH             1      5
1         0    4         PDBSUBAGENT ACTIVE     SUBSECTION:1      1      5
1         1    2         PDBSUBAGENT ACTIVE     SUBSECTION:2      1      5
```

The results show a coordinator agent and a subagent on member 0 and a subagent on member 1 operating on behalf of an activity with a unit of work identifier of 1 and an activity identifier of 5. The coordinator agent information indicates that the request is a fetch request.

Example: Obtaining point-in-time statistics from service classes

Every activity is mapped to a service class before being executed. You can monitor the system by using the service class statistics table functions and querying all of the service classes on all of the database members to obtain point-in-time statistics.

You can use the following statement to obtain service class statistics, such as the average activity lifetime. Passing an empty string for an argument for the WLM_GET_SERVICE_SUBCLASS_STATS table function means that the result is not to be restricted by that argument. The value of the last argument, *member*, is -2 (a wildcard character), which means that data from all database members is to be returned.

Note: Lifetime information is only returned for those service classes that are defined with COLLECT AGGREGATE ACTIVITY DATA.

```
SELECT SUBSTR(SERVICE_SUPERCLASS_NAME,1,19) AS SUPERCLASS_NAME,
       SUBSTR(SERVICE_SUBCLASS_NAME,1,18) AS SUBCLASS_NAME,
       SUBSTR(CHAR(MEMBER),1,4) AS MEMB,
       CAST(COORD_ACT_LIFETIME_AVG / 1000 AS DECIMAL(9,3)) AS AVGLIFETIME,
       CAST(COORD_ACT_LIFETIME_STDDEV / 1000 AS DECIMAL(9,3)) AS STDDEVLIFETIME,
       SUBSTR(CAST(LAST_RESET AS VARCHAR(30)),1,16) AS LAST_RESET
FROM TABLE(WLM_GET_SERVICE_SUBCLASS_STATS('', '', -2)) AS SCSTATS
ORDER BY SUPERCLASS_NAME, SUBCLASS_NAME, MEMB
```

```
SUPERCLASS_NAME     SUBCLASS_NAME      MEMB AVGLIFETIME STDDEVLIFETIME LAST_RESET
------------------- ------------------ ---- ----------- -------------- ----------------
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 0        691.242         34.322 2006-07-24-11.44
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 1        644.740         22.124 2006-07-24-11.44
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 2        612.431         43.347 2006-07-24-11.44
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 3        593.451         28.329 2006-07-24-11.44
```

You can also use the WLM_GET_SERVICE_SUBCLASS_STATS table function to obtain the high watermark for the concurrency of coordinator activities that run in the service class on each member:

```
SELECT SUBSTR(SERVICE_SUPERCLASS_NAME,1,19) AS SUPERCLASS_NAME,
       SUBSTR(SERVICE_SUBCLASS_NAME,1,18) AS SUBCLASS_NAME,
       SUBSTR(CHAR(MEMBER),1,4) AS MEMB,
       CONCURRENT_ACT_TOP AS ACTHIGHWATERMARK
FROM TABLE(WLM_GET_SERVICE_SUBCLASS_STATS('', '',  -2)) AS SCSTATS
ORDER BY SUPERCLASS_NAME, SUBCLASS_NAME, MEMB

SUPERCLASS_NAME     SUBCLASS_NAME      MEMB ACTHIGHWATERMARK
------------------- ------------------ ---- ----------------
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 0                  10
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 1                   0
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 2                   0
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 3                   0
```

By reviewing the average lifetime and number of completed activities, you can use the output of the WLM_GET_SERVICE_SUBCLASS_STATS table function to obtain a rolled-up view of the workload on each member in the database. Significant variations in the high watermarks and averages returned by a table function might indicate a change in the workload on the system.

Example: Aggregating data using DB2 workload management table functions

You can perform various aggregations on table data in a DB2 workload management configuration to monitor the system and identify potential problems.

The following is an example of data aggregation that you can perform to identify problems.

Identifying sudden increases in the number of queries running in a workload

Assume that you have a workload called WL1. You can identify a situation in which a large number of queries are running in the workload by showing the total number of executing non-nested coordinator activities for the workload across the whole system:

```
SELECT SUBSTR(WORKLOAD_NAME,1,22) AS WLNAME,
COUNT(*) AS TOTAL_EXE_ACT
FROM TABLE(WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES('', '', -2)) AS APPS,
TABLE(WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES(APPS.APPLICATION_HANDLE, -2)) AS APPACTS
WHERE WORKLOAD_NAME = 'WL1' AND
APPS.DBPARTITIONNUM = APPS.COORD_PARTITION_NUM AND
ACTIVITY_STATE = 'EXECUTING' AND
NESTING_LEVEL = 0
GROUP BY WORKLOAD_NAME

WLNAME               TOTAL_EXE_ACT
-------------------- -------------
WL1                  5
```

Example: Determining which activities are queued by a WLM threshold and their queue order

You can use a DB2 workload manager (WLM) table function, WLM_GET_SERVICE_CLASS_AGENTS, to view which applications or activities are queued by a WLM threshold and the order of the applications or activities in the queue.

Any agent queued by a WLM threshold will have the value WLM_QUEUE in the EVENT_OBJECT column in the corresponding row returned for the agent. In addition, the AGENT_STATE_LAST_UPDATE_TIME column will contain the time that the agent entered the WLM_QUEUE state, which is the time that the agent was queued. Using this information, a simple view can be constructed to list all applications or activities that are queued by a WLM threshold, and to obtain their queue entry time.

To create a view that uses the WLM_GET_SERVICE_CLASS_AGENTS table function to obtain the WLM queue information for the examples provided here, run the following statement:

```
CREATE VIEW WLM_QUEUE_INFO (APPLICATION_HANDLE, UOW_ID, ACTIVITY_ID,
    THRESHOLD_NAME, QUEUE_ENTRY_TIME, MEMBER)
    AS SELECT APPLICATION_HANDLE, UOW_ID, ACTIVITY_ID,
    VARCHAR(EVENT_OBJECT_NAME, 128), AGENT_STATE_LAST_UPDATE_TIME,
    MEMBER FROM TABLE(WLM_GET_SERVICE_CLASS_AGENTS(NULL,NULL,NULL,-2))
    AS T WHERE EVENT_OBJECT = 'WLM_QUEUE'
```

Note: For TOTALSCPARTITIONCONNECTIONS thresholds, **uow_id** and **activity_id** are not applicable (NA) and, therefore, show up as NULL.

This view can be used to easily answer questions such as the following:
- How many applications or activities are currently queued by a WLM threshold?
- What is the order of the applications or activities in the WLM threshold queue?

Example 1

To count the number of applications queued by each queuing threshold, run the following statement:

```
SELECT VARCHAR(THRESHOLD_NAME, 30) AS THRESHOLD, COUNT(*)
     AS QUEUED_ENTRIES FROM WLM_QUEUE_INFO GROUP BY THRESHOLD_NAME
```

The following is a sample of the output obtained after running the preceding statement:

```
THRESHOLD                      QUEUED_ENTRIES
------------------------------ --------------
TH1                                         3

  1 record(s) selected.
```

Example 2

To list all the activities that are queued in the TH1 CONCURRENTDBCOORDACTIVITIES threshold and show the order of the activities in the queue determined by their queue entry time, run the following statement:

```
SELECT QUEUE_ENTRY_TIME, APPLICATION_HANDLE, UOW_ID, ACTIVITY_ID FROM
     WLM_QUEUE_INFO WHERE THRESHOLD_NAME = 'TH1' ORDER BY QUEUE_ENTRY_TIME ASC
```

The following is a sample of the output obtained after running the preceding statement:

```
QUEUE_ENTRY_TIME           APPLICATION_HANDLE   UOW_ID      ACTIVITY_ID
-------------------------- -------------------- ----------- -----------
2009-11-09-18.08.32.583286                  145           1           2
```

```
2009-11-09-18.08.42.589623                146          1           1
2009-11-09-18.08.54.607083                147          1           1

  3 record(s) selected.
```

Historical monitoring with WLM event monitors

DB2 workload management uses event monitors to capture information that might be of use in the future or for historical analysis.

Three event monitors are available for you to use. Each event monitor serves a different purpose:

Activity event monitor

This monitor captures information about individual activities in a service class, workload, or work class or activities that violated a threshold. The amount of data that is captured for each activity is configurable and should be considered when you determine the amount of disk space and the length of time required to keep the monitor data. A common use for activity data is to use it as input to tools such as **`db2advis`** or to use access plans (from the explain utility) to help determine table, column, and index usage for a set of queries.

You can collect information about an activity by specifying COLLECT ACTIVITY DATA for the service class, workload, or work action to which such an activity belongs or a threshold that might be violated by such an activity. The information is collected when the activity completes, regardless of whether the activity completes successfully.

Note that if an activities event monitor is active when the database deactivates, any backlogged activity records in the queue are discarded. To ensure that you obtain all activities event monitor records and that none are discarded, explicitly deactivate the activities event monitor first before deactivating the database. When an activities event monitor is explicitly deactivated, all backlogged activity records in the queue are processed before the event monitor deactivates.

Threshold violations event monitor

This monitor captures information when a threshold is violated. It indicates what threshold was violated, the activity that caused the violation, and what action was taken when it occurred.

If you specify COLLECT ACTIVITY DATA for the threshold and an activities event monitor is created and active, information is also collected about activities that violate the threshold, but this information is collected when the activity ends (either successfully or unsuccessfully).

You can obtain details about a threshold by querying the SYSCAT.THRESHOLDS view.

Statistics event monitor

This monitor serves as a low-overhead alternative to capturing detailed activity information by collecting aggregate data (for example, the number of activities completed and average execution time). Aggregate data includes histograms for a number of activity measurements including lifetime, queue time, execution time and estimated cost. You can use histograms to understand the distribution of values, identify outliers, and compute additional statistics such as averages and standard deviations. For example, histograms can help you understand the variation in lifetime that users experience. The average life time alone does not reflect what a user experiences if there is a high degree of variability. See "Collecting workload management statistics using a statistics event monitor" on page 262 for a description of how to send statistics to the event monitor.

The following figure shows the different monitoring options available to access workload information: table functions to access real-time statistics, and activity details and historical information captured as efficient aggregates or as details about individual activities:

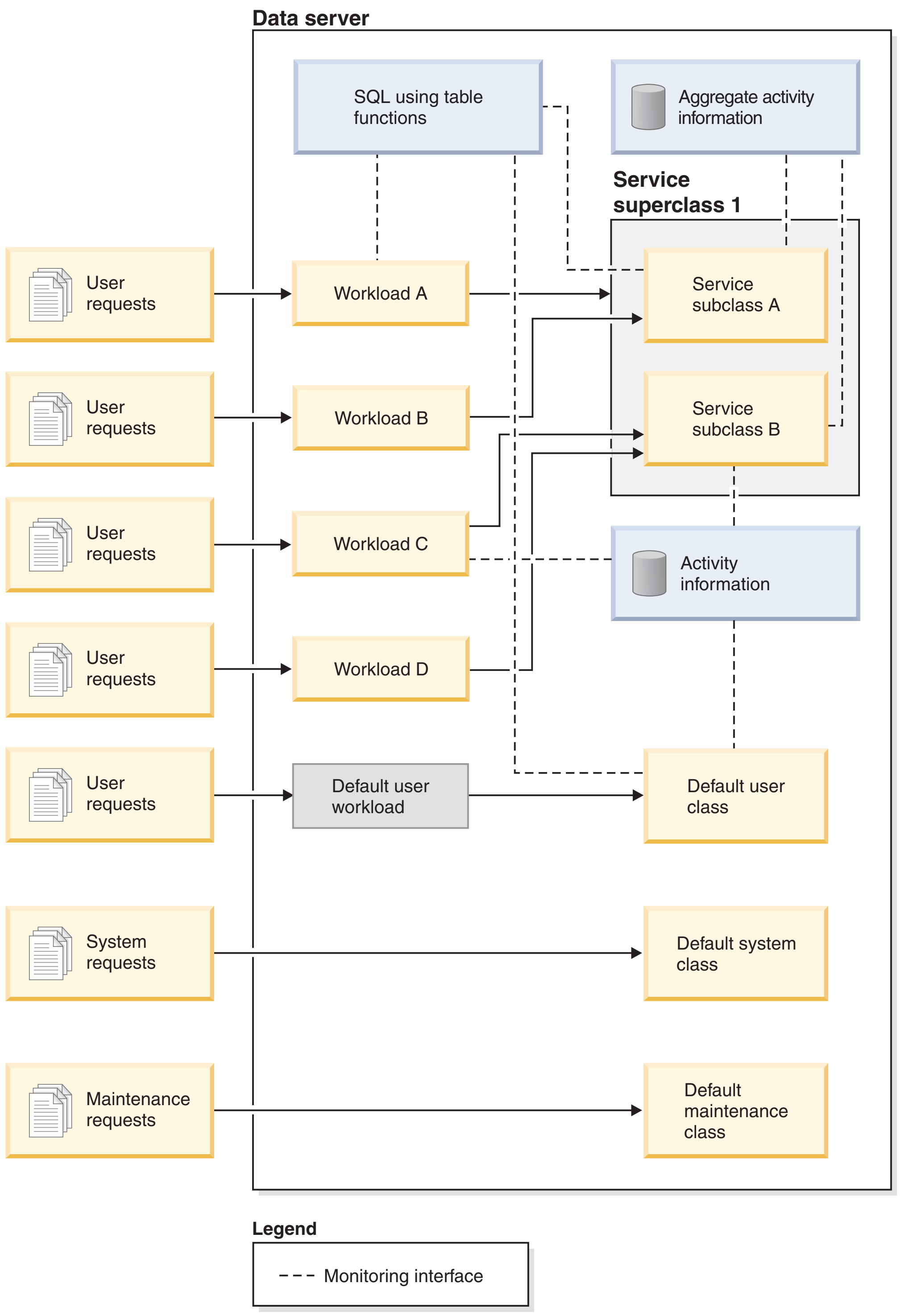


Figure 46. Workload management with monitoring

Unlike statement, connection, and transaction event monitors, the activity, statistics, and threshold violations event monitors do not have event conditions (that is, conditions specified on the WHERE keyword of the CREATE EVENT MONITOR statement). Instead, these event monitors rely on the attributes of service classes, workloads, work classes, and thresholds to determine whether these objects send their activity information or aggregate information to these monitors.

Typically, event monitors write data to either tables or files. You need to prune these tables or files periodically because they are not automatically pruned.

You can use the **wlmevmon.ddl** script in the sqllib/misc directory to create and enable three event monitors called DB2ACTIVITIES, DB2STATISTICS, and DB2THRESHOLDVIOLATIONS. If necessary, modify the script to change the table space or other parameters.

Example

Example: Identify queries with a large estimated cost using the statistics event monitor: You suspect that your database workload occasionally includes large, expensive queries, possibly due to the poor optimization of the queries themselves. You want to identify these queries so that you can prevent them from consuming excessive resources on your system, with a long-term goal of perhaps rewriting some of the queries to improve performance. The statistics event monitor provides you with a low-overhead way to measure the estimated cost of your queries which you can then use to determine what the maximum acceptable estimated cost for a query on your data server should be. A query that is poorly optimized is typically distinguished by a large estimated cost that is many times larger than the estimated cost of most other queries.

To get started, you need to create and activate a statistics event monitor and to start collecting extended aggregate activity data for the service class where the queries run:

```
CREATE EVENT MONITOR DB2STATISTICS
  FOR STATISTICS WRITE TO TABLE

SET EVENT MONITOR DB2STATISTICS STATE 1
```

In this example, all queries run in the SYSDEFAULTSUBCLASS subclass of the SYSDEFAULTUSERCLASS service class, which you can alter to collect the required data:

```
ALTER SERVICE CLASS SYSDEFAULTSUBCLASS UNDER SYSDEFAULTUSERCLASS
   COLLECT AGGREGATE ACTIVITY DATA EXTENDED
```

A full day of work might provide a reasonable approximation of the range of queries your data server typically processes. At the end of the day, you can copy the statistics collected from memory to the statistics event monitor by running the WLM_COLLECT_STATS stored procedure:

```
CALL WLM_COLLECT_STATS()
```

Included with the different statistics written to the event monitor tables are the estimated cost statistics of queries. To see them, you can query the service class statistics table SCSTATS_DB2STATISTICS:

```
SELECT STATISTICS_TIMESTAMP,
       COORD_ACT_EST_COST_AVG,
       COST_ESTIMATE_TOP
FROM SCSTATS_DB2STATISTICS
WHERE SERVICE_SUPERCLASS_NAME = 'SYSDEFAULTUSERCLASS'
  AND SERVICE_SUBCLASS_NAME = 'SYSDEFAULTSUBCLASS'

STATISTICS_TIMESTAMP       COORD_ACT_EST_COST_AVG COST_ESTIMATE_TOP
-------------------------- ---------------------- --------------------
2008-09-03-09.49.04.455979                 169440             13246445

  1 record(s) selected.
```

The output shows that the average query has an estimated cost in the range of hundreds of thousands of timerons, and that the largest queries have estimated costs larger than ten million timerons. You can confirm that queries of ten million or more timerons are outliers by looking at the estimated cost histogram, which was generated at the same time that the average and high watermarks shown in the output were written to the event monitor table. You can look at the histogram by querying the HISTOGRAMBIN_DB2STATISTICS table as follows:

```
SELECT STATISTICS_TIMESTAMP,
       TOP,
       NUMBER_IN_BIN
FROM HISTOGRAMBIN_DB2STATISTICS HIST,
     SYSCAT.SERVICECLASSES SC
WHERE HIST.SERVICE_CLASS_ID = SC.SERVICECLASSID
  AND SC.PARENTSERVICECLASSNAME = 'SYSDEFAULTUSERCLASS'
  AND SC.SERVICECLASSNAME = 'SYSDEFAULTSUBCLASS'
  AND HISTOGRAM_TYPE = 'COORDACTESTCOST'"
```

```
STATISTICS_TIMESTAMP       TOP                  NUMBER_IN_BIN
-------------------------- -------------------- --------------------
2008-09-03-09.49.04.455979                    1                    0
2008-09-03-09.49.04.455979                    2                    0
2008-09-03-09.49.04.455979                    3                    0
2008-09-03-09.49.04.455979                    5                    0
2008-09-03-09.49.04.455979                    8                    0
2008-09-03-09.49.04.455979                   12                    1
2008-09-03-09.49.04.455979                   19                    0
2008-09-03-09.49.04.455979                   29                    0
2008-09-03-09.49.04.455979                   44                    2
2008-09-03-09.49.04.455979                   68                    5
2008-09-03-09.49.04.455979                  103                   22
2008-09-03-09.49.04.455979                  158                   14
2008-09-03-09.49.04.455979                  241                   54
2008-09-03-09.49.04.455979                  369                    2
2008-09-03-09.49.04.455979                  562                  142
2008-09-03-09.49.04.455979                  858                   21
2008-09-03-09.49.04.455979                 1309                  123
2008-09-03-09.49.04.455979                 1997                  512
2008-09-03-09.49.04.455979                 3046                  643
2008-09-03-09.49.04.455979                 4647                  201
2008-09-03-09.49.04.455979                 7089                  875
2008-09-03-09.49.04.455979                10813                 1445
2008-09-03-09.49.04.455979                16493                 5386
2008-09-03-09.49.04.455979                25157                 2409
2008-09-03-09.49.04.455979                38373                 8940
2008-09-03-09.49.04.455979                58532                 9820
2008-09-03-09.49.04.455979                89280                 2149
2008-09-03-09.49.04.455979               136181                  798
2008-09-03-09.49.04.455979               207720                 2411
2008-09-03-09.49.04.455979               316840                14989
2008-09-03-09.49.04.455979               483283                 9831
2008-09-03-09.49.04.455979               737162                 1451
2008-09-03-09.49.04.455979              1124409                  213
2008-09-03-09.49.04.455979              1715085                   24
2008-09-03-09.49.04.455979              2616055                    1
2008-09-03-09.49.04.455979              3990325                    0
2008-09-03-09.49.04.455979              6086529                    0
2008-09-03-09.49.04.455979              9283913                    0
2008-09-03-09.49.04.455979             14160950                    3
2008-09-03-09.49.04.455979             21600000                    0
2008-09-03-09.49.04.455979                   -1                    0
```

In the histogram, the value in the number_in_bin column for queries whose top is greater than 2616055 is zero until top reaches 14160950, where the number_in_bin becomes 3. These three queries are outliers and can be controlled with an ESTIMATEDSQLCOST threshold set to trigger if the estimated cost of a query exceeds 10 million timerons which you can use to prevent such activities from executing and to monitor them more closely.

Example: Using the threshold violations event monitor: To control activities of a certain estimated cost, you want to define an ESTIMATEDSQLCOST threshold on your workload that applies only to that subset of your total workload exceeding a certain estimated cost. Having looked at the estimated cost histogram, you determined that activities with an estimated cost in the range of 0 to under 3 million timerons occur frequently and that activities with an estimated cost over 10 million timerons occur rarely (perhaps only a few times a day and perhaps always due to some flaw in the query, such as the use of a Cartesian join).

To verify that a threshold of 10 million timerons is effective in stopping those few activities a day that should not be allowed to run, you can create and activate a threshold event monitor:

```
CREATE THRESHOLD TH1
  FOR DATABASE ACTIVITIES
  ENFORCEMENT DATABASE
  WHEN ESTIMATEDSQLCOST > 10000000
  STOP EXECUTION

CREATE EVENT MONITOR DB2THRESHOLDVIOLATIONS
  FOR THRESHOLD VIOLATIONS
  WRITE TO TABLE

SET EVENT MONITOR DB2THRESHOLDVIOLATIONS STATE 1
```

After the end of the day, you can see what threshold violations occurred by querying the threshold violations table:

```
SELECT THRESHOLDID,
       SUBSTR(THRESHOLD_PREDICATE, 1, 20) PREDICATE,
       TIME_OF_VIOLATION,
       THRESHOLD_MAXVALUE,
       THRESHOLD_ACTION
FROM THRESHOLDVIOLATIONS_DB2THRESHOLDVIOLATIONS
ORDER BY TIME_OF_VIOLATION, THRESHOLDID
```

```
THRESHOLDID PREDICATE            TIME_OF_VIOLATION          THRESHOLD_MAXVALUE   THRESHOLD_ACTION
----------- -------------------- -------------------------- -------------------- ----------------
          1 EstimatedSQLCost     2008-09-02-22.39.10.000000             10000000 Stop

  1 record(s) selected.
```

Example: Using the activity event monitor

The previous example showed how you can collect threshold information in an event monitor table to confirm that activities with a large estimated cost are being prevented from executing by a threshold. After seeing these threshold violations, you want to determine what the SQL statement texts producing these large queries are, so that you can use the explain facility to determine if an index is needed on the tables being queried.

Collecting this additional information requires creating and activating an activity event monitor and altering the threshold to turn on activity collection with details:

```
CREATE EVENT MONITOR DB2ACTIVITIES
  FOR ACTIVITIES WRITE TO TABLE

SET EVENT MONITOR DB2ACTIVITIES STATE 1
```

```
ALTER THRESHOLD TH1
  WHEN EXCEEDED
  COLLECT ACTIVITY DATA WITH DETAILS
```

When you query the threshold violations table again after another business day has passed, you can perform a join with the ACTIVITYSTMT_DB2ACTIVITIES table to see the SQL statement text of any activity that violated the threshold:

```
SELECT THRESHOLDID,
       SUBSTR(THRESHOLD_PREDICATE, 1, 20) PREDICATE,
       TIME_OF_VIOLATION,
       SUBSTR(STMT_TEXT,1,70) STMT_TEXT
FROM THRESHOLDVIOLATIONS_DB2THRESHOLDVIOLATIONS TV,
     ACTIVITYSTMT_DB2ACTIVITIES A
WHERE TV.APPL_ID = A.APPL_ID
  AND TV.UOW_ID = A.UOW_ID
  AND TV.ACTIVITY_ID = A.ACTIVITY_ID
```

```
THRESHOLDID PREDICATE            TIME_OF_VIOLATION          STMT_TEXT
----------- -------------------- -------------------------- ----------------------------------------------------------------------
          1 EstimatedSQLCost     2008-09-02-23.04.49.000000 select count(*) from syscat.tables,syscat.tables,syscat.tables

  1 record(s) selected.
```

Available monitoring data

Monitoring data is available from workloads, service subclasses and service superclasses, work classes, and threshold queues. You can use this data to diagnose and correct problems and for performance tuning.

Workload monitoring data

The following figure shows the monitoring information that is available for workloads. You can collect workload statistics and information about activities that run in the workloads using event monitors. For workloads, you can also obtain aggregate activity statistics. You can access workload statistics and information about workload occurrences in real time using table functions.

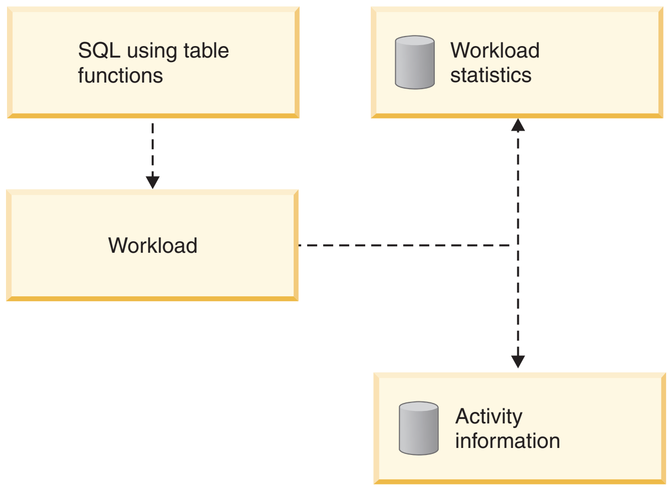


Figure 47. Monitoring data that is available for workloads

Service class monitoring data

The following figure shows the monitoring information that is available for service classes. You can collect statistics for service subclasses and service superclasses. For service subclasses, you can also obtain aggregate activity and request statistics, and information about activities that run in the service subclass. You can access service superclass and service subclass statistics and information about agents running in a particular service class in real time using table functions.

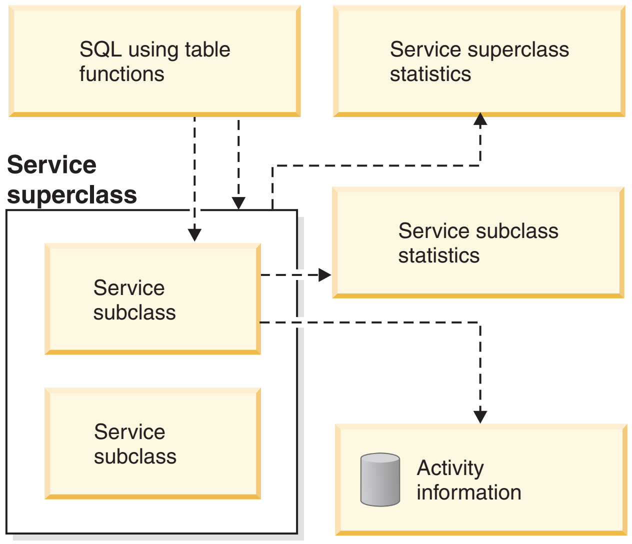

SQL using table functions
Service superclass statistics
Service superclass
Service subclass statistics
Service subclass
Service subclass
Activity information

Figure 48. Monitoring data that is available for service classes

Work class monitoring data

The following figure shows the monitoring information that is available for work classes. You can collect work class statistics and information about activities that are associated with a particular work class. You can access work class statistics in real time using table functions.

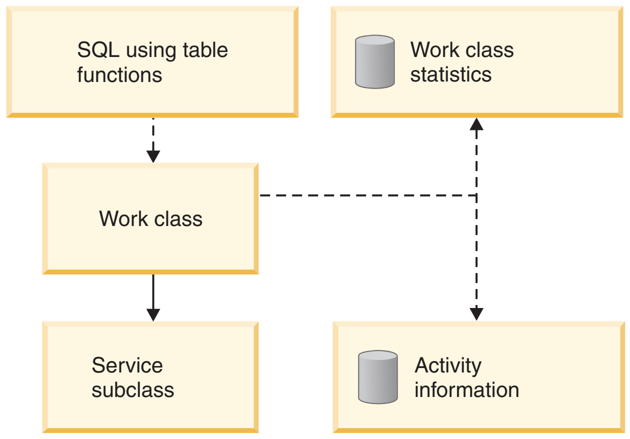


Figure 49. Monitoring data that is available for work classes

Threshold monitoring data

The following figure shows the monitoring information that is available for thresholds. You can obtain information about threshold violations, the activities that caused the threshold violations, and queuing statistics (for queuing thresholds). You can access queuing threshold statistics in real time using table functions.

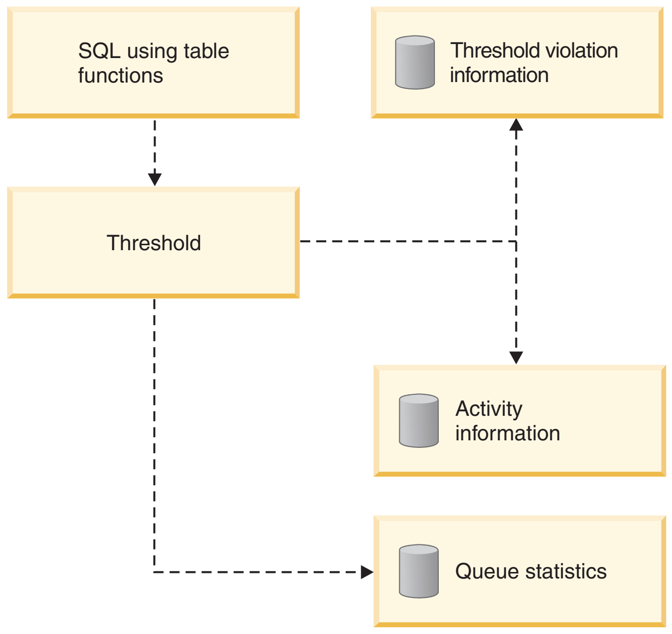


Figure 50. Monitoring data that is available for thresholds

DB2 workload management stored procedures

You can use stored procedures for canceling an activity, capturing details about an activity, resetting the statistics on DB2 workload management objects, and setting client information at the data server.

The following stored procedures are available for use with DB2 workload management:

WLM_CANCEL_ACTIVITY(*application_handle***,** *uow_id***,** *activity_id***)**
: Use this stored procedure to cancel a running or queued activity. You identify the activity by its application handle, unit of work identifier, and activity identifier. You can cancel any type of activity. The application with the cancelled activity receives the error SQL4725N.

WLM_CAPTURE_ACTIVITY_IN_PROGRESS(*application_handle***,** *uow_id***,** *activity_id***)**
: Use this stored procedure to send information about an individual activity that is currently executing to the activities event monitor. This stored procedure sends the information immediately, rather than waiting until the activity completes.

WLM_COLLECT_STATS()
: Use this stored procedure to collect and reset statistics for DB2 workload management objects. All statistics tracked for service classes, workloads, threshold queues, and work action sets are sent to the active statistics event monitor (if one exists) and reset. If there is no active statistics event monitor, the statistics are only reset, but not collected.

WLM_SET_CLIENT_INFO(*client_userid***,** *client_wrkstnname***,***client_applname***,** *client_acctstr***,***client_workload***)**
: Use this procedure to set the client information attributes used at the data server to record the identity of the application or end-user currently using

the connection. In cases where middleware exists between applications or users and your data server, use the WLM_SET_CLIENT_INFO procedure to set distinguishing connection attributes explicitly.

Statistics for DB2 workload management objects

Statistics are maintained for DB2 workload management objects including service classes, work classes, workloads, and threshold queues. These statistics reside in memory and can be viewed in real-time using DB2 workload management statistics table functions, or the statistics can be collected and sent to a statistics event monitor where they can be viewed later for historical analysis.

Note that you can also obtain monitoring metrics through the statistics event monitor. These are not discussed in this topic, which covers only those statistics that are specific to DB2 workload management.

When statistics are sent to the event monitor, the values in memory are reset to prevent duplicate data from being collected on subsequent collection intervals. Because the DB2 workload management statistics table functions report the current in-memory values, following a collection they report the reset values. The DB2 workload management table functions report only a subset of the statistics. To view the full set of statistics, you must collect the statistics and send them to a statistics event monitor.

Aggregate activity data statistics collection

The following statistics are maintained on the given objects on each member, regardless of the value of the COLLECT AGGREGATE ACTIVITY DATA option specified for those objects when they are created or altered.

Table 52. Statistics collected for database objects regardless of COLLECT AGGREGATE ACTIVITY DATA setting

Database object	Statistic	Description
Service subclasses	1. Concurrent activity top (concurrent_act_top) 2. Coordinator activities completed total (coord_act_completed_total) 3. Coordinator activities aborted total (coord_act_aborted_total) 4. Coordinator activities rejected total (coord_act_rejected_total) 5. The number of active requests (num_requests_active) 6. The number of activities mapped in and the number of activities mapped out (act_remapped_in and act_remapped_out)	1. Use this activity concurrency high watermark to determine the highest concurrency of activities (including nested activities) reached on a member for a service class in the time interval for which the statistic is collected. 2. Use this statistic to determine how much work is being performed in a service class. 3. Use this statistic, which measures the unsuccessful completion of activities, to determine how healthy the system is. Activities can be aborted because of cancellation, errors, or reactive thresholds. 4. Use this rejected non-nested coordinator activity count, which measures the rejection of activities, to obtain an indication of the usefulness of the rejection policy. Activities are counted as rejected when they violate a predictive threshold that has an action of STOP EXECUTION or when they are prevented from executing by a work action. 5. Use this statistic to determine the number of requests that are currently executing in a service class. 6. Use these statistics to determine the number of activities that are remapped into or out of a service subclass as part of the priority aging of ongoing activities.
Service superclasses	Concurrent connection top (concurrent_connection_top)	Use this coordinator connection concurrency high watermark to tune a connection concurrency threshold.

Table 52. Statistics collected for database objects regardless of COLLECT AGGREGATE ACTIVITY DATA setting (continued)

Database object	Statistic	Description
Workloads	1. Concurrent workload occurrences top (concurrent_wlo_top) 2. Concurrent workload occurrences activity top (concurrent_wlo_act_top) 3. Coordinator activities completed total (coord_act_completed_total) 4. Coordinator activities aborted total (coord_act_aborted_total) 5. Coordinator activities rejected total (coord_act_rejected_total) 6. Workload occurrences completed total (wlo_completed_total) 7. Activities total (act_total)	1. Use this workload occurrence high watermark to identify the maximum number of concurrent workload occurrences and to help set or tune a workload occurrence concurrency threshold if the number of concurrently executing workload occurrences is too high (that is, too many applications that are associated with the same workload definition are running on the system at the same time). 2. Use this element to know the highest number of concurrent activities reached on a member for any occurrence of this workload in the time interval collected. 3. Use this statistic, which measures the rate of successful completion of activities, to obtain an indication of the health of the system. 4. Use this statistic, which measures the unsuccessful completion of activities, to determine how healthy the system is. Activities can be aborted due to cancellation, errors, or reactive thresholds. 5. Use this statistic, which measures the rate of rejection of activities, to determine the usefulness of a rejection policy. Activities are counted as rejected when they violate a predictive threshold that has an action of STOP EXECUTION or when they are prevented from executing by a work action. 6. Use this statistic to determine how many occurrences of a workload complete in a specific period of time. 7. Use this statistic to determine the effectiveness of the work action set and determine the relative percentages of the types of activities on the system.

Table 52. Statistics collected for database objects regardless of COLLECT AGGREGATE ACTIVITY DATA setting (continued)

Database object	Statistic	Description
Work class (through a work action)	Queue assignments total (queue_assignments_total)	Use this statistic to determine whether excessive queuing is occurring, or whether the right number of activities are being queued (that is, whether the concurrency threshold is too restrictive or not restrictive enough).
Threshold queues	1. Queue size top (queue_size_top) 2. Queue time total (queue_time_total)	1. Use this statistic to help determine the maximum queue size and to identify whether the queue size is sufficient. 2. Use this statistic to determine how much time activities are spending in the queue and whether that time is excessive.

When you set the value of the COLLECT AGGREGATE ACTIVITY DATA option to BASE for a service subclass, workload, or a work class (through a work action), some of the following statistics are also collected, or the corresponding histograms are generated for each member. Use the averages to quickly understand where activities are spending most of their time (for example, queued or executing) and the response time (lifetime). You can also use the averages to tune the histogram templates. That is you can compare a true average with the average computed from a histogram, and if the average from the histogram deviates from the true average, consider altering the histogram template for the corresponding histogram, using a set of bin values that are more appropriate for your data.

Table 53. Statistics or histograms collected when COLLECT AGGREGATE ACTIVITY DATA is set to BASE

Statistic or histogram	Description
Average request execution time (request_exec_time_avg)	Use this statistic to determine the arithmetic mean of the execution times for requests associated with a service class.
Average coordinator activity lifetime (coord_act_lifetime_avg)	Use this statistic to determine the arithmetic mean of the lifetime for non-nested coordinator activities associated with a service class, workload or a work class.
Average coordinator activity execution time (coord_act_exec_time_avg)	Use this statistic to determine the arithmetic mean of execution time for non-nested coordinator activities associated with a service class, workload or a work class.
Average coordinator activity queue time (coord_act_queue_time_avg)	Use this statistic to determine the arithmetic mean of the queue time for non-nested coordinator activities associated with a service class, workload or a work class.
Cost estimate top (cost_estimate_top)	Use this statistic to tune estimated cost thresholds.
Actual rows returned top (rows_returned_top)	Use the information to tune the actual rows returned thresholds.

Table 53. Statistics or histograms collected when COLLECT AGGREGATE ACTIVITY DATA is set to BASE (continued)

Statistic or histogram	**Description**
Aggregate temporary table space top (agg_temp_tablespace_top)	Use this statistic to tune aggregate system temporary table space usage. This statistic is monitored only if you define a threshold for aggregate temporary table space usage. For any given service subclass, this statistic is monitored whenever you define a AGGSQLTEMPSPACE threshold on the service subclass itself, or when you define a similar threshold on any service subclass within the same superclass.
Temporary table space top (temp_tablespace_top)	Use this statistic to tune temporary table space usage thresholds. This statistic is monitored only if you define a threshold for temporary table space usage. For any given service subclass, this threshold is also monitored whenever you define a AGGSQLTEMPSPACE threshold on the service subclass itself, or when you define a similar threshold on any service subclass within the same superclass.
Coordinator activity lifetime (CoordActLifetime) histogram	Use this histogram to obtain a view of overall system performance. This histogram collects the time duration between the activity arrival and end time for non-nested coordinator activities. If the activity is a routine that leaves a cursor open after it ends, the lifetime histogram does not count the lifetime of the cursor toward the lifetime of the routine that is the parent of the cursor.

Table 53. Statistics or histograms collected when COLLECT AGGREGATE ACTIVITY DATA is set to BASE (continued)

Statistic or histogram	**Description**
Coordinator activity execution time (CoordActExecTime) histogram	Use this histogram to measure the impact of changes to the system that affect execution time. This histogram collects the execution time for non-nested coordinator activities. The execution time is calculated as follows: • For cursors, the execution time is the combined time for the open cursor request, any fetches, and the close cursor request. Time when the cursor is idle is not counted towards the execution time. • For routines, the execution time is from the start to the end of the routine invocation. If any cursors are left open by the routine after it ends, the lifetimes of these cursors are not counted towards the routine execution time. • For all other activities, the execution time is the difference between the activity lifetime and the time that the activity spends queued.
Coordinator activity queue time (CoordActQueueTime) histogram	Use this histogram to measure the impact of queuing thresholds on activities. This histogram collects the amount of time that non-nested coordinator activities spend queued.

When you set the value of the COLLECT AGGREGATE ACTIVITY DATA option to EXTENDED for a service subclass, workload or a work class, the following system statistics are collected or histograms are generated for each member for the corresponding service class or work class (through a work action). Use the averages to quickly understand the average rate of arrival of activities (arrival rate is the inverse of inter-arrival time) and the expense of activities (estimated cost). You can also use the averages to tune the histogram templates. That is you can compare a true average with the average computed from a histogram, and if the average from the histogram deviates from the true average, consider altering the histogram template for the corresponding histogram, using a set of bin values that are more appropriate for your data. EXTENDED statistics are useful for more detailed performance modelling. Also see "Workload management performance modelling" on page 276.

Table 54. Statistics or histograms collected when COLLECT AGGREGATE ACTIVITY DATA is set to EXTENDED

Statistic or histogram	**Description**
Coordinator activity estimated cost average (coord_act_est_cost_avg)	Use this statistic to determine the arithmetic mean of the estimated costs of coordinator DML activities at nesting level 0 that are associated with this service subclass, workload or work class since the last statistics reset.

Table 54. Statistics or histograms collected when COLLECT AGGREGATE ACTIVITY DATA is set to EXTENDED (continued)

Statistic or histogram	Description
Non-nested coordinator activity inter-arrival time average (coord_act_interarrival_time_avg)	Use this statistic to determine the arithmetic mean of the time between the arrival of one coordinator activity at nesting level 0 that is associated with this service class, workload or work class and the next coordinator activity to arrive. The average is computed since the last statistics reset.
Coordinator activity estimated cost (CoordActEstCost) histogram.	Use this histogram to obtain an approximate service time distribution. This histogram collects the estimated cost for non-nested coordinator activities. This data is useful for modelling your system or for inputting into performance-modelling applications.
Coordinator activity inter-arrival time (CoordActInterArrivalTime) histogram.	Use this histogram to obtain the inter-arrival time distribution for non-nested coordinator activities. This histogram collects the inter-arrival time for non-nested coordinator activities. This data is useful for modelling your system or for inputting into performance-modeling applications.

The following table provides a reference for which activity statistics are collected for each DB2 workload management object and includes all aggregate statistics available to you from both table functions and event monitors. Some statistics are always collected for some objects. Other statistics are only collected when a particular COLLECT AGGREGATE option is specified. For aggregate activity statistics, if COLLECT AGGREGATE ACTIVITY DATA EXTENDED is specified, all the BASE aggregate activity statistics are also collected.

Table 55. Aggregate activity statistics collection for DB2 workload management objects

Object type	Activity statistics always collected by default	Activity statistics collected when you specify COLLECT AGGREGATE ACTIVITY DATA BASE	Activity statistics collected when you specify COLLECT AGGREGATE ACTIVITY DATA EXTENDED
Service subclass	act_remapped_in act_remapped_out concurrent_act_top coord_act_completed_total coord_act_rejected_total coord_act_aborted_total	agg_temp_tablespace_top coord_act_exec_time_avg coord_act_lifetime_avg coord_act_lifetime_top coord_act_queue_time_avg coord_act_lifetime_stddev coord_act_exec_time_stddev coord_act_queue_time_stddev CoordActLifetime histogram CoordActExecTime histogram CoordActQueueTime histogram cost_estimate_top rows_returned_top temp_tablespace_top	coord_act_est_cost_avg coord_act_interarrival_time_avg CoordActEstCost histogram CoordActInterArrivalTime histogram

Table 55. Aggregate activity statistics collection for DB2 workload management objects (continued)

Object type	Activity statistics always collected by default	Activity statistics collected when you specify COLLECT AGGREGATE ACTIVITY DATA BASE	Activity statistics collected when you specify COLLECT AGGREGATE ACTIVITY DATA EXTENDED
Service superclass	concurrent_connection_top	N/A	N/A
Workload	concurrent_wlo_act_top concurrent_wlo_top coord_act_aborted_total coord_act_completed_total coord_act_rejected_total wlo_completed_total	coord_act_exec_time_avg coord_act_lifetime_top coord_act_lifetime_avg coord_act_queue_time_avg coord_act_lifetime_stddev coord_act_exec_time_stddev coord_act_queue_time_stddev CoordActLifetime histogram CoordActExecTime histogram CoordActQueueTime histogram cost_estimate_top rows_returned_top temp_tablespace_top	coord_act_est_cost_avg coord_act_interarrival_time_avg CoordActEstCost histogram CoordActInterArrivalTime histogram
Work class (through a work action)	act_total	agg_temp_tablespace_top coord_act_lifetime_top coord_act_lifetime_avg coord_act_exec_time_avg coord_act_queue_time_avg CoordActLifetime histogram CoordActExecTime histogram CoordActQueueTime histogram cost_estimate_top rows_returned_top temp_tablespace_top	coord_act_est_cost_avg coord_act_interarrival_time_avg CoordActEstCost histogram CoordActInterArrivalTime histogram
Threshold	N/A	N/A	N/A
Threshold queue	queue_assignments_total queue_size_top queue_time_total	N/A	N/A

Aggregate request data statistics collection

When you set the value of the COLLECT AGGREGATE REQUEST DATA option for a service subclass to BASE, the following statistics are maintained for the service subclass.

Table 56. Statistics or histograms collected when COLLECT AGGREGATE REQUEST DATA is set to BASE

Statistic or histogram	Description
Request execution time average (request_exec_time_avg)	Use this statistic to quickly understand the average amount of time that is spent processing each request on a member and to help tune the histogram template for the corresponding request execution time histogram.

Table 56. Statistics or histograms collected when COLLECT AGGREGATE REQUEST DATA is set to BASE (continued)

Statistic or histogram	**Description**
Request execution time (ReqExecTime) histogram	Use this histogram to understand where work is being performed and whether the distribution of work across members is uniform. This histogram indicates the volume of work executing in a service class and the distribution of this work across database members. The execution time for requests is collected in a histogram for each member and for all requests. This histogram includes requests on the coordinator member, and any subrequests on both coordinator and non-coordinator members (like RPC requests or SMP subagent requests). Requests included may or may not be associated with an activity: Both PREPARE and OPEN requests are included in this histogram, for example, but while OPEN requests are always associated with a cursor activity, PREPARE requests are not part of any activity. The request execution time approximates the effort spent by agents working in a service class. For example, coordinator activity counts might show that most user activities originate on one member, but as part of processing the activities, the coordinator agent might be sending subrequests to another member that performs most of the work. The request execution time histogram can be useful in determining the size of requests sent to a member, that is, whether the work that is sent to the member consists of mostly small requests or mostly large requests or whether there is no specific distribution. Request execution time histograms should not be used for activity response time analysis, because activities may be composed of a number of requests and subrequests, because there is no one-to-one mapping between request and activity execution time, and because not all requests are associated with activities.

The following table provides a reference for which request statistics are collected for each DB2 workload management object and includes all aggregate statistics available to you from both table functions and event monitors. Some statistics are always collected for some objects. Other statistics are only collected when the COLLECT AGGREGATE REQUEST DATA option is specified.

Table 57. Aggregate request statistics collection for DB2 workload management objects

Object type	Request statistics always collected by default	Request statistics collected when you specify COLLECT AGGREGATE REQUEST DATA BASE
Service subclass	num_requests_active	request_exec_time_avg request_exec_time_stddev request_exec_time_total ReqExecTime histogram
Service superclass	N/A	N/A
Workload	N/A	N/A
Work class (through a work action)	N/A	N/A
Threshold	N/A	N/A
Threshold queue	N/A	N/A

Statistics collection and monitoring with remapped activities

How you collect statistics and how you monitor are both affected by the dynamic remapping of activities between service subclasses.

Remapping occurs when an activity that is executing in one service class is moved to another service class to continue execution. This remapping can be done using thresholds, such as CPUTIMEINSC, and can be an integral part of your workload management configuration, as is the case with the priority aging approach.

Statistics affected by remapped activities

As one exception to the rule, the activity interarrival time, estimated cost, and queue time are all associated with the subclass in which an activity starts running, rather than with the subclass in which the activity finishes running. Because a remapped activity affects the statistics collection of both subclasses, a different number of activities can be counted in an interarrival time, an estimated cost, or a queue-time histogram than in a lifetime or execution-time histogram.

For example, consider an activity that starts running in service subclass A and later is remapped to service subclass B, in which it finishes running. The estimated cost of this activity is associated with service subclass A, but its lifetime is associated with service subclass B. As a result, for subclass A, the estimated cost histogram has one more element counted in it than the lifetime histogram has counted in it, and for service subclass B, the lifetime histogram has one more element counted in it than the estimated cost histogram has counted in it.

As a second exception to the rule, the monitor element **concurrent_act_top** can be updated in and attributed to any subclass that an activity passes through. In addition to being incremented when an activity begins and decremented when an activity ends, the monitor element is incremented when an activity is mapped to the subclass and is decremented when an activity is mapped out of the subclass (mapped to a different subclass).

Statistics about activity remapping

You can use two monitor elements to count the number of activities entering or leaving a service subclass because of a remapping action: **act_remapped_in** and **act_remapped_out**. The **act_remapped_in** and **act_remapped_out** monitor elements count the number of activities for any given subclass at any partition that were mapped into or out of the subclass since the last reset. You can use these monitor elements to validate that the remapping of activities between service subclasses is occurring as expected.

To determine the source and destination service subclasses targeted by a remapping action, you can refer to the threshold violation event monitor record, which includes a destination service class ID (destination_service_class_id). You can also determine the source service class by using the threshold violation record.

Monitoring with activity remapping

Remapping activities to different subclasses affects how you monitor these activities. To ensure that all statistics are collected for an activity that starts in one service class and finishes in another because of remapping, turn on aggregate activity data collection for both the service subclass in which the activity starts running and the service subclass in which the activity finishes running when you create or alter the service classes. If you turn on aggregate activity data collection for only the service subclass in which the activity started, the activity contributes only to queue time statistics and, in the case of extended statistics, to the estimated cost and interarrival time statistics. If you turn on aggregate activity data collection for only the service subclass in which the activity finishes running, the activity contributes only to lifetime and execution time statistics, regardless of whether the option is COLLECT AGGREGATE DATA BASE or COLLECT AGGREGATE DATA EXTENDED when you issue the CREATE SERVICE CLASS or ALTER SERVICE CLASS statement.

The following tables summarize how statistics collection is affected by remapping and collection settings.

Table 58. Effect of the COLLECT AGGREGATE DATA BASE option on aggregate statistics collection for subclasses involved in remapping

Statistics	**Starting subclass collection setting and ending subclass collection setting**			
	NONE and NONE	BASE and NONE	NONE and BASE	BASE and BASE
Lifetime	Not collected	Not collected	Collected	Collected
Queue time	Not collected	Collected	Not collected	Collected
Execution time	Not collected	Not collected	Collected	Collected

Table 59. Effect of the COLLECT AGGREGATE DATA EXTENDED option on aggregate statistics collection for subclasses involved in remapping

Statistics	**Starting subclass collection setting and ending subclass collection setting**			
	NONE and NONE	EXTENDED and NONE	NONE and EXTENDED	EXTENDED and EXTENDED
Lifetime	Not collected	Not collected	Collected	Collected
Queue time	Not collected	Collected	Not collected	Collected
Execution time	Not collected	Not collected	Collected	Collected
Inter-arrival time	Not collected	Collected	Not collected	Collected
Estimated cost	Not collected	Collected	Not collected	Collected

Table 60. Effect of mixing the COLLECT AGGREGATE DATA BASE and the COLLECT AGGREGATE DATA EXTENDED options on aggregate statistics collection for subclasses involved in remapping

Statistics	**Starting subclass collection setting and ending subclass collection setting**	
	BASE and EXTENDED	EXTENDED and BASE
Lifetime	Collected	Collected
Queue time	Collected	Collected
Execution time	Collected	Collected
Inter-arrival time	Not collected	Collected
Estimated cost	Not collected	Collected

Histograms in workload management

A histogram is a collection of bins, which are containers for collecting discrete ranges of data. Histograms are useful for a variety of workload analysis and performance-tuning tasks.

DB2 workload management histograms have a fixed number of 41 bins. The 40th bin contains the highest defined value for the histogram, and the 41st bin is for values that are beyond the highest defined value. Each bin represents a specific range of values, and the bin ranges follow a logarithmic scale, with each bin representing a progressively larger range as one progresses from the 1st to 40th bin. The following figure shows a histogram of activity lifetimes that are plotted using a bar chart.

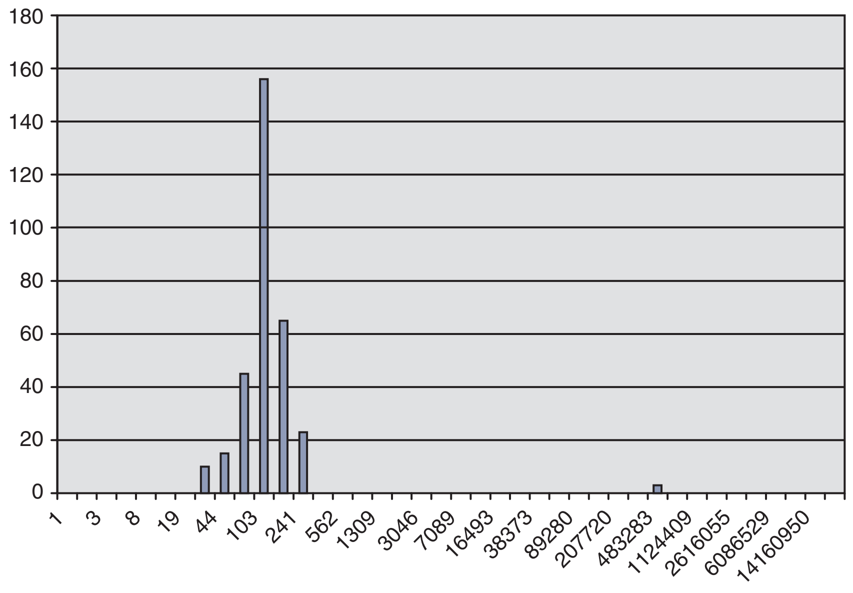


Figure 51. Histogram of activity lifetimes that are plotted using a bar chart

The activity lifetime histogram corresponds to the following data. Each count represents the number of activities whose lifetimes (in milliseconds) are within the range of the low bin value to the high bin value. For example, 156 activities had a lifetime in the range of 68 milliseconds to 103 milliseconds.

```
 Low Bin  High Bin Count
       0         1     0
       1         2     0
       2         3     0
       3         5     0
       5         8     0
       8        12     0
      12        19     0
      19        29    10
      29        44    15
      44        68    45
      68       103   156
     103       158    65
     158       241    23
     241       369     0
     369       562     0
     562       858     0
     858      1309     0
    1309      1997     0
    1997      3046     0
    3046      4647     0
    4647      7089     0
    7089     10813     0
   10813     16493     0
   16493     25157     0
   25157     38373     0
   38373     58532     0
   58532     89280     0
   89280    136181     0
  136181    207720     0
  207720    316840     0
  316840    483283     3
  483283    737162     0
  737162   1124409     0
 1124409   1715085     0
 1715085   2616055     0
 2616055   3990325     0
 3990325   6086529     0
 6086529   9283913     0
 9283913  14160950     0
14160950  21600000     0
21600000  Infinity     0
```

You can use histograms for a number of different purposes. For example, you can use them to see the distribution of values, use them to identify outlying values, or use them to compute averages and standard deviations. See “Scenario: Tuning a DB2 workload management configuration when capacity planning information is unavailable” on page 356 and “Example: Computing averages and a standard deviation from histograms in a DB2 workload management configuration” on page 260 for examples of how to use histograms to better understand and characterize your workload.

In a multimember database environment, histograms are collected on each member. Histogram bins have the same range of values on all database members, with specific counts per bin per member. You can use the bins to analyze information on a per-member basis. You can also combine the histograms from all database members by adding the counts in the corresponding bins and use this single histogram to obtain a global view of the data, which you can then use for tasks such as calculating the global average and standard deviation.

Histograms are available for service subclasses, workloads, and work classes, through work actions. Histograms are collected for these objects when you specify one of the COLLECT AGGREGATE ACTIVITY DATA, COLLECT AGGREGATE

REQUEST DATA, or COLLECT AGGREGATE UNIT OF WORK DATA clauses when creating or altering the objects. For work classes, histograms are also collected if you apply a COLLECT AGGREGATE ACTIVITY DATA work action to the work class. The following histograms are available:

- Non-nested coordinator activity lifetime, when you specify AGGREGATE ACTIVITY DATA BASE or AGGREGATE ACTIVITY DATA EXTENDED for a service subclass, for a workload, or for a work action applied to a work class
- Non-nested coordinator activity execution time, when you specify AGGREGATE ACTIVITY DATA BASE or AGGREGATE ACTIVITY DATA EXTENDED for a service subclass, for a workload, or for a work action applied to a work class
- Non-nested coordinator activity queue time, when you specify AGGREGATE ACTIVITY DATA BASE or AGGREGATE ACTIVITY DATA EXTENDED for a service subclass, for a workload, or for a work action applied to a work class
- Request execution time, when you specify AGGREGATE REQUEST DATA BASE for a service subclass; this histogram does not apply to workloads or work classes
- Non-nested activity interarrival time histogram, when you specify AGGREGATE ACTIVITY DATA EXTENDED for a service subclass, for a workload, or for a work action applied to a work class
- Non-nested DML activity estimated cost, when you specify AGGREGATE ACTIVITY DATA EXTENDED for a service subclass, for a workload, or for a work action applied to a work class
- Unit of work lifetime, when you specify AGGREGATE UNIT OF WORK DATA BASE for a service class

All activity-related histograms contain information about activities that are completed, are cancelled, or are rejected.

Histogram templates

You can optionally specify a histogram template that is used to determine what a particular histogram looks like, including the high bin value. A histogram template is a *unitless* object, meaning that there is no predefined measurement unit assigned to it. A measurement unit, which depends on the context in which the histogram template is used, is assigned to the histogram when a service class, workload, or work action is created or altered. Time-based histograms, such as those specified with the ACTIVITY LIFETIME HISTOGRAM clause as an example, use millisecond units, while cost-based histograms, such as those specified with the ACTIVITY ESTIMATED COST HISTOGRAM clause as an example, use timeron units.

You can create a histogram template by using the CREATE HISTOGRAM TEMPLATE statement, specifying the maximum high bin value. All other bin values are automatically defined as exponentially increasing values that approach the high bin value. For example, to create a histogram template with a high bin value of 3 000 000, issue a statement such as the following one:

```
CREATE HISTOGRAM TEMPLATE TEMPLATE1 HIGH BIN VALUE 3000000
```

This statement creates a histogram template with the following bin values:

```
Low Bin High Bin
      0        1
      1        2
      2        3
      3        4
      4        6
      6        9
      9       13
     13       19
     19       28
     28       41
     41       60
     60       87
     87      127
    127      184
    184      268
    268      389
    389      565
    565      821
    821     1192
   1192     1732
   1732     2514
   2514     3651
   3651     5300
   5300     7696
   7696    11173
  11173    16222
  16222    23553
  23553    34196
  34196    49649
  49649    72084
  72084   104657
 104657   151948
 151948   220609
 220609   320297
 320297   465030
 465030   675163
 675163   980250
 980250  1423197
1423197  2066299
2066299  3000000
3000000 Infinity
```

You apply a histogram template by using the appropriate HISTOGRAM TEMPLATE keyword when creating or altering service subclasses, workloads, or work actions. If you do not specify a histogram template, the default template, SYSDEFAULTHISTOGRAM, is used. If you do not enable AGGREGATE ACTIVITY DATA collection for an object, the histogram template is ignored.

For example, to use the TEMPLATE1 histogram template for the existing activity lifetime histogram of service subclass MYSUBCLASS under the service superclass MYSUPERCLASS, issue the following statement:

```
ALTER SERVICE CLASS MYSUBCLASS UNDER MYSUPERCLASS
ACTIVITY LIFETIME HISTOGRAM TEMPLATE TEMPLATE1
```

After you commit the ALTER SERVICE CLASS statement, the activity lifetime histogram that is collected for the MYSUBCLASS service subclass has high bin values that are determined by the TEMPLATE1 histogram template instead of by the SYSDEFAULTHISTOGRAM histogram template.

If you change a service class or a workload to use a different histogram template or change a histogram template, the change does not take effect until a statistics reset occurs.

You can drop a histogram template by using the DROP HISTOGRAM TEMPLATE statement.

You can view the histogram templates by querying the SYSCAT.HISTOGRAMTEMPLATES view and view the corresponding histogram template high bin values by querying the SYSCAT.HISTOGRAMTEMPLATEBINS view. The low bin value is always 0 for the first bin; for any other bins, the low bin value is the high bin value from the preceding bin.

Example

The following example creates a table function to compute the CoordActLifetime, CoordActExecTime, CoordActQueueTime, or CoordActEstCost histogram for a service superclass as a whole by summing across the subclasses. Summing across subclasses is useful when activities are remapped to different service subclasses under the same service superclass during execution, as can occur under a priority aging scenario where service class tiers and specialized thresholds are used to control resources for activities dynamically. This example does not apply to the CoordActInterArrivalTime histogram because the weighted averages computed do not account for the fact that the CoordActInterArrivalTime histogram of a subclass measures the time between the arrival of a query in that subclass and the next query but the CoordActInterArrivalTime histogram of a superclass measures the time between the arrival of a query in any of its subclasses and the next query.

```
CONNECT TO SAMPLE

DROP FUNCTION histsuper

CREATE FUNCTION histsuper(superclass varchar(128),
                          histogram_type varchar(24))
RETURNS TABLE (statistics_timestamp timestamp,
               bin_top integer,
               number_in_bin integer,
               graph varchar(60))
LANGUAGE SQL
READS SQL DATA
NO EXTERNAL ACTION
DETERMINISTIC
RETURN WITH HISTOGRAMS AS
       (SELECT HISTOGRAM_TYPE,
              substr(PARENTSERVICECLASSNAME,1,26) as SUPERCLASS,
              STATISTICS_TIMESTAMP,
              TOP as BIN_TOP,
              sum(NUMBER_IN_BIN) as NUMBER_IN_BIN
       FROM HISTOGRAMBIN_DB2STATISTICS H,
            SYSCAT.SERVICECLASSES S
       WHERE H.SERVICE_CLASS_ID = S.SERVICECLASSID
         AND PARENTSERVICECLASSNAME = histsuper.superclass
         AND HISTOGRAM_TYPE = histsuper.histogram_type
         AND HISTOGRAM_TYPE IN ('CoordActLifetime', 'CoordActExecTime',
     'CoordActQueueTime', 'CoordActEstCost')
       GROUP BY HISTOGRAM_TYPE, PARENTSERVICECLASSNAME, STATISTICS_TIMESTAMP, TOP)
       SELECT STATISTICS_TIMESTAMP,
              BIN_TOP,
              NUMBER_IN_BIN,
              substr(repeat('#', cast(NUMBER_IN_BIN * 60 /
                (SELECT CASE WHEN MAX(NUMBER_IN_BIN) = 0 THEN 1
     ELSE MAX(NUMBER_IN_BIN) END FROM HISTOGRAMS) AS INTEGER)),1,60)
     AS GRAPH FROM HISTOGRAMS

CONNECT RESET
```

The output looks as follows:

```
STATISTICS_TIMESTAMP       BIN_TOP     NUMBER_IN_BIN GRAPH
-------------------------- ----------- ------------- ------------------------------------------------------------
2008-11-06-14.47.08.833188 -1          0
2008-11-06-14.47.08.833188 1           1
2008-11-06-14.47.08.833188 2           1
2008-11-06-14.47.08.833188 3           2
2008-11-06-14.47.08.833188 5           4
2008-11-06-14.47.08.833188 8           7
2008-11-06-14.47.08.833188 12          15
```

```
2008-11-06-14.47.08.833188 19            29             #
2008-11-06-14.47.08.833188 29            41             #
2008-11-06-14.47.08.833188 44            67             ##
2008-11-06-14.47.08.833188 68            112            ###
2008-11-06-14.47.08.833188 103           228            #####
2008-11-06-14.47.08.833188 158           335            ########
2008-11-06-14.47.08.833188 241           723            #################
2008-11-06-14.47.08.833188 369           1289           ###############################
2008-11-06-14.47.08.833188 562           1890           #############################################
2008-11-06-14.47.08.833188 858           2484           ############################################################
2008-11-06-14.47.08.833188 1309          1943           ###############################################
2008-11-06-14.47.08.833188 1997          478            ###########
2008-11-06-14.47.08.833188 3046          221            #####
2008-11-06-14.47.08.833188 4647          29             #
2008-11-06-14.47.08.833188 7089          7
2008-11-06-14.47.08.833188 10813         0
2008-11-06-14.47.08.833188 16493         2
2008-11-06-14.47.08.833188 25157         0
2008-11-06-14.47.08.833188 38373         1
2008-11-06-14.47.08.833188 58532         0
2008-11-06-14.47.08.833188 89280         0
2008-11-06-14.47.08.833188 136181        0
2008-11-06-14.47.08.833188 207720        0
2008-11-06-14.47.08.833188 316840        0
2008-11-06-14.47.08.833188 483283        0
2008-11-06-14.47.08.833188 737162        0
2008-11-06-14.47.08.833188 1124409       0
2008-11-06-14.47.08.833188 1715085       0
2008-11-06-14.47.08.833188 2616055       0
2008-11-06-14.47.08.833188 3990325       0
2008-11-06-14.47.08.833188 6086529       0
2008-11-06-14.47.08.833188 9283913       0
2008-11-06-14.47.08.833188 14160950      0
2008-11-06-14.47.08.833188 21600000      0

41 record(s) selected.
```

Creating a histogram template

Use the CREATE HISTOGRAM TEMPLATE statement to create a histogram template. Histogram templates are used by service subclasses and work actions to define the bin values for the statistics that are maintained using histograms.

Before you begin

To create a histogram template, you require WLMADM or DBADM authority.

See the following topics for more information about prerequisites:
- “Workload management DDL statements” on page 18
- Appendix A, “General naming rules,” on page 491

About this task

Some DB2 service subclass, work class activity, and request statistics are collected using histograms. All histograms have a set number of bins, and each bin represents a range in which activities or requests are counted. The type of units used for the bins depends on the type of histogram that you create. The histogram template describes the high value of the second-to-last bin in the histogram, which affects the values of all of the bins in the histogram. For more information about histograms, see “Histograms in workload management” on page 253.

Procedure

To create a histogram template:
1. Issue the CREATE HISTOGRAM TEMPLATE statement, specifying the name of the histogram template that you want to create and a value for the HIGH BIN VALUE keyword to set the top value for the second-to-last bin.

2. Commit your changes. When you commit your changes, the histogram is added to the SYSCAT.HISTOGRAMTEMPLATES view and the bins are added to the SYSCAT.HISTOGRAMTEMPLATEBINS view.

Altering a histogram template

Use the ALTER HISTOGRAM TEMPLATE statement to alter an existing histogram template. Histogram templates are used by service subclasses and work actions to define the bin values for the statistics that are maintained using histograms.

Before you begin

You require WLMADM or DBADM authority to alter a histogram template.

See "Workload management DDL statements" on page 18 for more information about prerequisites.

About this task

Some DB2 service subclass, work class activity, and request statistics are collected using histograms. All histograms have a set number of bins, and each bin represents a range in which activities or requests are counted. The type of units used for the bins depends on the type of histogram that you create. The histogram template describes the high value of the second-to-last bin in the histogram, which affects the values of all of the bins in the histogram. For more information on histograms, see "Histograms in workload management" on page 253.

Procedure

To alter a histogram template:

1. Issue the ALTER HISTOGRAM TEMPLATE statement, specifying the name of the histogram template that you want to alter and a value for the HIGH BIN VALUE parameter to alter the top value for the second-to-last bin.
2. Commit your changes. When you commit your changes the high bin value for the histogram is updated in the SYSCAT.HISTOGRAMTEMPLATEBINS view. The change does not take effect until the next time the workload management statistics are reset. See "Resetting statistics on DB2 workload management objects" on page 264 for more information.
3. Optional: Run the WLM_COLLECT_STATS stored procedure to collect and reset the statistics so that the new histogram template is used immediately.

Dropping a histogram template

You can drop a histogram template if you no longer require it.

Before you begin

To drop a histogram template, you require WLMADM or DBADM authority.

See "Workload management DDL statements" on page 18 for more information about prerequisites.

You cannot drop the SYSDEFAULTHISTOGRAM histogram template.

You cannot drop a histogram template if it is being referenced by a service subclass, work action, or workload. You can view the service subclasses and work actions that reference a histogram template by querying the

SYSCAT.HISTOGRAMTEMPLATESUSE view.

Procedure

To drop a histogram template:

1. Use the DROP HISTOGRAM TEMPLATE statement.
2. Commit your changes. When you commit your changes the histogram is removed from the SYSCAT.HISTOGRAMTEMPLATES view, and its bins are removed from the SYSCAT.HISTOGRAMTEMPLATEBINS view.

Example: Computing averages and a standard deviation from histograms in a DB2 workload management configuration

One use for histograms is for obtaining the standard deviation for activity lifetimes. The example in this topic shows how bins are used for the calculation of this statistic.

A calculation of the average lifetime for each activity is a useful piece of information. However, the average alone does not accurately describe the user experience. If the variability in activity lifetime is large, the users whom you are supporting might see queries run fast at some times (which is fine) and slow at others (which might not be acceptable). When you define a goal for activity lifetimes, not only is the average lifetime of the activities important but also the standard deviation of the activity lifetime. You need to both understand and control variability to ensure that your users actually experience the observed average.

In a DB2 workload management configuration, statistics are collected on each member. The following example shows how to obtain the average activity lifetime for a single member.

Suppose that you have a single-member environment and histogram with the following bins. There are more bins in the real histograms, but this example is limited to eight bins to make the example simpler.

```
Bin 1 - 0 to 2 seconds
Bin 2 - 2 to 4 seconds
Bin 3 - 4 to 8 seconds
Bin 4 - 8 to 16 seconds
Bin 5 - 16 to 32 seconds
Bin 6 - 32 to 64 seconds
Bin 7 - 64 to 128 seconds
Bin 8 - 128 seconds to infinity
```

You can compute an approximation of the average by assuming that the average response time for a query that falls into a bin with the range `x to y` is `(x + y)/2`. You can then multiply this number by the number of queries that fell into the bin, sum across all bins, then divide the sum by the total count. For the preceding example, assume that the average response time for each bin is:

```
Bin 1 average lifetime = (0+2)/2 = 1
Bin 2 average lifetime = (2+4)/2 = 3
Bin 3 average lifetime = (4+8)/2 = 6
Bin 4 average lifetime = (8+16)/2 = 12
Bin 5 average lifetime = (16+32)/2 = 24
Bin 6 average lifetime = (32+64)/2 = 48
Bin 7 average lifetime = (64+128)/2 = 96
```

Assume that the following histogram was collected during the measurement period:

```
Bin 1     Bin 2     Bin 3    Bin 4     Bin 5     Bin 6     Bin 7     Bin 8
count     count     count    count     count     count     count     count
   20        30        80       10         5         3         2         0
```

To calculate average lifetime, bin 8 must be empty. Bin 8 only exists to let you know when you need to change the upper boundary of your range. For this reason, you must specify the upper bound for the range.

You can approximate the average lifetime for member 1 as follows:

```
average lifetime = (20 x 1 + 30 x 3 + 80 x 6 + 10 x 12 + 5 x 24 + 3 x 48 + 2 x 96) / 150
                 = (20 + 90 + 480 + 120 + 120 + 144 + 192) / 150
                 = 1166 / 150
                 = 7.77 seconds
```

You can approximate the lifetime standard deviation as follows:

```
Standard deviation = [(20 x (1 - 7.77)2 + 30 x (3 - 7.77)2 + ... ) / 150]^1/2
```

For multimember database environments, averages and standard deviations can be computed by first computing a combined histogram across all database members by adding the counts of each bin across the database members.

For example, assume that the database has two members, the histogram bin sizes are as described previously, and the histogram has the following data:

```
Database  Bin 1     Bin 2     Bin 3    Bin 4     Bin 5      Bin 6     Bin 7     Bin 8
  member  count     count     count    count     count      count     count     count
       1    20        30        80       10         5          3         2         0
       2     1         5        20       20         4          0         0         0
```

Because the bin sizes are the same across all database members, the overall histogram is easy to compute:

```
Bin 1     Bin 2     Bin 3     Bin 4     Bin 5     Bin 6     Bin 7     Bin 8
count     count     count     count     count     count     count     count
   21        35       100        30         9         3         2         0
```

From the combined histogram, you can calculate the overall lifetime average and standard deviation in a similar way to how they were computed for a single-member environment:

```
Average lifetime = (21 x 1 + 35 x 3 + 100 x 6 + 30 x 12 + 9 x 24 + 3 x 48 + 2 x 96) / 200
                 = (21 + 105 + 600 + 360 + 216 + 144 + 192) / 200
                 = 1638 / 200
                 = 8.19 seconds

Standard deviation = [(21 x (1 – 8.19)^2 + 35 x (3 - 7.77)^2 + ... ) / 200]^1/2
```

Historical analysis tool

Your DB2 data server installation includes a pair of Perl scripts as a sample that generate information about which tables, indexes, and columns have or have not been accessed by performing historical analysis.

These scripts provide historical analysis functionality by using information captured by the workload management activities event monitor. The workload management historical analysis tool was written in Perl; you can use these scripts as is or you can modify them to produce additional historical analysis reports to suit your needs.

The workload management historical analysis tool consists of two scripts, which can be found in the `samples/perl` path of your installation directory:

- wlmhist.pl - generates historical data
- wlmhistrep.pl - produces reports from the historical data.

A DB2WlmHist.pm file, which contains common Perl routines used by the two scripts, is included also.

Refer to the README_WLMHIST file found in the same file directory for more information on how to set up and run the scripts.

Collecting workload management statistics using a statistics event monitor

Statistics for DB2 workload management objects can be sent to a statistics event monitor for historical analysis.

About this task

You can use statistics to understand the behavior of your system over time (for example, what is the average lifetime of activities, how much time do activities spend queued, what is the distribution of large compared to small activities, and so on), set thresholds (for example, find the upper boundary for concurrent activities), and detect problems (for example, detect whether the average lifetime that users are experiencing is higher than normal). See “Statistics for DB2 workload management objects” on page 242 for a description of which statistics are collected for each DB2 workload management object.

You can automatically send workload management statistics to an event monitor on a fixed interval of time, or you can manually send statistics to an event monitor at any point in time.

Procedure

To automatically collect workload management statistics on a fixed time interval:

1. Use the CREATE EVENT MONITOR statement to create a STATISTICS event monitor. For example, you could issue the following statement:
   ```
   CREATE EVENT MONITOR STATS1 FOR STATISTICS WRITE TO TABLE
   ```
2. Use the COMMIT statement to commit your changes.
3. Use the SET EVENT MONITOR STATE statement to activate the event monitor. Instead of using the SET EVENT MONITOR STATE statement, you can use the AUTOSTART default for the STATISTICS event monitor to have it activated the next time that the database is activated. If you want to define multiple STATISTICS event monitors, you should not use the AUTOSTART option.
4. Use the COMMIT statement to commit your changes.
5. Optional: Enable the collection of additional statistics. By default, only a minimal set of statistics is collected for each DB2 workload management object. See “Statistics for DB2 workload management objects” on page 242 for details on which statistics are collected by default for each object. Specify the collection of aggregate activity data for service subclasses, workloads, and work classes using the COLLECT AGGREGATE ACTIVITY DATA keyword on the ALTER SERVICE CLASS and ALTER WORK ACTION SET statements. Specify the collection of aggregate request data for service subclasses using the COLLECT AGGREGATE REQUEST DATA keyword on the ALTER SERVICE CLASS statement. COMMIT any changes.

6. Specify a collection interval by updating the database configuration parameter **wlm_collect_int**. The **wlm_collect_int** parameter specifies an interval of time in minutes. Every interval, the copy of the workload management statistics for all DB2 workload management objects is written to the active statistics event monitor and the statistics are reset. In a multimember database environment, the **wlm_collect_int** parameter must be updated on the catalog member. This parameter can be updated dynamically. For example:

   ```
   CONNECT TO database alias
   UPDATE DATABASE CONFIGURATION USING WLM_COLLECT_INT 5 IMMEDIATE
   ```

Results

After you perform the preceding steps, workload management statistics are written to the statistics event monitor every **wlm_collect_int** minutes. Each record written to the statistics event monitor has a STATISTICS_TIMESTAMP value and a LAST_WLM_RESET value. The interval of time from LAST_WLM_RESET to STATISTICS_TIMESTAMP defines the collection interval (that is, interval of time over which the statistics in that record were collected).

Collections occur at the specified interval times as measured relative to Sunday at 00:00:00. When the catalog member becomes active, the next collection will occur at the start of the next scheduled interval relative to this fixed time. The scheduled interval is not relative to the catalog member activation time. If a member is not active at the time of collection, no statistics are gathered for that member. For example, if the interval value was set to 60 and the catalog member was activated on 9:24 AM on Sunday, then the collections would be scheduled to occur each hour on the hour. Therefore, the next collection will occur at 10:00 AM. If the member is not active at 10:00 AM, then no statistics will be gathered for that member

If the **wlm_collect_int** parameter is set to a nonzero value and there is no active statistics event monitor, the workload management statistics are still reset every **wlm_collect_int** minutes, but statistics are not collected. The data will be lost. For this reason, it is not recommended that you specify a nonzero **wlm_collect_int** value without activating a statistics event monitor.

If the **wlm_collect_int** parameter is set to 0 (the default) statistics are not sent to the statistics event monitor automatically. You can manually send statistics to the statistics event monitor for later historical analysis by using the WLM_COLLECT_STATS stored procedure. When this procedure is invoked, it performs the same actions that occur with an automatic statistics collection interval. That is, the statistics are sent to the statistics event monitor and the statistics are reset. If there is no active statistics event monitor, the values are reset, but data is not collected. If you only want to reset statistics, you can invoke the WLM_COLLECT_STATS procedure while there is no active statistics event monitor.

Manual collection of statistics does not interfere with the automatic collection of statistics. For example, assume that you have **wlm_collect_int** set to `60`. Statistics are sent to the statistics event monitor every hour. Now assume that the last time the statistics were collected was 5:00 AM. You can invoke the WLM_COLLECT_STATS procedure at 5:55 AM, which sends the values of the statistics to the event monitor and resets the statistics. The next automatic statistics collection still occurs at 6:00 AM, one hour after the last automated collection. The collection interval is not affected by any manual collection and resetting of statistics that occurs during the interval.

Notes:

- The DB2 workload management statistics table functions report the current values of the statistics. If you have automatic workload management statistics collection enabled, these values are reset periodically on the interval defined by the **wlm_collect_int** database configuration parameter. When looking at the statistics reported by the table functions, you should always consider the LAST_RESET column. This column indicates the last time the statistics were reset. If the time interval between the last reset time to the current time is not sufficiently large, there may not be enough data to draw any meaningful conclusions.
- If you are using automatic collection of workload management statistics, you need to prune your event monitor files or tables periodically. The event monitor does not automatically prune the data that is collected, and the automatic collection will fill your files or tables over time.
- When a database is deactivated, the statistics are reset. Deactivating the database does not send statistics to the statistics event monitor. If you do not want to lose the statistics accumulated since the last collection because of a deactivation, you should manually invoke the WLM_COLLECT_STATS procedure before deactivating the database.
- The WLM_COLLECT_STATS procedure resets statistics differently than the **RESET MONITOR** command. The **RESET MONITOR** command resets the values of snapshot monitor elements by storing their present values. After the **RESET MONITOR** command has been issued, snapshot processing reports the delta between these values and the current values. In contrast, the reset caused by the WLM_COLLECT_STATS procedure does not store any values, but instead resets all of the statistics counters themselves for each applicable DB2 workload management object.

  Also, with the **RESET MONITOR** command, each process (attachment) has its own private view of the monitor data. If one user performs a reset, other users are unaffected. By contrast, a reset of the workload management statistics applies to all users.

Resetting statistics on DB2 workload management objects

This topic describes how to reset statistics for DB2 workload management objects.

Note that resetting statistics applies only to DB2 workload management statistics; metrics reported by monitoring interfaces will be collected, but not reset.

Four events will reset the statistics stored for each DB2 workload management object. (For a description of the statistics maintained for each object, see “Statistics for DB2 workload management objects” on page 242.)

- The WLM_COLLECT_STATS stored procedure is invoked. See “Collecting workload management statistics using a statistics event monitor” on page 262 for details.
- The automatic DB2 workload management statistics collection and reset process controlled by the **wlm_collect_int** database configuration parameter causes a collection and reset. See “Collecting workload management statistics using a statistics event monitor” on page 262 for details.
- The database is reactivated. Every time the database is activated on a member, the statistics for all DB2 workload management objects on that member are reset.
- The object for which the statistics are maintained is modified and the change is committed. For example if a service subclass is altered, when the ALTER statement is committed, the statistics for that service subclass are reset.

You can determine the last time the statistics were reset for a given DB2 workload management object using the statistics table functions and looking at timestamp in the LAST_RESET column. For example, to see the last time the statistics were reset for the service subclass SYSDEFAULTSUBCLASS under the SYSDEFAULTUSERCLASS service superclass, you could issue a query such as:

```
SELECT LAST_RESET
   FROM TABLE(WLM_GET_SERVICE_SUBCLASS_STATS( 'SYSDEFAULTUSERCLASS',
   'SYSDEFAULTSUBCLASS', -2)) AS T
```

All statistics table functions return the statistics that accumulated since the last time that the statistics were reset. A statistics reset occurs when a database is activated or reactivated, when you alter a DB2 workload management object (only the statistics for that object are reset), and when you call the WLM_COLLECT_STATS stored procedure. Statistics are also reset automatically according to the time period defined by the **wlm_collect_int** database configuration parameter, if you set this parameter to a nonzero value.

The period of time specified by **wlm_collect_int** is unaffected by a statistics reset that occurs during the interval specified by the configuration parameter. For example, if you run the WLM_COLLECT_STATS table function 5 minutes after the start of a 20-minute interval specified by **wlm_collect_int**, the interval still expires 15 minutes later. The statistics collection and reset that occur do not delay the occurrence of the next statistics collection and reset by 5 minutes.

If you change a service class or a workload to use a different histogram template or change a histogram template, the change does not take effect until a statistics reset occurs.

If you invoke the WLM_COLLECT_STATS table function to collect and reset statistics at the same time that another collection and reset is in progress (for example, if the invocation of the table function overlaps with the periodic collection and reset interval caused by **wlm_collect_int** or if another user invokes WLM_COLLECT_STATS at the same time), the collection and reset request from WLM_COLLECT_STATS is ignored, and warning SQL1632W is returned.

Monitoring metrics for DB2 workload management

Monitoring metrics provide data about the health of and query performance on your DB2 data server, which can then be used as input to a 3rd party tool or in conjunction with additional scripting you provide to analyze the metrics returned.

Metrics are maintained for a number of DB2 database objects. These metrics reside in memory and can be viewed in real-time using DB2 monitoring metrics table functions, or the metrics can be collected and sent to an event monitor where they can be viewed later for historical analysis.

Monitoring metrics for activities

You can obtain monitoring metrics for activities using:

- The activities event monitor (the ACTIVITYMETRICS table or the DETAILS_XML column of the ACTIVITY table)
- The MON_GET_ACTIVITY_DETAILS table function

Monitoring metrics for activities are controlled by the **mon_act_metrics** database configuration parameter and the COLLECT ACTIVITY METRICS clause on a workload. Metrics will be collected for an activity, if the database configuration parameter is set to a value other than NONE or if the activity is submitted by a connection that is associated with a workload which has a COLLECT ACTIVITY METRICS setting other than NONE.

You can use workload-level controls to achieve better monitoring granularity, if you do not want to collect metrics for all activities. If activity metrics collection is enabled at the database level (enabled by default), then metrics are collected for all activities, regardless of the setting at the workload level.

See the monitoring documentation for more details.

System-level monitoring metrics

You can obtain system-level monitoring metrics aggregated by service classes and workloads using:
- The statistics event monitor (DETAILS_XML column in the wlstats and scstats logical groups)
- The MON_GET_SERVICE_SUBCLASS, MON_GET_SERVICE_SUBCLASS_DETAILS, MON_GET_WORKLOAD and MON_GET_WORKLOAD_DETAILS table functions

Monitoring metrics for requests to the data server, including those requests that are part of an activity, are controlled by the **mon_req_metrics** database configuration parameter and the COLLECT REQUEST METRICS clause on a service superclass. Metrics will be collected for a request, if the database configuration parameter is set to a value other than NONE or if the request is submitted by a connection that mapped to a subclass under a superclass which has a COLLECT COLLECT REQUEST METRICS setting other than NONE.

You can use service superclass-level controls to achieve better monitoring granularity, if you do not want to collect metrics for all requests. If request metrics collection is enabled at the database level (enabled by default), then metrics are collected for all requests, regardless of the setting at the service superclass level.

See the monitoring documentation for more details.

Workload management table functions and snapshot monitor integration

You can use DB2 workload management table functions with the snapshot monitor table functions when performing problem determination or performance tuning.

The DB2 workload management table functions and the snapshot monitor table functions share the following fields. You can perform joins on these fields to derive data that you need to perform diagnostic and performance-tuning activities. Note that, unlike the snapshot table functions, the WLM table functions do not get their information from the snapshot monitor, so that the information available in the WLM table functions is not available from the snapshot monitor.

Table 61. Fields shared between the DB2 workload management and snapshot monitor table functions

Workload management table function field	Snapshot monitor table function field
agent_tid	**agent_pid**

Table 61. Fields shared between the DB2 workload management and snapshot monitor table functions (continued)

Workload management table function field	Snapshot monitor table function field
application_handle	**agent_id** **agent_id_holding_lock**
session_auth_id	**session_auth_id**
member	**node_number**
utility_id	**utility_id**
workload_id	**workload_id**

As an example of a reason to use a join between different table functions, assume that you want to obtain basic information about all of the utilities running in the BATCH service superclass. You might issue the following query:

```
SELECT SUBSTR(UTILITY_TYPE,1,4) TYPE,
       UTILITY_PRIORITY PRIORITY,
       SUBSTR(UTILITY_DESCRIPTION,1,12) AS UTILITY_DESCRIPTION,
       SUBSTR(UTILITY_DBNAME,1,8) AS DBNAME,
       UTILITY_STATE,
       SUBSTR(UTILITY_INVOKER_TYPE,1,7) INVOKER,
       SUBSTR(CHAR(WLM.MEMBER),1,4) MEMB,
       SUBSTR(CLASSES.PARENTSERVICECLASSNAME,1,19) SUPERCLASS_NAME,
       SUBSTR(CLASSES.SERVICECLASSNAME,1,18) SUBCLASS_NAME
FROM SYSIBMADM.SNAPUTIL SNAP,
     TABLE(WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES(CAST(NULL AS BIGINT), -2)) WLM,
     SYSCAT.SERVICECLASSES CLASSES
WHERE SNAP.UTILITY_ID = WLM.UTILITY_ID
  AND WLM.SERVICE_CLASS_ID = CLASSES.SERVICECLASSID
  AND CLASSES.SERVICECLASSNAME = 'SYSDEFAULTSUBCLASS'
  AND CLASSES.PARENTSERVICECLASSNAME = 'BATCH'
ORDER BY WLM.MEMBER
```

The output might resemble the following output:

```
TYPE PRIORITY    UTILITY_DESCRIPTION DBNAME   UTILITY_STATE INVOKER MEMB SUPERCLASS_NAME     SUBCLASS_NAME
---- ----------- ------------------- -------- ------------- ------- ---- ------------------- ------------------
LOAD           - OFFLINE LOAD        SAMPLE   EXECUTE       USER    1    BATCH               SYSDEFAULTSUBCLASS
LOAD           - OFFLINE LOAD        SAMPLE   EXECUTE       USER    1    BATCH               SYSDEFAULTSUBCLASS
LOAD           - OFFLINE LOAD        SAMPLE   EXECUTE       USER    1    BATCH               SYSDEFAULTSUBCLASS
LOAD           - OFFLINE LOAD        SAMPLE   EXECUTE       USER    2    BATCH               SYSDEFAULTSUBCLASS
LOAD           - OFFLINE LOAD        SAMPLE   EXECUTE       USER    2    BATCH               SYSDEFAULTSUBCLASS
LOAD           - OFFLINE LOAD        SAMPLE   EXECUTE       USER    2    BATCH               SYSDEFAULTSUBCLASS
LOAD           - OFFLINE LOAD        SAMPLE   EXECUTE       USER    3    BATCH               SYSDEFAULTSUBCLASS
LOAD           - OFFLINE LOAD        SAMPLE   EXECUTE       USER    3    BATCH               SYSDEFAULTSUBCLASS
LOAD           - OFFLINE LOAD        SAMPLE   EXECUTE       USER    3    BATCH               SYSDEFAULTSUBCLASS
```

Monitoring threshold violations

When a DB2 workload manager threshold is violated, a threshold violation record is written to the active THRESHOLD VIOLATIONS event monitor, if one exists.

About this task

The threshold violation record includes the following information:

- A description of the threshold that was violated (the identifier, maximum value, and so on).
- An identification of the activity that violated the threshold, including the identifier of the application that submitted the activity, the unique activity identifier, and the unit of work identifier.
- The time that the threshold was violated.

- The action that was taken. The action indicates whether the activity that violated the threshold was permitted to continue or was stopped. If the activity was stopped, the application that submitted the activity will have received an SQL4712N error.

When a threshold violation occurs for a threshold that has a REMAP ACTIVITY action defined for it, a threshold violation record is optional. Whether or not a threshold violation record is recorded is determined by the NO EVENT MONITOR RECORD or LOG EVENT MONITOR RECORD clause of your CREATE THRESHOLD statement.

You can optionally have detailed activity information (including statement text) written to an active activities event monitor if the threshold violation is caused by an activity. The activity information is written when the activity completes, not when the threshold is violated. Specify that activity information should be collected when a threshold is violated by using the COLLECT ACTIVITY DATA keyword on either the CREATE or ALTER threshold or work action set statements.

Procedure

To monitor threshold violations:

1. Use the CREATE EVENT MONITOR statement to create an event monitor of type THRESHOLD VIOLATIONS. For example:
   ```
   CREATE EVENT MONITOR VIOLATIONS FOR THRESHOLD VIOLATIONS WRITE TO TABLE
   ```
2. Use the COMMIT statement to commit your changes.
3. Use the SET EVENT MONITOR STATE statement to activate the event monitor. Instead of using the SET EVENT MONITOR STATE statement, you can use the AUTOSTART default for the THRESHOLD VIOLATIONS event monitor to have it activated the next time that the database is activated. If you want to define multiple THRESHOLD VIOLATIONS event monitors, you should not use the AUTOSTART option.
4. Use the COMMIT statement to commit your changes.

   Note: If you create any thresholds, you should create and activate a threshold violations event monitor so you can monitor any threshold violations that occur. A threshold violations event monitor does not have any impact unless thresholds are violated.

Example

This example shows how you can determine what remappings of a particular activity occurred as the result of a threshold violation that included a REMAP ACTIVITY action. To find the activities that were remapped, use a statement like the following:

```
SELECT VARCHAR(APPL_ID, 30) AS APPLID,
   UOW_ID,
   ACTIVITY_ID,
   VARCHAR(T.PARENTSERVICECLASSNAME,20) AS SERVICE_SUPERCLASS,
   VARCHAR(T.SERVICECLASSNAME,20) AS FROM_SERVICE_SUBCLASS,
   VARCHAR(S.SERVICECLASSNAME,20) AS TO_SERVICE_SUBCLASS
FROM THRESHOLDVIOLATIONS_TH1,
   SYSCAT.SERVICECLASSES AS T,
   SYSCAT.SERVICECLASSES AS S
WHERE SOURCE_SERVICE_CLASS_ID = T.SERVICECLASSID AND
      DESTINATION_SERVICE_CLASS_ID = S.SERVICECLASSID AND
      THRESHOLD_ACTION = 'REMAP'
ORDER BY APPLID, ACTIVITY_ID, UOW_ID, TIME_OF_VIOLATION ASC;
```

In this example, two remappings occurred for the activity submitted by the application with the ID *N0.swalkty.080613140844 which is identified by activity ID 1 and unit of work (UOW) ID 1:

```
APPLID                         UOW_ID      ACTIVITY_ID          SERVICE_SUPERCLASS   FROM_SERVICE_SUBCLASS TO_SERVICE_SUBCLASS
------------------------------ ----------- -------------------- -------------------- --------------------- --------------------
*N0.swalkty.080613140844                 1                    1 WORK                 HIGH                  MED
*N0.swalkty.080613140844                 1                    1 WORK                 MED                   LOW

  2 record(s) selected.
```

The output is ordered by the time of threshold violation and shows that the activity was remapped twice after it started executing. Although not shown in the output, the initial service subclass the activity was mapped to is likely a high priority service subclass, typical of a three-tiered configuration that permits shorter running queries to complete more quickly. Because the activity did not complete quickly enough in the high priority service subclass, it violated a threshold and was remapped to a medium priority service subclass, and then remapped again to a low priority service subclass after a second threshold violation later on.

How to generate email notifications for threshold violations

Using the method described here, you can generate email notifications when a DB2 workload manager (WLM) threshold is violated.

Before you begin

In order to implement this email notification approach, you must have DB2 Version 9.7 or higher installed. The SMTP support used here was provided since DB2 V9.7.

About this task

Upon completion of this task, email notifications are sent if WLM threshold violations occur during the 10 minutes since the threshold notification procedure was last run. The DB2 Administrative Task Scheduler is used to schedule the threshold notification procedure to run every 10 minutes in this example.

Procedure

1. Update the **smtp_server** database configuration parameter by issuing the following command:
   ```
   UPDATE DB CONFIG USING SMTP_SERVER smtp_server_name
   ```
2. Create a write-to-table event monitor for threshold violations and write violations to the TEST.THRESHOLDVIOLATIONS_T table by issuing the following statement:
   ```
   CREATE EVENT MONITOR T FOR THRESHOLD VIOLATIONS WRITE TO TABLE
   THRESHOLDVIOLATIONS( TABLE TEST.THRESHOLDVIOLATIONS_T )
   ```
3. Activate the write-to-table event monitor T for threshold violations by issuing the following statement:
   ```
   SET EVENT MONITOR T STATE 1
   ```
4. Create a control table to track the last threshold for which an alert was generated by issuing the following statement:
   ```
   CREATE TABLE TEST.THRESHOLD_NOTIFY_CONTROL( LAST_NOTIFICATION TIMESTAMP )
   ```
5. Create a stored threshold notification procedure to generate threshold violation messages. The following example procedure iterates over the threshold violations table and builds a report listing all threshold violations that have occurred since the last time the procedure was invoked. The report is emailed using the DB2 SMTP procedures.

```
CREATE PROCEDURE TEST.NOTIFY_ON_THRESHOLD_VIOLATION()
  LANGUAGE SQL
  BEGIN
     DECLARE NEWEST_VIOLATION    TIMESTAMP;
     DECLARE LAST_VIOLATION_SEEN TIMESTAMP;
     DECLARE NOT_FOUND           INTEGER DEFAULT 0;
     DECLARE SENDER              VARCHAR(128);
     DECLARE RECIPIENTS          VARCHAR(128);
     DECLARE MESSAGE             VARCHAR(8192);
     DECLARE SUBJECT             VARCHAR(128);
     DECLARE THRESHOLDID         BIGINT;
     DECLARE APPL_ID             VARCHAR(64);
     DECLARE THRESHOLD_PREDICATE VARCHAR(64);
     DECLARE TIME_OF_VIOLATION   TIMESTAMP;

     DECLARE C1 CURSOR FOR SELECT MAX(TIME_OF_VIOLATION)
                        FROM TEST.THRESHOLDVIOLATIONS_T;
     DECLARE C2 CURSOR FOR SELECT LAST_NOTIFICATION
                        FROM TEST.THRESHOLD_NOTIFY_CONTROL;
     DECLARE C3 CURSOR FOR SELECT THRESHOLD_PREDICATE, THRESHOLDID,
                                         TIME_OF_VIOLATION, APPL_ID
                       FROM TEST.THRESHOLDVIOLATIONS_T
                       WHERE LAST_VIOLATION_SEEN IS NULL OR TIME_OF_VIOLATION
                                                        > LAST_VIOLATION_SEEN;

     DECLARE CONTINUE HANDLER FOR NOT FOUND
        SET NOT_FOUND = 1;

     OPEN C1;
     FETCH C1 INTO NEWEST_VIOLATION;
     CLOSE C1;

     IF ( NOT_FOUND = 0 ) THEN

        OPEN C2;
        FETCH C2 INTO LAST_VIOLATION_SEEN;
        CLOSE C2;

        IF ( NOT_FOUND = 1 ) THEN
           SET LAST_VIOLATION_SEEN = NULL;
        END IF;

        IF ( NOT_FOUND = 1 OR NEWEST_VIOLATION > LAST_VIOLATION_SEEN ) THEN

           DELETE FROM TEST.THRESHOLD_NOTIFY_CONTROL;
           INSERT INTO TEST.THRESHOLD_NOTIFY_CONTROL VALUES
                                       ( NEWEST_VIOLATION );

           SET SENDER = '<sender email address>';
           SET RECIPIENTS = '<receiver email address>';
           SET SUBJECT = 'New WLM Threshold Violations' ;

           SET NOT_FOUND = 0;
           SET MESSAGE = '';

           OPEN C3;

           FETCH C3 INTO THRESHOLD_PREDICATE, THRESHOLDID, TIME_OF_VIOLATION,
                                                                  APPL_ID;

           WHILE ( NOT_FOUND = 0 ) DO

              SET MESSAGE = MESSAGE || 'Violation Timestamp = ' ||
                                 TIME_OF_VIOLATION || CHAR(X'0A');
              SET MESSAGE = MESSAGE || 'Threshold Predicate = ' ||
                               THRESHOLD_PREDICATE || CHAR(X'0A');
              SET MESSAGE = MESSAGE || 'Threshold Id        = ' ||
                                       THRESHOLDID || CHAR(X'0A');
              SET MESSAGE = MESSAGE || 'Appl Id             = ' ||
                            APPL_ID || CHAR(X'0A') || CHAR(X'0A');

              FETCH C3 INTO THRESHOLD_PREDICATE, THRESHOLDID,
                                  TIME_OF_VIOLATION, APPL_ID;
           END WHILE;

           CLOSE C3;

           CALL UTL_MAIL.SEND( SENDER, RECIPIENTS, NULL, NULL, SUBJECT,
                                                             MESSAGE );

           COMMIT;

        END IF;

    END IF;

END@
```

6. Enable the DB2 Administrative Task Scheduler by running the following command:

```
db2set DB2_ATS_ENABLE=YES
```

7. Schedule the threshold notification procedure to execute every 10 minutes. To schedule the procedure, you must have execute privileges on the procedure. The following is an example of how this can be done:

```
CALL SYSPROC.ADMIN_TASK_ADD(
   'CHECK THRESHOLD VIOLATIONS EVERY 10 MINUTES',
   NULL,
   NULL,
   NULL,
   '0-59/10 * * * *',
   'TEST',
   'NOTIFY_ON_THRESHOLD_VIOLATION',
   NULL,
   NULL,
   NULL )@
```

Results

An email is sent whenever a WLM threshold violation occurs (with a latency of at most 10 minutes). The email describes all the WLM threshold violations since the last run of the threshold violation procedure scheduled to run every 10 minutes.

Example

The following output is an example of the content of an email notification message showing the accumulated new threshold violations since the last run of the threshold violation procedure:

```
Subject: New WLM Threshold Violations

Violation Timestamp = 2010-01-11-10.57.21.000000
Threshold Predicate = CPUTime
Threshold Id        = 1
Appl Id             = *LOCAL.horton.100111154912

Violation Timestamp = 2010-01-11-10.57.28.000000
Threshold Predicate = CPUTime
Threshold Id        = 1
Appl Id             = *LOCAL.horton.100111154912

Violation Timestamp = 2010-01-11-10.57.35.000000
```

```
Threshold Predicate = CPUTime
Threshold Id        = 1
Appl Id             = *LOCAL.horton.100111154912
```

Collecting data for individual activities

You can use an ACTIVITIES event monitor to collect data for individual activities that run in your system. The data collected includes items such as statement text and compilation environment, and can be used to investigate and diagnose problems, and as input to other tools (for example, the Design Advisor).

About this task

You can collect information about individual activities for service subclasses, workloads, work classes (through work actions), and threshold violations. You enable activity collection using the COLLECT ACTIVITY DATA keyword of the CREATE and ALTER statements for these DB2 workload management objects. When an activity completes, information about the activity is sent to the active ACTIVITIES event monitor if:

- The activity was submitted by an application that is mapped to a workload for which COLLECT ACTIVITY DATA is specified, or
- The activity runs in a service subclass for which COLLECT ACTIVITY DATA is specified, or
- The activity has a COLLECT ACTIVITY DATA work action applied to it, or
- The activity violates a threshold that was defined with the COLLECT ACTIVITY DATA action

You can also use the WLM_SET_CONN_ENV procedure to turn on activity collection for your own application's connection before executing the user's query, then execute the user's query, then use WLM_SET_CONN_ENV to turn off activity collection for your application's own connection. Assuming that you have created and activated an activity event monitor, the application could look something like the following:

```
call WLM_SET_CONN_ENV(cast (NULL as bigint),
  '<collectactdata>WITHOUT DETAILS</collectactdata>')
```

... execute user's query ...

```
call WLM_SET_CONN_ENV(cast(NULL as bigint), '<collectactdata>NONE</collectactdata>')
```

The COLLECT ACTIVITY DATA keyword also controls the amount of information that is sent to the ACTIVITIES event monitor. If the keyword specifies WITH DETAILS, statement information (such as statement text) is collected. If the keyword specifies WITH DETAILS AND VALUES, data values are collected as well.

An activity might have multiple COLLECT ACTIVITY DATA keywords applied to it. For example, the activity might run in a service subclass for which COLLECT ACTIVITY DATA is specified, and while executing it might violate a threshold that has the COLLECT ACTIVITY DATA action. In this situation, the activity is only collected once. The COLLECT keyword that specifies the largest amount of information to be collected is applied to the activity. For example, if both COLLECT ACTIVITY DATA WITHOUT DETAILS and COLLECT ACTIVITY DATA WITH DETAILS are applied to an activity, the activity is collected with detailed information.

If the ON ALL DATABASE MEMBERS keywords are used with the COLLECT ACTIVITY DATA clause, an activity record will be captured on each member where the activity executes in a multimember database environment. Activity event monitor records are written when the last agent working on the activity at that member completes execution. Depending on the sequencing of events in a section, it is possible for agents to start and stop working on an activity at a member several times, causing multiple activity records to be captured at that member for the same query. The total work done by the activity on that member is the aggregate of the metrics for each record that is captured for the activity on the member.

Procedure

To enable collection of activities for a given DB2 workload management object:

1. Use the CREATE EVENT MONITOR statement to create an ACTIVITIES event monitor.
2. Use the COMMIT statement to commit your changes.
3. Use the SET EVENT MONITOR STATE statement to activate the event monitor. Instead of using the SET EVENT MONITOR STATE statement, you can use the AUTOSTART default for the ACTIVITIES event monitor to have it activated the next time that the database is activated. If you want to define multiple ACTIVITIES event monitors, you should not use the AUTOSTART option.
4. Use the COMMIT statement to commit your changes.
5. Identify the objects for which you want to collect activities by using the ALTER SERVICE CLASS, ALTER WORK ACTION SET, ALTER THRESHOLD, or ALTER WORKLOAD statement and specify the COLLECT ACTIVITY DATA keywords.
6. Use the COMMIT statement to commit your changes.

Results

Note: Individual activity collection is more expensive than workload management statistics collection. You should try to set up activity collection to collect as few activities as possible. For example, if you need to investigate activities submitted by a specific application, you could isolate that application by creating a workload or service class specifically for that application, and only enable activity collection for that workload or service class.

You might not always know in advance that you will want to capture an activity. For example, you might have a query that is taking a long time to run and you want to collect information about it for later analysis. In this situation, it is too late to specify the COLLECT ACTIVITY DATA keyword on the DB2 workload management objects, because the activity has already entered the system. In this situation, you can use the WLM_CAPTURE_ACTIVITY_IN_PROGRESS stored procedure. The WLM_CAPTURE_ACTIVITY_IN_PROGRESS stored procedure sends information about an executing activity to the active ACTIVITIES event monitor. You identify the activity to be collected using the application handle, unit of work identifier, and activity identifier. Information about the activity is immediately be sent to the ACTIVITIES event monitor when the procedure is invoked: you do not need to wait for the activity to complete.

Importing activity information into the Design Advisor

You can import activities collected by an activities event monitor into the Design Advisor to help you make decisions about the database objects accessed by these activities.

About this task

Activities imported into the design advisor must have been collected using the COLLECT ACTIVITY DATA WITH DETAILS or COLLECT ACTIVITY DATA WITH DETAILS AND VALUES options. The COLLECT ACTIVITY DATA WITHOUT DETAILS option is not sufficient, it will not capture the statement text which is required by the Design Advisor.

To import activity information from the activity event monitor tables into the Design Advisor, run the **db2advis** command with the **-wlm** parameter, followed by additional parameters:
1. The activities event monitor name
2. Optional: the workload or service class name
3. Optional: the start time and end time

For example, to import information about all the activities collected by the DB2ACTIVITIES event monitor in the SAMPLE database, use the following command:

```
db2advis -d SAMPLE -wlm DB2ACTIVITIES
```

Note: You can only import information from activities event monitor tables through the Design Advisor command line interface.

Canceling activities

If an activity is consuming too many resources, or is running too long, you can cancel it. Canceling an activity is gentler than forcing the application that submitted the activity. A canceled activity returns SQL4725N to the user, but does not end the connection or affect any other user activity. Forcing the application ends both the connection and user activities.

About this task

You can only explicitly cancel an activity if a coordinator activity is currently working on a request for the activity. If you cancel an activity in the IDLE state (that is, no requests are being processed), the activity is placed in the CANCEL_PENDING state and is canceled on the next request that is received. For example, if you attempt to cancel a CURSOR activity between fetches, the SQL4725N error is not returned to the user until the next fetch after the cancel.

All user activities are cancelable, including the load utility and stored procedures.

Procedure

1. Identify the activity that you want to cancel. You can use the WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES table function to identify the activities running in an application. You can also use the MON_GET_ACTIVITY_DETAILS_COMPLETE table function to view additional details about a particular activity if the information in

WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES is not sufficient to identify the work that the activities are performing.

2. Cancel the activity using the WLM_CANCEL_ACTIVITY stored procedure. The stored procedure takes the following arguments: *application_handle*, *uow_id*, and *activity_id*. For an example of how to use this stored procedure, see "Scenario: Identifying activities that are taking too long to complete" on page 346.

Guidelines for capturing information about and investigating a rogue activity

This topic provides guidelines for capturing information about, and investigating, a rogue activity.

First establish a set of criteria for what you would consider a rogue activity. For example:

- An activity in that runs in a service class for activities with a low estimated cost, and runs for more that 1 hour
- An activity that returns an unusually large number of rows
- An activity that consumes an unusually high amount of temporary table space

Then create thresholds that describe these criteria and contain a COLLECT ACTIVITY DATA WITH DETAILS action. When the threshold is violated, information about the activity that violated the threshold is sent to the active ACTIVITIES event monitor when the activity completes.

For example, to collect information about any database activity that runs for more than 3 hours, create a threshold such as the following threshold:

```
CREATE THRESHOLD LONGRUNNINGACTIVITIES
   FOR DATABASE ACTIVITIES ENFORCEMENT DATABASE
   WHEN ACTIVITYTOTALTIME > 3 HOURS COLLECT ACTIVITY DATA WITH DETAILS
   CONTINUE
```

Monitoring with DB2 workload manager is lightweight, if you are careful to apply it only to a small subset of your queries, as shown in the example, where only queries running for at least three hours are monitored. You can refine this example further by creating a threshold not at the global database level, but at the level of a user-defined superclass. If this more narrowly scoped monitoring suits your purpose, it can further reduce the cost of monitoring and it will provide information only at the level you need:

```
CREATE SERVICE CLASS LONGQUERIES
   AGENT PRIORITY 20
   PREFETCH PRIORITY LOW

CREATE THRESHOLD LONGRUNNINGACTIVITIES2
   FOR SERVICE CLASS LONGQUERIES ACTIVITIES ENFORCEMENT DATABASE
   WHEN ACTIVITYTOTALTIME > 3 HOURS COLLECT ACTIVITY DATA WITH DETAILS
   CONTINUE
```

. The service class created for the threshold is assigned low agent and prefetch priority, because it is intended to be used for long running queries (this SQL statement works on UNIX operating systems and Linux; on Windows operating systems, substitute an agent priority of -6).

After your data server has performed some work, you can analyze the information that is written to the threshold violations and activities event monitors. DML activities also have their statement text and compilation environment information written to the activities event monitor, so you can run **DB2 explain** on them to further investigate the performance of the activity.

Workload management performance modelling

The workload on your system can be modelled as a set of activities that arrive at the system at a rate governed by an arrival rate distribution for activities (often measured as its inverse, the *inter-arrival* time distribution) and the amount of time activities spend executing in the system following a service time distribution.

Inter-arrival time is the time between the arrival of one activity and the arrival of the next activity. Service time is the time that an activity spends executing on the system. For example, if you submit a query at time 0 seconds, it spends 2 seconds in a queue, and it finishes at time 5 seconds, the service time is `5 - 2 = 3` seconds. Service time assumes no other work executing on the system (that is, it is not the observed execution time, but rather the time it would take to execute the activity in isolation). The service time distribution can be approximated for DML activities using the estimated cost in timerons, which considers both processor and I/O time for an activity.

You can build a workload model for your system by measuring the inter-arrival time distribution and the service time distribution of the activities on the system. Inter-arrival time distributions and approximate service time distributions (using estimated cost) can be obtained by using extended aggregate activity statistics for service subclasses or work classes (using work actions) and a statistics event monitor. These statistics are not collected by default. For more information, see:

- "Statistics for DB2 workload management objects" on page 242
- A gentle introduction to histograms
- Understanding the six histograms of DB2 workload management
- Visualizing and deriving statistics from DB2 histograms using SQL

Example: Capturing information about an activity for later analysis

You can use workload management features to capture information about an activity for later analysis.

Assume that you have a stored procedure called MYSCHEMA.MYSLOWSTP and that it is running more slowly than usual. You begin to receive complaints about this situation and decide to investigate the cause of the slowdown. If investigating while the stored procedure is running is impractical, you can capture information about the stored procedure activity and any activities nested in it.

Assuming that you have an active activities event monitor called DB2ACTIVITIES, you can create a work class for CALL statements that apply to the schema of the MYSCHEMA.MYSLOWSTP stored procedure. Then you can create a work action to map the CALL activity and all nested activities to a service class that has activity collection enabled. The CALL activity, and any activities nested in it, are sent to the event monitor. Following are examples of the DDL required to create the DB2 workload management objects:

```
CREATE SERVICE CLASS SC1;
CREATE WORKLOAD WL1 APPLNAME ('DB2BP') SERVICE CLASS SC1;
CREATE SERVICE CLASS PROBLEMQUERIESSC UNDER SC1 COLLECT ACTIVITY DATA ON COORDINATOR WITH DETAILS;

CREATE WORK CLASS SET PROBLEMQUERIES
(WORK CLASS CALLSTATEMENTS WORK TYPE CALL ROUTINES IN SCHEMA MYSCHEMA);
```

```
CREATE WORK ACTION SET DATABASEACTIONS FOR SERVICE CLASS SC1 USING WORK CLASS SET PROBLEMQUERIES
(WORK ACTION CAPTURECALL ON WORK CLASS CALLSTATEMENTS MAP ACTIVITY WITH NESTED TO PROBLEMQUERIESSC);
```

After the MYSCHEMA.MYSLOWSTP stored procedure runs, you can issue the following query to obtain the application handle, the unit of work identifier, and the activity identifier for the activity:

```
SELECT AGENT_ID,
       UOW_ID,
       ACTIVITY_ID
FROM ACTIVITY_DB2ACTIVITIES
WHERE SC_WORK_ACTION_SET_ID = (SELECT ACTIONSETID
                            FROM SYSCAT.WORKACTIONSETS
                            WHERE ACTIONSETNAME = 'DATABASEACTIONS')
AND SC_WORK_CLASS_ID = (SELECT WORKCLASSID
                     FROM SYSCAT.WORKCLASSES
                     WHERE WORKCLASSNAME = 'CALLSTATEMENTS'
                     AND WORKCLASSSETID =
                     (SELECT WORKCLASSSETID FROM SYSCAT.WORKACTIONSETS WHERE ACTIONSETNAME
                     = 'DATABASEACTIONS'));
```

Assuming that the captured activity has an application handle of 1, a unit of work identifier of 2, and an activity identifier of 3, the following results are generated:

```
AGENT_ID             UOW_ID      ACTIVITY_ID
==================== =========== ===========
                   1           2           3
```

Using this information, you can issue the following query against the ACTIVITY_DB2ACTIVITIES and the ACTIVITYSTMT_DB2ACTIVITIES tables to determine where the activity spent its time:

```
WITH RAH (LEVEL, APPL_ID, PARENT_UOW_ID, PARENT_ACTIVITY_ID,
          UOW_ID, ACTIVITY_ID, STMT_TEXT, TIME_CREATED, TIME_COMPLETED) AS
  (SELECT 1, ROOT.APPL_ID, ROOT.PARENT_UOW_ID,
          ROOT.PARENT_ACTIVITY_ID, ROOT.UOW_ID, ROOT.ACTIVITY_ID,
          ROOTSTMT.STMT_TEXT, ROOT.TIME_CREATED, ROOT.TIME_COMPLETED
   FROM ACTIVITY_DB2ACTIVITIES ROOT, ACTIVITYSTMT_DB2ACTIVITIES ROOTSTMT
   WHERE ROOT.APPL_ID = ROOTSTMT.APPL_ID AND ROOT.AGENT_ID = 1
     AND ROOT.UOW_ID = ROOTSTMT.UOW_ID AND ROOT.UOW_ID = 2
     AND ROOT.ACTIVITY_ID = ROOTSTMT.ACTIVITY_ID AND ROOT.ACTIVITY_ID = 3
  UNION ALL
   SELECT PARENT.LEVEL +1, CHILD.APPL_ID, CHILD.PARENT_UOW_ID,
          CHILD.PARENT_ACTIVITY_ID, CHILD.UOW_ID,
          CHILD.ACTIVITY_ID, CHILDSTMT.STMT_TEXT, CHILD.TIME_CREATED,
          CHILD.TIME_COMPLETED
   FROM RAH PARENT, ACTIVITY_DB2ACTIVITIES CHILD,
        ACTIVITYSTMT_DB2ACTIVITIES CHILDSTMT
   WHERE PARENT.APPL_ID = CHILD.APPL_ID AND
         CHILD.APPL_ID = CHILDSTMT.APPL_ID AND
         PARENT.UOW_ID = CHILD.PARENT_UOW_ID AND
         CHILD.UOW_ID = CHILDSTMT.UOW_ID AND
         PARENT.ACTIVITY_ID = CHILD.PARENT_ACTIVITY_ID AND
         CHILD.ACTIVITY_ID = CHILDSTMT.ACTIVITY_ID AND
         PARENT.LEVEL < 64
  )
SELECT UOW_ID, ACTIVITY_ID, SUBSTR(STMT_TEXT,1,40),
               TIMESTAMPDIFF(2, CHAR(TIME_COMPLETED - TIME_CREATED)) AS
               LIFE_TIME
FROM RAH
  ORDER BY UOW_ID, ACTIVITY_ID;
```

The results would resemble the following ones:

```
UOW_ID ACTIVITY_ID STMT_TEXT                           LIFE_TIME
====== =========== =================================== =============
2      3           CALL SLOWPROC                                1000
2      4           SELECT COUNT(*) FROM ORG                        1
2      5           SELECT * FROM MYHUGETABLE                     999
```

The results indicate that the stored procedure is spending most of its time querying the MYHUGETABLE table. Your next step is to investigate what changes to the MYHUGETABLE table might cause queries running against it to slow down.

When many stored procedures run simultaneously, greater overhead is incurred when performing the analysis. To solve this problem, you can create a workload and service class for running a stored procedure that is issued by a specific authorization identifier, a specific application, or both. You can then use the preceding method to analyze the behavior of the stored procedure.

Chapter 5. Integration with operating system workload managers

If available, use DB2 workload management in conjunction with an operating system workload manager, which provides you with additional capabilities.

The point of integration between DB2 workload management and operating system workload managers is the DB2 service class. You create a mapping between a DB2 service class and an operating system workload manager class when you define a DB2 service class by using the OUTBOUND CORRELATOR option of the CREATE SERVICE CLASS or the ALTER SERVICE CLASS statement.

If the outbound correlator is set, all threads in the DB2 service class are associated with the operating system workload manager using the outbound correlator when the next activity begins.

Integration of AIX Workload Manager with DB2 workload management

On the AIX operating system, the optional integration between DB2 service classes and AIX WLM classes permits you to control the amount of processor resource allocated to each service class.

Implementing AIX WLM controls may not be needed to meet your performance objectives, but even if you do not need to exercise AIX WLM, the operating system statistics provided by AIX WLM per AIX class are often useful for monitoring and tuning efforts.

AIX WLM assigns relative or absolute amounts of processor resource as shares to classes which benefit from controls that you can change dynamically and that become effective immediately. If relative AIX CPU shares do not provide the level of control you require, you also have the choice of assigning hard maximum percentage of CPU resource. By doing so, you surrender some of the flexibility of relative CPU allocation, which is useful during off-peak times, but you also gain excellent and guaranteed control with a hard maximum limit on CPU time resource allocation.

Recommended mappings between DB2 service classes and AIX classes

Use a 1:1 mapping of DB2 service classes to AIX Workload Manager service classes to take advantage of AIX WLM processor controls. By having a 1:1 mapping between DB2 service classes and AIX Workload Manager service classes, you can adjust the AIX processor resource for each DB2 service class individually to meet your business priority goals.

The following figure shows the integration of DB2 workload management with the AIX Workload Manager. Note the 1:1 mapping between each DB2 service class and AIX Workload Manager service class at the service superclass and service subclass levels.

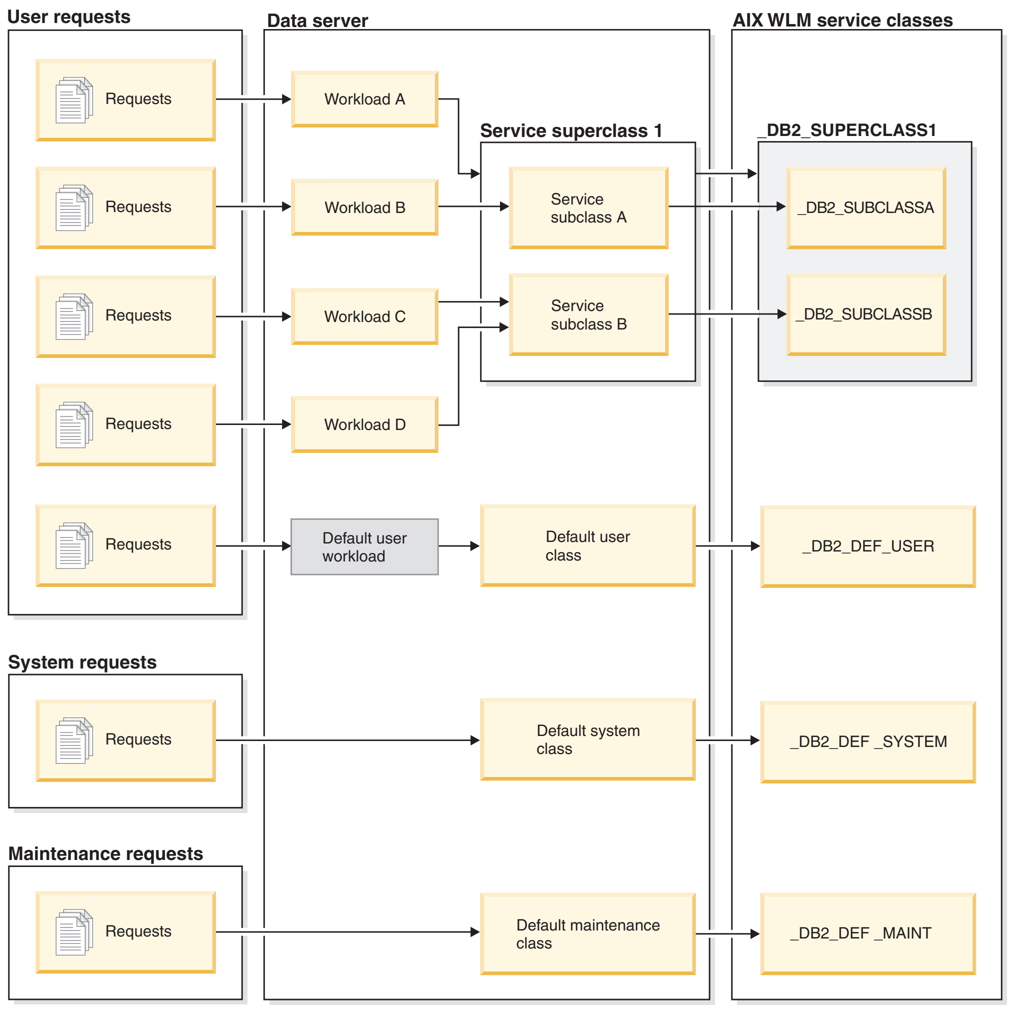


Figure 52. Integration of DB2 workload management with the AIX Workload Manager

When a DB2 environment consists of a single database in a single DB2 instance, such as the example portrayed in the previous figure, it is possible to map directly between DB2 service classes and AIX Workload Manager classes. Each DB2 service superclass can have a corresponding AIX Workload Manager service superclass and each DB2 service subclass can map to a corresponding AIX service subclass.

In situations where the DB2 environment consists of multiple databases and DB2 instances, several levels might be candidates for resource control. Because the AIX Workload Manager supports a two-level hierarchy, that is, superclass and subclass, only two levels of a DB2 environment can be mapped to AIX Workload Manager classes at any time. The following figure shows one way to achieve a 1:1 mapping with multiple databases, each with multiple superclasses. Here, each database has its own AIX Workload Manager superclass and each DB2 service superclass is mapped to an AIX Workload Manager subclass.

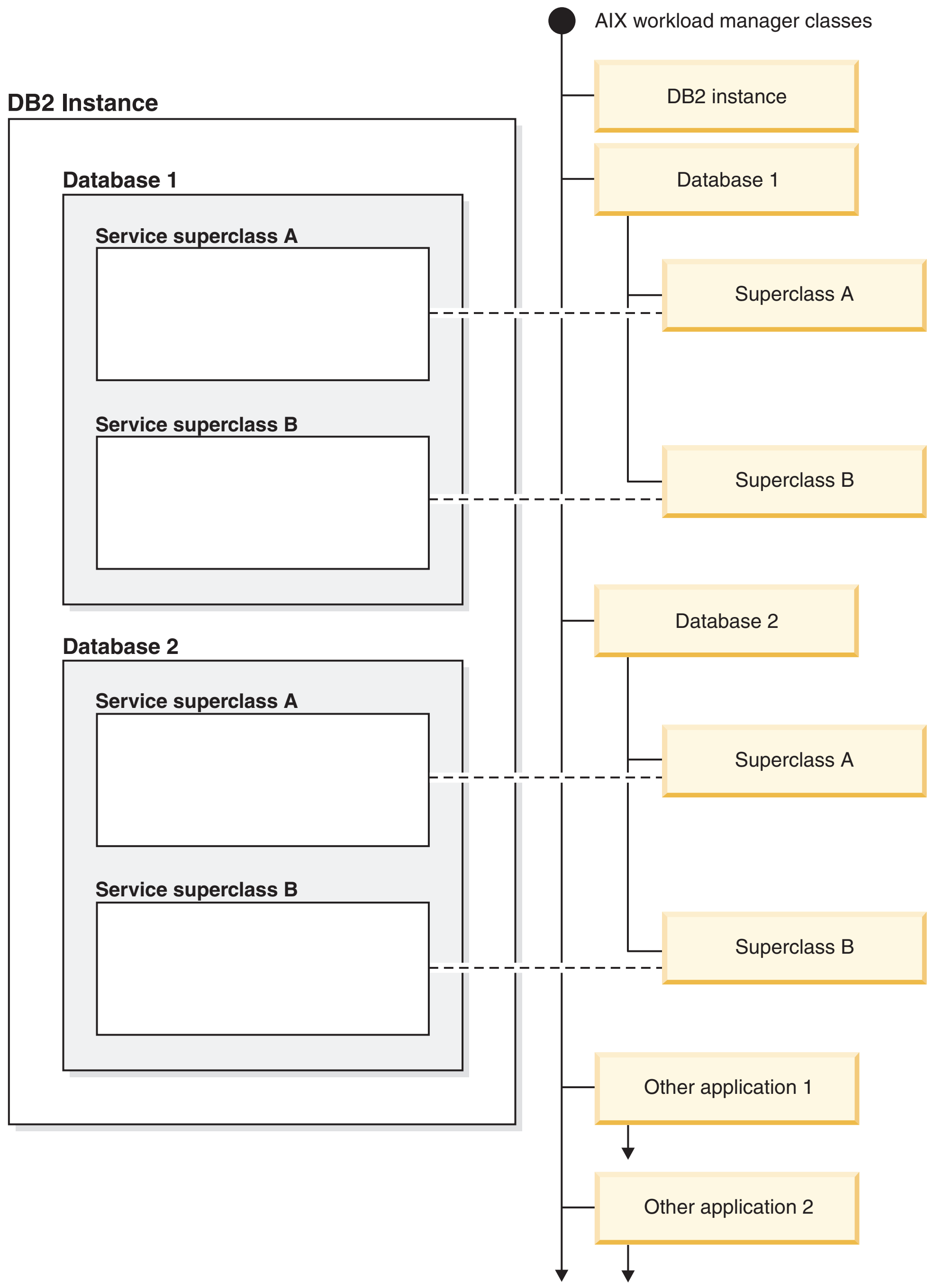


Figure 53. DB2 service classes mapped to AIX classes (with DB2 service superclasses only)

An alternative configuration is to map each DB2 service superclass to its own AIX Workload Manager superclass, which results in four superclasses in this example. In this situation, the database level of resource control is represented explicitly in the AIX Workload Manager service class definitions.

The following figure shows one way to achieve the 1:1 mapping in the situation where you have multiple databases, each with service superclasses and service subclasses. Here, each database corresponds to an AIX superclass and each DB2 service subclass is mapped to an AIX Workload Manager subclass. The DB2 service superclass is not shown explicitly in the AIX Workload Manager service class definitions.

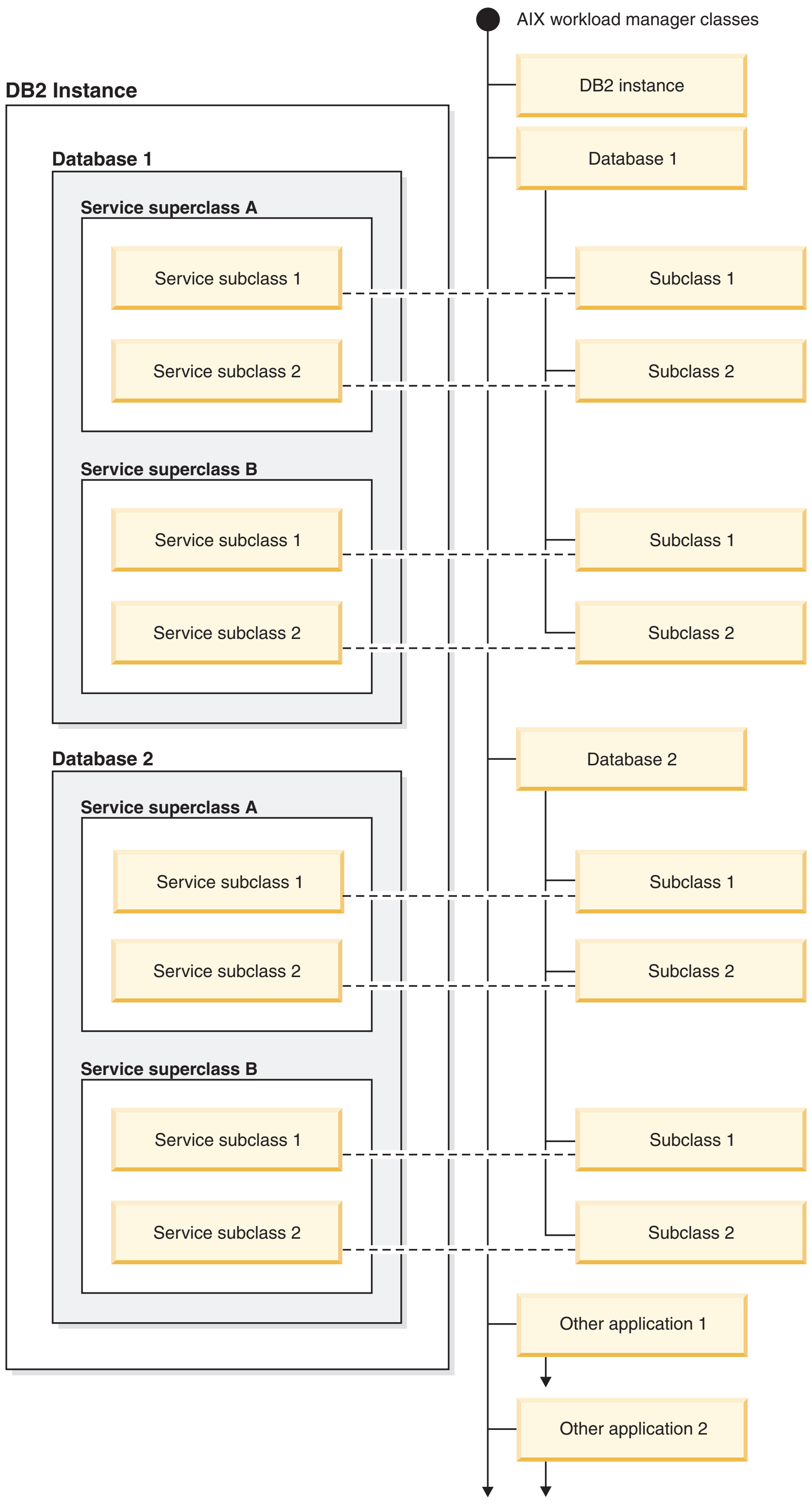


Figure 54. DB2 service classes mapped to AIX Workload Manager classes (with DB2 service subclasses)

Defining mappings between DB2 service classes and AIX classes

Mapping between DB2 service classes and AIX Workload Manager classes is specified for the DB2 service class using the OUTBOUND CORRELATOR keyword of the CREATE SERVICE CLASS or the ALTER SERVICE CLASS statements.

The steps for setting up the AIX Workload Manager classes with the DB2 data server are:

1. Create the DB2 service superclasses and service subclasses, and specify the OUTBOUND CORRELATOR tags.
2. Create the corresponding AIX classes.
3. Create the associated AIX Workload Manager rules files to contain the DB2 workload management to AIX Workload Manager mappings using the OUTBOUND CORRELATOR tags under the tag columns.
4. Start the AIX Workload Manager.
5. If required, set this AIX Workload Manager configuration as active.

When a thread joins a DB2 service class, the DB2 data server calls the appropriate AIX Workload Manager API to associate the thread to the corresponding AIX service class. The DB2 data server sends the thread's target AIX service class to the AIX Workload Manager by passing it the application tag set in the OUTBOUND CORRELATOR parameter.

You must ensure that the AIX Workload Manager is properly installed, configured, and active. If the DB2 data server cannot communicate with the AIX Workload Manager, a message is logged to the db2diag log files and DB2 administrator log. The database activity continues.

The DB2 data server cannot detect whether the OUTBOUND CORRELATOR value that it passes to the AIX Workload Manager is recognized by the AIX Workload Manager. You must verify that the value specified for the DB2 service class matches the application tags that map DB2 threads to the AIX service classes. If the OUTBOUND CORRELATOR value is not recognized by the AIX Workload Manager, the database activity continues to execute.

Other points to note are:

- DB2 service classes cannot work with the AIX Workload Manager inheritance feature. Inheritance is the default setting for an AIX service class; inheritance must be explicitly disabled by setting the inheritance attribute to `NO`. AIX Workload Manager inheritance forces all child threads and processes to map to the same class as the parent thread or process. If inheritance is enabled, DB2 workload management cannot change the AIX Workload Manager class of a thread by using tagging. This restriction makes any integration of DB2 workload management and the AIX Workload Manager unusable. The DB2 data server cannot detect whether AIX Workload Manager inheritance is enabled and does not issue an error message if inheritance is enabled.
- DB2 service classes are not compatible with the AIX Workload Manager manual assignment feature. With the manual assignment feature, users can manually assign a process to a specific AIX Workload Manager class. By manually assigning the DB2 process, all threads in the process are assigned to a target AIX Workload Manager class, the DB2 service class mapping logic is defeated and results are not predictable.

For more information on the AIX Workload Manager, see the AIX Information Center at http://publib.boulder.ibm.com/infocenter/pseries/v5r3/index.jsp

Setting processor controls on AIX classes

The AIX Workload Manager can be used to control the amount of processor resource allocated to each service class. Options include setting a minimum, maximum, or relative proportion share of processor resource for each service class.

When integrating the AIX Workload Manager with DB2 Workload Management, only processor resource allocation is supported. You should not set memory and I/O settings for the AIX classes. DB2 database-level memory is shared among all agents from different DB2 service classes, so you cannot divide memory allocation between different service classes. AIX-level I/O control does not support the DB2 engine threaded model. To control I/O, you can use the prefetcher priority attribute of a DB2 service class to differentiate I/O priorities between different DB2 service classes.

If you use AIX to control the amount of processor resource allocated to a service class, do not also change the agent priority setting for that DB2 service class. Use only one of these mechanisms to govern the access to processor resource. You cannot set both the AGENT PRIORITY and the OUTBOUND CORRELATOR value for a service class. See "Agent priority of service classes" on page 76 for more information.

AIX Workload Manager settings should be consistent on all physical computers that participate in an instance. For example, if the resource setting for an AIX service class is set high on one computer, the same setting should be used for that AIX service class on all other computers. If the resource usage settings are inconsistent across computers, requests running in the same AIX service class will exhibit different performance levels on different database members. This situation can lead to poor overall throughput for connections in an AIX service class.

Integration of Linux workload management with DB2 workload management

On the Linux operating system, the optional integration between DB2 service classes and Linux classes (control groups) permits you to control the amount of processor resource allocated to each service class. If enabled, all threads running in a DB2 service class are mapped to a Linux class where they are subject to the processor resource controls you define.

To make use of Linux workload management support, you require a Linux kernel version 2.6.26 or later on a 64-bit system and the `libcgroup` library package.

Linux workload management supports a hierarchy of classes with superclasses and subclasses, with processor shares for subclasses divided in proportion to the shares of the parent class. These shares provide a method of control over processor resource such that all threads in the system will always run, but the amount of processor time each thread receives is dependent on the number of shares assigned to the Linux class.

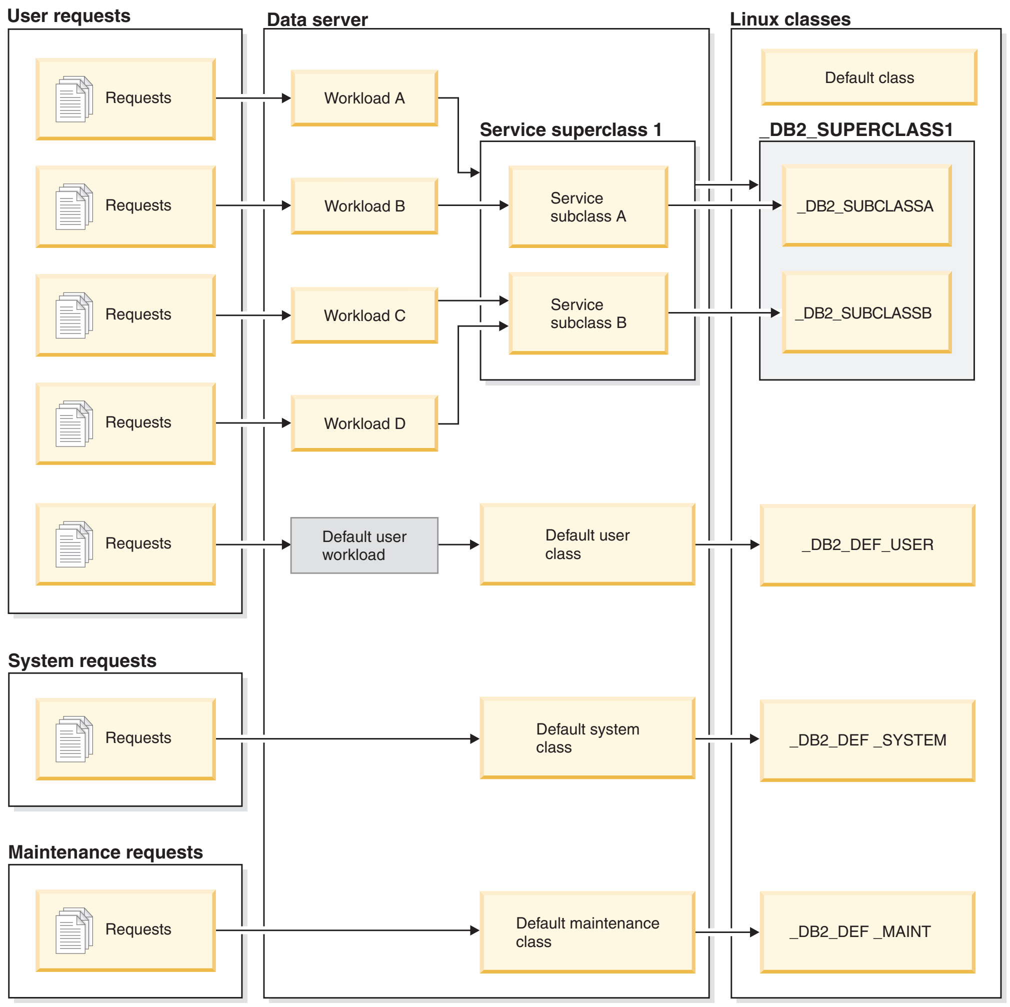
Processor resource on the Linux operating system is assigned in shares relative to the Linux workload management default class, which by default has a processor share at a value of 1024. If you define no other Linux classes, all threads run in this default class. If you define a class that has a share value equal to 1024, then this class receives the same amount of processor resource as the Linux default class with the default processor share. Similarly, a class with a share of 2048 receives a target processor usage quota twice that of the default class. On more complex systems, you should consider raising the processor share of the Linux default class, which improves the granularity for shares across the system so that you can assign processor resources more accurately.

Recommended mappings between DB2 service classes and Linux classes

You should use a 1:1 mapping between DB2 service classes and Linux classes which permits you to adjust the Linux processor shares assigned to activities in each DB2 service class individually according to business priority. It is important that you associate every DB2 service class with a Linux WLM class, either by setting an outbound correlator for each service superclass and subclass, or through inheritance from the parent service class for subclasses. This includes the default SYSDEFAULTSYSTEMCLASS, SYSDEFAULTMAINTENANCECLASS and SYSDEFAULTUSERCLASS service classes.

The following figure shows how two DB2 service subclasses under the same user defined service superclass can get mapped 1:1 to Linux subclasses under a common superclass. In this example, the work identified and assigned by two workloads for each DB2 service subclass is subject to the processor resource controls imposed by the corresponding Linux subclasses (_DB2_SUBCLASSA, _DB2_SUBCLASSB). Also shown are three Linux classes that correspond to the default DB2 workload management service classes (_DB2_DEF_USER, _DB2_DEF_SYSTEM, _DB2_DEF_MAINT). If you integrate DB2 workload management with Linux workload management, you should always create these additional Linux classes to match the default DB2 service classes. To avoid any bottleneck, the Linux class corresponding to the DB2 default system class should receive more processor shares than any other Linux class that DB2 activities map to, whilst the Linux class corresponding to the default maintenance class should receive less processor shares.

Figure 55. Integration of DB2 workload management with Linux workload management



Defining mappings between DB2 service classes and Linux workload management classes

The steps for integrating DB2 workload management with Linux workload management, which runs as an operating system service, are as follows:

1. Define the Linux classes, class permissions, and processor shares by editing the `/etc/cgconfig.conf` control groups configuration file. What Linux classes you create depends on the conditions dictated by your business priorities for the work your data server performs. If you want to apply processor resource based on the source of certain work, for example, create a Linux class to match the DB2 service class that work is going to be assigned to by the workload identifying the work. Define an entry for each Linux class corresponding to the DB2 service class to be created that you want to use for the mapping. The following sections must be provided in the `/etc/cgconfig.conf` configuration file:
   - `group`: The Linux class name. For example, if you specify group `_class1`, you create a superclass _class1. If you specify group `_class1/_subclass1`, you create the subclass _subclass1 under the superclass _class1.
     - `perm`: The permissions section that determines who can control what threads are assigned to a Linux class and who can change the processor shares of classes in the `/etc/cgconfig.conf` configuration file.

- task: The user ID (**uid**) and group ID (**gid**) whose threads can run in the Linux workload management class. To enable Linux workload management to work with DB2 workload management, you should set **uid** to the DB2 instance owner user ID.
- admin: The user ID (**uid**) and group ID (**gid**) that can change processor shares for a Linux workload management class.

– cpu: The processor shares definition section
  - cpu.shares: The share assigned to this Linux class relative to the default class

The /etc/cgconfig.conf configuration file must contain these sections in the following format:

```
# Superclass name
group _name
{
   perm
   {
      task
      {
         uid = db2inst1;
         gid = db2iadm1;
      }
      admin
      {
         uid = db2inst1;
         gid = db2iadm1;
      }
   }

   cpu
   {
      cpu.shares = 1024;
   }
}
```

2. Start the Linux workload management service daemon with the **service cgconfig start** command, then start your DB2 data server with the **db2start** command.
3. To map a DB2 service class to one of the Linux classes, include the Linux class name in the OUTBOUND CORRELATOR clause when you create or alter the service class, which associates threads from the DB2 service class with the external Linux class.
4. If you want to find out what threads are assigned to a particular Linux class, you can use the cat command on the /cgroup/*class_name*/tasks file, where *class_name* represents the name of the Linux class you are interested in. All threads that are not mapped to a user-defined Linux class are assigned to the Linux default class, which you can find at MOUNTPOINT/sysdefault, where MOUNTPOINT is defined in the cgconfig.conf configuration file.
5. To add or remove Linux classes, you must stop with the Linux workload management service with the **service cgconfig stop** command, make your changes, and then restart the service. Note that stopping the service affects the entire system, because all tasks are moved to the default class. If you used the /etc/init.d/cgred script to start the service daemon, issue **/etc/init.d/cgred stop** to stop it.

For the integration with DB2 workload management to work, you must ensure that the Linux workload management service is properly installed, configured, and active. If the DB2 data server cannot communicate with the Linux workload management service, a message is logged to the db2diag log files and DB2 administrator log. Database activities will continue to execute.

The DB2 data server cannot detect whether the outbound correlator that it passes to external workload managers is recognized by Linux workload management. You must verify that the OUTBOUND CORRELATOR value specified for a DB2 service class matches the Linux class name so that DB2 threads are mapped to the Linux class. If an outbound correlator is not recognized, database activities will continue to execute.

Example

The following example illustrates how you can make use of Linux workload management processor controls by integrating with DB2 workload management. In this example, we create two user-defined DB2 service classes, one for batch applications (BATCHAPPS) and one for online applications (ONLINEAPPS). For simplicity, this example does not show the default service classes, which should be included in an implementation that creates the recommended 1:1 mapping between DB2 service classes and Linux classes. Because response time is critical for the online applications, we want the ONLINEAPPS service class to receive three times the amount of processor shares relative to work that runs in the Linux default class (3 x 1024 = 3072 shares). Batch applications have a lower business priority, and the BATCHAPPS class should be assigned half the processor resource of work that runs in the Linux default class (1024 / 2 = 512 shares). All other work on the system will run in the Linux default class. Note that this example does not create Linux classes corresponding to the three default DB2 workload management service classes.

To create this setup, first create the two corresponding Linux classes _BATCHAPPS and _ONLINEAPPS and set their relative processor shares by editing the `/etc/cgconfig.conf` tasks file. After editing, the tasks file contains the following two entries, one for each Linux class:

```
# Superclass ONLINEAPPS
group _ONLINEAPPS
{
   perm
   {
      task
      {
         uid = db2inst1;
         gid = db2iadm1;
      }
      admin
      {
         uid = db2inst1;
         gid = db2iadm1;
      }
   }

   cpu
   {
      # 3 x 1024 = 3072 shares
      cpu.shares = 3072;
   }
}

# Superclass BATCHAPPS
group _BATCHAPPS
{
   perm
   {
      task
      {
         uid = db2inst1;
         gid = db2iadm1;
      }
      admin
      {
         uid = db2inst1;
         gid = db2iadm1;
      }
   }

   cpu
   {
      # 1024 / 2 = 512 shares
      cpu.shares = 512;
   }
}
```

The absolute processor time in percent assigned to each Linux class as processor shares is as follows:

Table 62. Processor shares and absolute processor time assigned to Linux classes

Linux class	Shares	Absolute processor time in percent
Default class	1024 (default)	1024 / 4608 = 22%
_ONLINEAPPS	1024 x 3 = 3072	3072 / 4608 = 67%
_BATCHAPPS	1024 x ½ = 512	512 / 4608 = 11%
	Total = 1024 + 3072 + 512 = 4608 shares	

Once the Linux WLM classes are created, you can start the Linux workload management service:

```
service cgconfig start
```

Next, create the associated DB2 service classes with the following statements:

```
DB2 CREATE SERVICE CLASS BATCHAPPS OUTBOUND CORRELATOR '_BATCHAPPS'
DB2 CREATE SERVICE CLASS ONLINEAPPS OUTBOUND CORRELATOR '_ONLINEAPPS'
```

To find out which threads are running in a Linux class, issue the cat command. For the business critical _ONLINEAPPS Linux class, the command and output look as follows. You can see that there are six thread running in this Linux class:

```
cat /cgroup/_ONLINEAPPS/tasks

1056
1087
1107
985
1036
1205
```

Chapter 6. Tutorial for DB2 workload management

The exercises in this tutorial were designed to provide you with a hands-on introduction to DB2 workload management. Each exercise highlights one or more of the workload management features available with DB2 workload management.

These exercises provide some guidance for using DB2 workload management features which you can adapt for your own purposes, but you should note that the initial configuration you chose for your own data server may differ and should be based on your specific workload management objectives.

Before you begin

This tutorial is designed to be run against the SAMPLE database and, unless noted otherwise, requires DBADM or WLMADM authority (or SQLADM authority if only the COLLECT ACTIVITY DATA clause is specified). You should also start the instance and activate the SAMPLE database before continuing:

```
db2start
db2 activate db sample
```

Some of the command and query statements shown in these exercises are quite long. You can find most of these statements in the text file `wlm-tutorial-steps.txt`, which you can copy from when working through the exercises. The scripts representing the workloads that are required for the different exercises are also included.

Both `wlm-tutorial-steps.txt` and the workload scripts can be found here.

Exercise 1: Getting started with basic monitoring using default DB2 workload management objects

This exercise demonstrates the basic types of monitoring information that can be obtained from the default workload and service class objects.

Estimated time: 20-25 minutes

By default, the user workload (SYSDEFAULTUSERWORKLOAD) and a default user service class (SYSDEFAULTUSERCLASS) are always created for each database. These default objects can be used to take advantage of the new DB2 workload management monitoring features without having to create any user defined workloads or service classes. If no user defined workloads and service classes are created, all user activities will be associated with these default objects.

There are two separate features of monitoring that are demonstrated by this exercise:

1. The ability to collect aggregate statistics for all activities that run in a service class. Aggregate activity statistics provide an inexpensive way of looking at work in a service class as a whole. They show information like the number of activities that ran in the service class, and the average lifetime of those activities.
2. The ability to capture information about individual activities. Activity information can be useful when investigating the performance or behavior of a

particular activity. Activity information includes things such as statement text, compilation environment, etc. Activity information is more expensive to collect than aggregate activity statistics and is usually targeted towards a specific subset of activities.

Step 1: Create and enable event monitors

Connect to the database and create and enable event monitors for activities and statistics.

```
CONNECT TO SAMPLE

CREATE EVENT MONITOR DB2ACTIVITIES FOR ACTIVITIES WRITE TO TABLE
CREATE EVENT MONITOR DB2STATISTICS FOR STATISTICS WRITE TO TABLE

SET EVENT MONITOR DB2ACTIVITIES STATE 1
SET EVENT MONITOR DB2STATISTICS STATE 1
```

Step 2: Collect individual activities

Enable collection of individual activities using the COLLECT ACTIVITY DATA clause on the CREATE or ALTER WORKLOAD STATEMENT. When the COLLECT ACTIVITY DATA clause is specified for a workload, information about any activity submitted by an occurrence of that workload will be sent to the active ACTIVITIES event monitor when the activity completes. The COLLECT ACTIVITY DATA clause permits you to specify how much information should be collected by applying one of the following options:

- WITHOUT DETAILS: Collect activity information without statement and compilation environment.
- WITH DETAILS: Collect activity information including statement and compilation environment.
- WITH DETAILS AND VALUES: Collect activity information including statement and compilation environment, and input data values.

For this exercise, you will specify the WITH DETAILS clause so that the statement text information is captured.

```
ALTER WORKLOAD SYSDEFAULTUSERWORKLOAD
   COLLECT ACTIVITY DATA ON COORDINATOR WITH DETAILS
```

In this example activity data is collected for the default user workload. This results in information about all user activities being collected since no other user defined workloads are currently active. This would be too expensive in a production environment. A better approach would be to isolate the activities of interest using a specific user defined workload or service class and apply the COLLECT ACTIVITY DATA clause to that workload or service class only.

Additional Information: The COLLECT ACTIVITY DATA clause can also be specified on a service class, work class (using a work action) or a threshold. If the clause is specified for a service class, information will be collected for any activity that runs in the service class. If it is specified for a work class (using a work action), any activity that has the work action applied to it will be collected. If the clause is specified for a threshold, activity information will be collected if the threshold is violated.

Step 3: Collect aggregate activity statistics

Enable collection of aggregate activity statistics for the default subclass under the default user service class using the COLLECT AGGREGATE ACTIVITY DATA clause. When this clause is specified, aggregate statistics will be maintained in memory for the corresponding service class (for example, statistics such as average activity lifetime). The statistics can be viewed using the service subclass statistics table function, or can be collected and sent to the active statistics event monitor for later analysis.

```
ALTER SERVICE CLASS SYSDEFAULTSUBCLASS UNDER SYSDEFAULTUSERCLASS
   COLLECT AGGREGATE ACTIVITY DATA BASE
```

Additional Information: There is a set of statistics collected by default for all DB2 workload management objects. The COLLECT AGGREGATE ACTIVITY DATA clause enables collection of a number of additional optional statistics, such as the activity lifetime histogram.

In this example all user activities will be run in the SYSDEFAULTSUBCLASS service subclass under the SYSDEFAULTUSERCLASS service super class because no user defined service classes have been created. Therefore, information will be collected for all user activities.

Step 4: Run some activities

Run some activities, which will result in statistics being updated and the activities being collected.

```
db2 –o –tvf work1.db2
db2 –o –tvf work2.db2
```

The scripts representing applications (such as `work1.db2` and `work2.db2`) disconnect you from the database, so that after running them you will need to reconnect.

Step 5: View statistics

You can view the service class statistics using the WLM_GET_SERVICE_SUBCLASS_STATS table function. For example:

```
CONNECT TO SAMPLE

SELECT VARCHAR(SERVICE_SUPERCLASS_NAME, 30) AS SUPERCLASS,
       VARCHAR(SERVICE_SUBCLASS_NAME, 30) AS SUBCLASS,
       LAST_RESET,
       COORD_ACT_COMPLETED_TOTAL,
       COORD_ACT_REJECTED_TOTAL,
       COORD_ACT_ABORTED_TOTAL,
       COORD_ACT_LIFETIME_AVG
FROM TABLE(SYSPROC.WLM_GET_SERVICE_SUBCLASS_STATS('SYSDEFAULTUSERCLASS',
       'SYSDEFAULTSUBCLASS', -1)) AS T
```

The output from this query will look something such as the following:

```
SUPERCLASS                     SUBCLASS                       LAST_RESET
COORD_ACT_COMPLETED_TOTAL COORD_ACT_REJECTED_TOTAL COORD_ACT_ABORTED_TOTAL
COORD_ACT_LIFETIME_AVG
------------------------------ ------------------------------ -------------------------- --
------------------------ ------------------------ ----------------------- ------------------
------
SYSDEFAULTUSERCLASS            SYSDEFAULTSUBCLASS             2007-07-18-16.03.51.752190
74                        0                        0   +1.40288000000000E+002

  1 record(s) selected.
```

The COORD_ACT_COMPLETED_TOTAL column indicates how many activities have completed successfully in this service class. The last reset time indicates the last time that statistics were reset for this service class.

Additional Information: If you do not enable aggregate activity statistics for a service class using the COLLECT AGGREGATE ACTIVITY DATA clause, some statistics reported by the WLM_GET_SERVICE_SUBCLASS_STATS table function will be NULL.

Step 6: Send statistics to event monitor

Use the WLM_COLLECT_STATS stored procedure to send the statistics for all DB2 workload management objects to the active statistics event monitor. When statistics are collected and sent to the statistics event monitor, the values are reset.

```
CALL SYSPROC.WLM_COLLECT_STATS()
```

Additional Information: If there is no active statistics event monitor, you can still use the WLM_COLLECT_STATS procedure to reset the statistics, but the current values will be lost. It is possible to automate workload management statistics collection using the WLM_COLLECT_INT database configuration parameter. If you set this parameter to a nonzero value, workload management statistics will be collected automatically every **wlm_collect_int** minutes (as if you manually invoked the WLM_COLLECT_STATS procedure every **wlm_collect_int** minutes).

Step 7: View statistics again

Invoke the WLM_GET_SERVICE_SUBCLASS_STATS table function again. Note that the LAST_RESET timestamp has been updated and the statistics have been reset.

```
SELECT VARCHAR(SERVICE_SUPERCLASS_NAME, 30) AS SUPERCLASS,
       VARCHAR(SERVICE_SUBCLASS_NAME, 30) AS SUBCLASS,
       LAST_RESET,
       COORD_ACT_COMPLETED_TOTAL,
       COORD_ACT_REJECTED_TOTAL,
       COORD_ACT_ABORTED_TOTAL,
       COORD_ACT_LIFETIME_AVG
FROM TABLE(SYSPROC.WLM_GET_SERVICE_SUBCLASS_STATS('SYSDEFAULTUSERCLASS',
       'SYSDEFAULTSUBCLASS', -1)) AS T
```

The output will look something like:

```
SUPERCLASS                     SUBCLASS                       LAST_RESET
COORD_ACT_COMPLETED_TOTAL COORD_ACT_REJECTED_TOTAL
COORD_ACT_ABORTED_TOTAL COORD_ACT_LIFETIME_AVG
------------------------------ ------------------------------ ----------
---------------- ------------------------ ------------------------ ----
------------------- ------------------------
SYSDEFAULTUSERCLASS            SYSDEFAULTSUBCLASS             2007-07-18-
16.04.03.505818                        0                         0
0   +0.00000000000000E+000

  1 record(s) selected.
```

Step 8: View service class statistics collected by the statistics event monitor

The WLM_COLLECT_STATS procedure sent the service class statistics to the statistics event monitor. You can look at the statistics that were collected by the event monitor using statement such as the following:

```
SELECT VARCHAR(SERVICE_SUPERCLASS_NAME, 30) AS SUPERCLASS,
       VARCHAR(SERVICE_SUBCLASS_NAME, 30) AS SUBCLASS,
       LAST_WLM_RESET,
       STATISTICS_TIMESTAMP,
       COORD_ACT_COMPLETED_TOTAL,
       COORD_ACT_REJECTED_TOTAL,
       COORD_ACT_ABORTED_TOTAL,
       COORD_ACT_LIFETIME_AVG
FROM SCSTATS_DB2STATISTICS
```

The output will look something like:

```
SUPERCLASS                     SUBCLASS
LAST_WLM_RESET             STATISTICS_TIMESTAMP
COORD_ACT_COMPLETED_TOTAL COORD_ACT_REJECTED_TOTAL
COORD_ACT_ABORTED_TOTAL COORD_ACT_LIFETIME_AVG
------------------------------ ------------------------------ -----------
--------------- -------------------------- -------------------------- ----
--------------------- ----------------------- ------------------------
SYSDEFAULTSYSTEMCLASS          SYSDEFAULTSUBCLASS             2007-07-18-
16.03.46.333724 2007-07-18-16.04.03.505818                         0
0                       0                     -1
SYSDEFAULTMAINTENANCECLASS     SYSDEFAULTSUBCLASS             2007-07-18-
16.03.46.334301 2007-07-18-16.04.03.505818                         0
0                       0                     -1
SYSDEFAULTUSERCLASS            SYSDEFAULTSUBCLASS             2007-07-18-
16.03.51.752190 2007-07-18-16.04.03.505818                        75
0                       0                    136

  3 record(s) selected.
```

Every time statistics are sent to the event monitor, a statistics record will be created for each DB2 workload management object. Note the two timestamps LAST_WLM_RESET and STATISTICS_TIMESTAMP. The interval of time from LAST_WLM_RESET to STATISTICS_TIMESTAMP indicates the period of time over which the statistics in that record were collected. The STATISTICS_TIMESTAMP indicates when the statistics were collected. Note that the average lifetime for activities on the coordinator is -1 for the default system and maintenance service classes. The average activity lifetime statistic is only maintained for a service class if aggregate activity statistics are enabled using the COLLECT AGGREGATE ACTIVITY DATA clause.

Step 9: View activity information

Information about every individual activity associated with the default user workload was also collected by the activities event monitor, due to the specification of the COLLECT ACTIVITY DATA clause on the default workload in step 2. You can look at this activity information using a query such as the following:

```
SELECT VARCHAR(A.APPL_NAME, 15) as APPL_NAME,
       VARCHAR(A.TPMON_CLIENT_APP, 20) AS CLIENT_APP_NAME,
       VARCHAR(A.APPL_ID, 30) as APPL_ID,
       A.ACTIVITY_ID,
       A.UOW_ID,
       VARCHAR(S.STMT_TEXT, 300) AS STMT_TEXT
FROM ACTIVITY_DB2ACTIVITIES AS A,
     ACTIVITYSTMT_DB2ACTIVITIES AS S
WHERE A.APPL_ID = S.APPL_ID AND
      A.ACTIVITY_ID = S.ACTIVITY_ID AND
      A.UOW_ID = S.UOW_ID
```

The output will look something like:

```
APPL_NAME       CLIENT_APP_NAME      APPL_ID
ACTIVITY_ID          UOW_ID      STMT_TEXT
--------------- -------------------- ------------------------------ -----
--------------- ----------- ------------------------------------------
-------------------------------------------------------------------------
-------------------------------------------------------------------------
-------------------------------------------------------------------------
------------------------------------
db2bp           CLP wlmmonbasic.db2  *LOCAL.db2inst1.070718200344
1           8 ALTER SERVICE CLASS SYSDEFAULTSUBCLASS UNDER
SYSDEFAULTUSERCLASS COLLECT AGGREGATE ACTIVITY DATA BASE
db2bp           CLP work1.db2        *LOCAL.db2inst1.070718200352
1           1 values(current client_applname)
db2bp           CLP work1.db2        *LOCAL.db2inst1.070718200352
2           1 select * from org
db2bp           CLP work1.db2        *LOCAL.db2inst1.070718200352
3           1 select * from employee
db2bp           CLP work1.db2        *LOCAL.db2inst1.070718200352
4           1 select * from sales

...
```

Note that you may see some truncation warnings (SQL0445).

When CLP executes a script, it will set the CURRENT CLIENT_APPLNAME special register to "CLP **script name**". So you can tell from the query shown previously, which script submitted each activity.

Step 10: Reset for next exercise

Update the SYSDEFAULTUSERWORKLOAD workload and the SYSDEFAULTSUBCLASS service subclass so that no activity data or aggregate activity statistics is collected, disable event monitors and clear out the activity and statistics tables, and call WLM_COLLECT_STATS() to reset the statistics.

```
ALTER WORKLOAD SYSDEFAULTUSERWORKLOAD COLLECT ACTIVITY DATA NONE

ALTER SERVICE CLASS SYSDEFAULTSUBCLASS UNDER SYSDEFAULTUSERCLASS
      COLLECT AGGREGATE ACTIVITY DATA NONE

SET EVENT MONITOR DB2ACTIVITIES STATE 0
SET EVENT MONITOR DB2STATISTICS STATE 0

DELETE FROM ACTIVITY_DB2ACTIVITIES
DELETE FROM ACTIVITYSTMT_DB2ACTIVITIES
DELETE FROM SCSTATS_DB2STATISTICS
DELETE FROM WLSTATS_DB2STATISTICS

CALL WLM_COLLECT_STATS()
```

Exercise 2: Isolating activities using service classes and workloads

This exercise demonstrates how to create service classes and how to send activities to a service class using a workload. It also demonstrates how to use some of the WLM monitoring features to determine the workload that activities are being mapped to and to get information about activities being run in a service class and under a workload.

Estimated time: 20-25 minutes

Service classes are the primary point of resource control for database activities. They are also useful for monitoring. For example, you can collect statistics for activities in a particular service class to determine whether the performance goals for that service class are being met. By default, three default service classes (SYSDEFAULTSYSTEMCLASS, SYSDEFAULTMAINTENANCECLASS, and SYSDEFAULTUSERCLASS) are created for each database. If no user defined service classes are created, user activities are run under the default user service class (SYSDEFAULTUSERCLASS).

A workload is an entity that groups one or more units of work based on criteria such as system user ID, session user ID, etc. Workloads provide a means of assigning work to a service class so that the work can later be managed. A default user workload (SYSDEFAULTUSERWORKLOAD) and a default administration workload (SYSDEFAULTADMWORKLOAD) are created for each database. If no user defined workloads are created, all user activities are associated with the default user workload.

There are four separate features that are demonstrated in this exercise:
- How to create a service class.
- How to create a workload.
- How to examine basic workload statistics.
- How to collect activity information for activities run under an individual workload.

Step 1: Examine where activities are run with no user-defined service classes and workloads

First examine where activities are executed if there is no user defined service class or workload. All DB2 activities are assigned to a workload and run in a service class. If no user defined service classes are created, activities run in the default subclass (SYSDEFAULTSUBCLASS) under the default user service class (SYSDEFAULTUSERCLASS) and if no user defined workloads are created, activities run under the default user workload (SYSDEFAULTUSERWORKLOAD).

Run the `work1.db2` and `work2.db2` scripts and then examine the statistics for the SYSDEFAULTSUBCLASS of SYSDEFAULTUSERCLASS using the WLM_GET_SERVICE_SUBCLASS_STATS .

```
db2 –o –tvf work1.db2
db2 –o –tvf work2.db2
```

```
CONNECT TO SAMPLE

SELECT VARCHAR( SERVICE_SUPERCLASS_NAME, 30) SUPERCLASS,
       VARCHAR( SERVICE_SUBCLASS_NAME, 30) SUBCLASS,
       COORD_ACT_COMPLETED_TOTAL
FROM TABLE(WLM_GET_SERVICE_SUBCLASS_STATS('','',-1)) AS T
```

You will see output such as the following:

```
SUPERCLASS                     SUBCLASS                       COORD_ACT_COMPLETE
D_TOTAL
------------------------------ ------------------------------ ------------------
-------
SYSDEFAULTSYSTEMCLASS          SYSDEFAULTSUBCLASS
      0
SYSDEFAULTMAINTENANCECLASS     SYSDEFAULTSUBCLASS
      0
SYSDEFAULTUSERCLASS            SYSDEFAULTSUBCLASS
     75

  3 record(s) selected.
```

Note all the activities are run in the SYSDEFAULTUSERCLASS service super class.

Additional Information: There are 2 other service classes as well, SYSDEFAULTSYSTEMCLASS and SYSDEFAULTMAINTENANCECLASS. These service classes are used for internal maintenance and system level tasks. User activities will not run in these service classes. You may notice nonzero activity counts in these service classes as well if the DB2 data server has issued any internal activities.

Use the WLM_GET_WORKLOAD_STATS table function to view workload statistics to determine which workload the applications are being associated with.

```
SELECT SUBSTR(WORKLOAD_NAME, 1, 22) AS WL_DEF_NAME,
       WLO_COMPLETED_TOTAL,
       CONCURRENT_WLO_ACT_TOP FROM
       TABLE(WLM_GET_WORKLOAD_STATS(CAST(NULL AS VARCHAR(128)), -2))
     AS WLSTATS
```

The output will look something such as the following:

```
WL_DEF_NAME           WLO_COMPLETED_TOTAL  CONCURRENT_WLO_ACT_TOP
---------------------- ------------------- ----------------------
SYSDEFAULTUSERWORKLOAD                   3                      5
SYSDEFAULTADMWORKLOAD                    0                      0

  2 record(s) selected.
```

Note there is one workload occurrence completed for both of the scripts (`work1.db2` and `work2.db2`) as well as a workload occurrence for the connection used to execute the previous command.

Step 2: Create a service class and workload

Create a service class and then create a workload such that all activities run from the `work1.db2` script get mapped to the newly created service class. When CLP executes a script, the CURRENT CLIENT_APPLNAME special register value is set to "CLP **`script name`**".

```
CREATE SERVICE CLASS work1_sc

CREATE WORKLOAD work1_wl CURRENT CLIENT_APPLNAME('CLP work1.db2')
       SERVICE CLASS work1_sc
```

Additional Information: There are a number of attributes that can be specified when creating a workload or a service class. For example, when creating a workload, you can identify the connection based on application name, session user, etc. For more information, refer the CREATE WORKLOAD and the CREATE SERVICE CLASS documentation.

Step 3: Grant usage on workload

Grant usage on the workload (requires ACCESSCTRL or SECADM authority).

```
GRANT USAGE ON WORKLOAD work1_wl TO PUBLIC
```

Additional information: A connection can be associated with a workload only if the session user has USAGE privilege on the workload. This is necessary to prevent users from changing connection attributes of their application in an attempt to run their work in a higher priority service class. Some connection attributes can be changed programmatically (using the sqleseti API, for example). In this exercise, we just grant USAGE privilege to PUBLIC. You would want to be more discriminating on a real system. Since the sample will be run as DBADM, this step could be skipped altogether.

Step 4: Reset statistics

Reset the statistics using the WLM_COLLECT_STATS function, to clear the statistics collected.

```
CALL SYSPROC.WLM_COLLECT_STATS()
```

Step 5: Run some activities

Run both the `work1.db2` and the `work2.db2` scripts.

```
db2 –o –tvf work1.db2
db2 –o –tvf work2.db2
```

Step 6: View workload and service class statistics

Use the WLM_GET_WORKLOAD_STATS table function to view workload statistics to determine which workload the applications are being associated with.

```
CONNECT TO SAMPLE

SELECT SUBSTR(WORKLOAD_NAME, 1, 22) AS WL_DEF_NAME,
       WLO_COMPLETED_TOTAL,
       CONCURRENT_WLO_ACT_TOP
       FROM TABLE(WLM_GET_WORKLOAD_STATS(CAST(NULL AS VARCHAR(128)), -2))
     AS WLSTATS
```

The output will look something such as the following:

```
WL_DEF_NAME            WLO_COMPLETED_TOTAL  CONCURRENT_WLO_ACT_TOP
---------------------- -------------------- ----------------------
WORK1_WL                                  1                      5
SYSDEFAULTUSERWORKLOAD                    1                      5
SYSDEFAULTADMWORKLOAD                     0                      0
```

Note that one workload occurrence completed under WORK1_WL which is the `work1.db2` script. One workload occurrence completed under SYSDEFAULTUSERWORKLOAD which is the `work2.db2` script.

You may see a 2nd workload occurrence completed for the SYSDEFAULTUSER WORKLOAD which is the connection that was used to call the WLM_COLLECT_STATS procedure. WLM_COLLECT_STATS is an asynchronous procedure which might be completed before the statistics are actually collected and therefore might be included.

You can also use the WLM_GET_SERVICE_SUBCLASS_STATS table function to show which service class the activities are being run under as a result of creating the new workload.

```
SELECT VARCHAR( SERVICE_SUPERCLASS_NAME, 30) SUPERCLASS,
       VARCHAR( SERVICE_SUBCLASS_NAME, 23) SUBCLASS,
       COORD_ACT_COMPLETED_TOTAL COORDACTCOMP
       FROM TABLE(WLM_GET_SERVICE_SUBCLASS_STATS('','',-1)) AS T
```

The results looking something such as the following:

```
SUPERCLASS                     SUBCLASS                COORDACTCOMP
------------------------------ ----------------------- --------------------
SYSDEFAULTSYSTEMCLASS          SYSDEFAULTSUBCLASS                         0
```

```
SYSDEFAULTMAINTENANCECLASS     SYSDEFAULTSUBCLASS                          0
SYSDEFAULTUSERCLASS            SYSDEFAULTSUBCLASS                         37
WORK1_SC                       SYSDEFAULTSUBCLASS                         37
```

Note the activities that completed under the WORK1_SC due to the WORK1_WL workload mapping.

Step 7: Create another service class and workload

Create a second service class and then create a workload such that all activities run from the `work2.db2` application get mapped to the newly created service class. In addition, set up the workload so that it will collect some activity data. For this example, we just collect activity data without any additional details or values.

```
CREATE SERVICE CLASS work2_sc

CREATE WORKLOAD work2_wl
             CURRENT CLIENT_APPLNAME('CLP work2.db2')
             SERVICE CLASS work2_sc
             COLLECT ACTIVITY DATA
```

Additional information: When the COLLECT ACTIVITY DATA clause is specified for a workload, information about any activity submitted by an occurrence of that workload will be sent to the active ACTIVITIES event monitor when the activity completes. The COLLECT ACTIVITY DATA clause permits you to specify how much information should be collected by applying one of the following options:

- WITHOUT DETAILS: Collect activity information without statement and compilation environment (the default)
- WITH DETAILS: Collect activity information including statement and compilation environment.
- WITH DETAILS AND VALUES: Collect activity information including statement and compilation environment, and input data values.

Step 8: Enable the activities event monitor

Enable the event monitors for activities.

The activity event monitor was created in Exercise 1.

```
SET EVENT MONITOR DB2ACTIVITIES STATE 1
```

Step 9: Reset statistics and run some activities

Use the WLM_COLLECT_STATS stored procedure to reset the statistics again and run the `work1.db2` and `work2.db2` scripts again.

```
CALL SYSPROC.WLM_COLLECT_STATS()

db2 –o –tvf work1.db2
db2 –o –tvf work2.db2
```

Step 10: View workload and service class statistics

Use the WLM_GET_WORKLOAD_STATS table function again to determine which workload the applications are being associated with

```
CONNECT TO SAMPLE

SELECT SUBSTR(WORKLOAD_NAME, 1, 22) AS WL_DEF_NAME,
       WLO_COMPLETED_TOTAL,
       CONCURRENT_WLO_ACT_TOP
FROM TABLE(WLM_GET_WORKLOAD_STATS(CAST(NULL AS VARCHAR(128)), -2))
     AS WLSTATS
```

The output will look something such as the following:

```
WL_DEF_NAME            WLO_COMPLETED_TOTAL  CONCURRENT_WLO_ACT_TOP
---------------------- -------------------- ----------------------
WORK1_WL                                  1                      5
WORK2_WL                                  1                      5
SYSDEFAULTUSERWORKLOAD                    0                      0
SYSDEFAULTADMWORKLOAD                     0                      0
```

Note this time both workload definitions have a workload occurrence run, once for each script.

You may or may not see a workload occurrence completed for the SYSDEFAULTUSERWORKLOAD depending on whether workload occurrence over which the call to the WLM_COLLECT_STATS procedure was submitted is closed before the statistics are collected.

Use WLM_GET_SERVICE_SUBCLASS_STATS again to show which service class the activities are being run under as a result of creating the new workload.

```
SELECT VARCHAR( SERVICE_SUPERCLASS_NAME, 30) SUPERCLASS,
       VARCHAR( SERVICE_SUBCLASS_NAME, 23) SUBCLASS,
       COORD_ACT_COMPLETED_TOTAL COORDACTCOMP
FROM TABLE(WLM_GET_SERVICE_SUBCLASS_STATS('','',-1)) AS T
```

With the results looking something like:

```
SUPERCLASS                     SUBCLASS                COORDACTCOMP
------------------------------ ----------------------- --------------------
SYSDEFAULTSYSTEMCLASS          SYSDEFAULTSUBCLASS                         0
SYSDEFAULTMAINTENANCECLASS     SYSDEFAULTSUBCLASS                         0
SYSDEFAULTUSERCLASS            SYSDEFAULTSUBCLASS                         1
WORK1_SC                       SYSDEFAULTSUBCLASS                        37
WORK2_SC                       SYSDEFAULTSUBCLASS                        37
```

Note this time service super class work2_sc has some activities run under it due to the WORK2_WL mapping. The one activity under SYSDEFAULTUSERCLASS is the query previously run on WLM_GET_WORKLOAD_STATS.

Step 11: View the activity data collected

Query the activity table for information on the activities that have been run. Note that only the activities from the `work2.db2` script have been collected because only the work2_wl workload definition has the COLLECT ACTIVITY DATA attribute specified.

```
SELECT SUBSTR(WORKLOADNAME, 1, 20) WL_DEF_NAME,
       SUBSTR(APPL_NAME, 1, 20) APPL_NAME,
       SUBSTR(ACTIVITY_TYPE, 1, 10) ACT_TYPE
FROM SYSCAT.WORKLOADS, ACTIVITY_DB2ACTIVITIES
WHERE WORKLOADID = WORKLOAD_ID
```

The results look something like:

```
WL_DEF_NAME          APPL_NAME            ACT_TYPE
-------------------- -------------------- ----------
WORK2_WL             db2bp                READ_DML
WORK2_WL             db2bp                READ_DML
WORK2_WL             db2bp                READ_DML
WORK2_WL             db2bp                READ_DML
```

```
WORK2_WL                 db2bp                    WRITE_DML
WORK2_WL                 db2bp                    WRITE_DML
WORK2_WL                 db2bp                    WRITE_DML
WORK2_WL                 db2bp                    WRITE_DML
WORK2_WL                 db2bp                    WRITE_DML
WORK2_WL                 db2bp                    WRITE_DML
WORK2_WL                 db2bp                    DDL
WORK2_WL                 db2bp                    DDL
WORK2_WL                 db2bp                    DDL
WORK2_WL                 db2bp                    OTHER
WORK2_WL                 db2bp                    READ_DML
WORK2_WL                 db2bp                    READ_DML
WORK2_WL                 db2bp                    READ_DML
WORK2_WL                 db2bp                    READ_DML
WORK2_WL                 db2bp                    READ_DML
WORK2_WL                 db2bp                    READ_DML
WORK2_WL                 db2bp                    OTHER
WORK2_WL                 db2bp                    DDL
WORK2_WL                 db2bp                    LOAD
WORK2_WL                 db2bp                    DDL
WORK2_WL                 db2bp                    DDL
WORK2_WL                 db2bp                    DDL
WORK2_WL                 db2bp                    DDL
WORK2_WL                 db2bp                    DDL
WORK2_WL                 db2bp                    READ_DML
WORK2_WL                 db2bp                    CALL
WORK2_WL                 db2bp                    READ_DML
WORK2_WL                 db2bp                    CALL
WORK2_WL                 db2bp                    CALL
WORK2_WL                 db2bp                    CALL
WORK2_WL                 db2bp                    DDL
WORK2_WL                 db2bp                    DDL
WORK2_WL                 db2bp                    DDL
WORK2_WL                 db2bp                    DDL
:
:
```

Step 12: Assign resources to service classes

Now that you have isolated the activities issued by these two scripts into separate service classes, you can assign resources to the service classes or monitor the activities that run in those service classes. A few examples: If the work performed by the script `work2.db2` is more important than the work performed by the script `work1.db2`, you could increase the priority of agents running in the WORK2_SC service class using a statement such as the following.

On UNIX operating environments (a negative value specifies a higher priority):

```
ALTER SERVICE CLASS WORK2_SC AGENT PRIORITY -6
```

On Windows operating environments (a positive value specifies a higher priority):

```
ALTER SERVICE CLASS WORK2_SC AGENT PRIORITY 6
```

If you wanted to capture details about every individual activity that executes in the WORK2_SC service class, you could enable activity collection for that service class using the following:

```
ALTER SERVICE CLASS SYSDEFAULTSUBCLASS UNDER WORK2_SC
   COLLECT ACTIVITY DATA ON COORDINATOR WITH DETAILS
```

Step 13: Reset for next exercise

Update workload work2_wl so that no activity data is collected, disable the event monitor and clean up the event monitor table, and call WLM_COLLECT_STATS() to reset the statistics.

```
ALTER WORKLOAD work2_wl
      COLLECT ACTIVITY DATA NONE

SET EVENT MONITOR DB2ACTIVITIES STATE 0

DELETE from ACTIVITY_DB2ACTIVITIES

CALL WLM_COLLECT_STATS()
```

Exercise 3: Using thresholds to control rogue activities and using the threshold violation monitor

This exercise demonstrates how you can use thresholds to detect resource misuse or the beginning of system overload by establishing limits over the consumption of a specific resource.

Estimated time: 15-20 minutes

If a threshold is violated, a specified action can be triggered. The supported actions are:

- STOP EXECUTION: Stop processing the activity that caused the threshold to be violated.
- CONTINUE: Continue processing
- Collect information about the activity that violated the threshold. This action can be specified in conjunction with the CONTINUE or STOP EXECUTION action.

Regardless of whether an activity that violates a threshold is stopped or permitted to continue running, a record of the violation is written to an active THRESHOLD VIOLATIONS event monitor (assuming one is defined in advance) each time a threshold is violated. The record contains information such as which threshold was violated, the time of the violation, and the threshold action.

This exercise demonstrates how thresholds can be used to detect or prevent rogue activities from running on your system and using up system resources. A rogue activity is any activity that uses an unexpectedly high amount of resources. For example, a query that runs for an abnormally long time, or returns an unexpectedly large result set.

Step 1: Create a threshold violation event monitor

Create and enable a write-to-table event monitor that will be used to capture the threshold violation information and enable the activity event monitor that was created in Exercise 1.

```
CREATE EVENT MONITOR threvio FOR THRESHOLD VIOLATIONS WRITE TO TABLE
         THRESHOLDVIOLATIONS(IN userspace1),
         CONTROL(IN userspace1)

SET EVENT MONITOR threvio STATE 1

SET EVENT MONITOR db2activities STATE 1
```

Step 2: Create a workload

Create a workload such that all activities run from the workth.db2 script will get mapped to the work1_sc service class.

The work1_sc service class already exists since it was created in Exercise 2.

```
CREATE WORKLOAD workth_wl
          CURRENT CLIENT_APPLNAME('CLP workth.db2')
          SERVICE CLASS work1_sc
```

Step 3: Create thresholds

Create two thresholds, one of which (th_estcost) is an ESTIMATEDSQLCOST threshold and another (th_sqlrows) is a SQLROWSRETURNED threshold and apply them to the service class you wish to control the activities for (in this case, work1_sc service class).

The th_estcost threshold specifies an upper bound (10000 timerons) for the optimizer-estimated cost (in timerons) for an activity running in the work1_sc service class. If any query with an estimated cost greater than 10000 timerons, tries to execute in the work1_sc service class, this threshold is violated and the query is not permitted to run.

The th_sqlrows threshold specifies that any activity running in the work1_sc service class can return at most 30 rows from the data server. If any query tries to return more than 30 rows, this threshold is violated, only 30 rows will be returned to the client and the query will be stopped. In addition, data about the activity that caused the threshold violation will be collected.

In either case, when an activity violates the threshold, a threshold violation record is written to the THRESHOLD VIOLATIONS event monitor as defined in step 1 and the execution of the activity is stopped (because of the STOP EXECUTION action). The application that submitted the activity will receive an SQL4712N error.

```
CREATE THRESHOLD th_estcost
    FOR SERVICE CLASS work1_sc ACTIVITIES
    ENFORCEMENT DATABASE
    WHEN ESTIMATEDSQLCOST > 10000
    STOP EXECUTION

CREATE THRESHOLD th_sqlrows
    FOR SERVICE CLASS work1_sc ACTIVITIES
    ENFORCEMENT DATABASE
    WHEN SQLROWSRETURNED > 30
    COLLECT ACTIVITY DATA WITH DETAILS AND VALUES
    STOP EXECUTION
```

Additional information: A threshold can be either predictive or reactive:

- Predictive threshold: The boundaries of a predictive threshold are checked before the activity starts running. To check whether a predictive threshold would be violated, the data server obtains usage estimates from the query compiler. For this example, the th_estcost threshold is a predictive threshold.
- Reactive threshold: The boundaries of a reactive threshold are checked while an activity is executing. Approximate runtime usage estimates of the controlled resource are used to evaluate the boundaries of reactive thresholds. The runtime usage estimates are not obtained continuously but rather at selected predefined checkpoints during the lifetime of the tracked work. For this example, the th_sqlrows is a reactive threshold.

Step 4: Run some activities

Run some activities, some of which violate the threshold upper bounds defined in the previous step.

```
db2 –o –tvf workth.db2
```

Note that the statements which violate the thresholds defined previously, fail with an error of SQL4712N/SQLSTATE 5U026.

Step 5: View the threshold violation event monitor

Information about every threshold violation is collected by the THRESHOLD VIOLATIONS event monitor. You can query the threshold violation information by issuing regular SQL statements against the threshold violation monitor table as shown in the following example.

```
CONNECT TO SAMPLE

SELECT  APPL_ID,
       UOW_ID,
       ACTIVITY_ID,
       COORD_PARTITION_NUM AS COORDPART,
       THRESHOLD_PREDICATE,
       THRESHOLD_ACTION,
       TIME_OF_VIOLATION
FROM THRESHOLDVIOLATIONS_THREVIO
ORDER BY THRESHOLD_ACTION, THRESHOLD_PREDICATE, TIME_OF_VIOLATION
```

The output will look something such as the following:

```
APPL_ID                                                           UOW_ID
ACTIVITY_ID          COORDPART   THRESHOLD_PREDICATE
                                        THRESHOLD_ACTION TIME_OF_VIOLATION
---------------------------------------------------------------------------- ----
---------------- ----------- -------------------------
------------------------------------------------------- ------------------------
--
*LOCAL.DB2.070821150008                                                   11
1           0 EstimatedSQLCost
                                        Stop            2007-08-21-
11.00.11.000000
*LOCAL.DB2.070821150008                                                   10
1           0 SQLRowsReturned
                                       Stop             2007-08-21-
11.00.10.000000

  2 record(s) selected.
```

Step 6: View information for the activity that violated the threshold

Activity information is collected for any activity that violates a threshold that is defined with a COLLECT clause. Show the detailed information about the activities that violated a threshold using the following query:

```
SELECT VARCHAR(A.APPL_NAME, 15) as APPL_NAME,
       VARCHAR(A.TPMON_CLIENT_APP, 20) AS CLIENT_APP_NAME,
       A.ACTIVITY_ID,
       A.ACTIVITY_TYPE,
       A.WORKLOAD_ID,
       T.THRESHOLD_PREDICATE,
       A.QUERY_CARD_ESTIMATE,
       T.THRESHOLD_MAXVALUE,
       T.TIME_OF_VIOLATION,
       VARCHAR(AS.STMT_TEXT, 100) AS STMT_TEXT
```

```
FROM  THRESHOLDVIOLATIONS_THREVIO AS T,
       ACTIVITY_DB2ACTIVITIES AS A,
       ACTIVITYSTMT_DB2ACTIVITIES AS AS
WHERE T.APPL_ID = A.APPL_ID AND
       T.UOW_ID = A.UOW_ID AND
            T.ACTIVITY_ID = A.ACTIVITY_ID AND
            A.APPL_ID = AS.APPL_ID AND
            A.ACTIVITY_ID = AS.ACTIVITY_ID AND
            A.UOW_ID = AS.UOW_ID
```

The output will look something such as the following:

```
APPL_NAME       CLIENT_APP_NAME      ACTIVITY_ID          ACTIVITY_TYPE
                                           WORKLOAD_ID THRESHOLD_PREDICATE
                                        QUERY_CARD_ESTIMATE  THRESHOLD_MAXVALUE
  TIME_OF_VIOLATION          STMT_TEXT

--------------- -------------------- -------------------- ----------------------
------------------------------------------ ----------- -------------------------
-------------------------------------- -------------------- --------------------
- -------------------------- ---------------------------------------------------
------------------------------------------------
db2bp           CLP workth.db2                        3 READ_DML
                                                   3 SQLRowsReturned
                                                      41                   3
0 2007-08-31-09.01.16.000000 SELECT * FROM SALES
```

Note that the activity that violated the th_estcost (EstimatedSqlCost) threshold is not shown. The reason is that the threshold did not specify the COLLECT ACTIVITY DATA clause, so that no activity data was collected for that activity.

Step 7: Reset for next exercise

Disable the event monitors that were enabled. Also disable and drop the th_estcost and th_sqlrows thresholds that were created.

```
SET EVENT MONITOR threvio STATE 0
SET EVENT MONITOR db2activities STATE 0

ALTER THRESHOLD th_estcost DISABLE
DROP THRESHOLD th_estcost

ALTER THRESHOLD th_sqlrows DISABLE
DROP THRESHOLD th_sqlrows
```

Also clean up the activities event monitor tables and the threshold violation table

```
DELETE from ACTIVITY_DB2ACTIVITIES
DELETE from ACTIVITYSTMT_DB2ACTIVITIES
DELETE from THRESHOLDVIOLATIONS_THREVIO

CALL WLM_COLLECT_STATS()
```

Exercise 4: Differentiating activities by activity type

This exercise demonstrates how a work action set can be used to: Collect information about all activities of a certain type; apply a threshold to all activities of a certain type; isolate activities of a certain type by mapping them to a specific service subclass

Estimated time: 25-30 minutes

Work action sets are used to apply an action to an activity based on what the activity is doing rather than who submitted it (as is done with workloads).

Actions can be applied to either:

- All database activities of a certain type (using a database work action set).
- Only to activities of a certain type in a particular service class (using a service class work action set).

This exercise shows both methods.

Additional Information: There are other actions that can be applied, such as collecting statistics for activities of a certain type that are not covered in this exercise.

Step 1: Create a work class set

First, create a work class set containing work classes that will represent the specific types of activities you are interested in. This work class set will be used in conjunction with work action sets to perform actions on the selected types of activities. The following example creates a work class set containing work classes of all possible types, but if you were interested only in one activity type, your work class set could be created to only contain that one work class.

```
CREATE WORK CLASS SET all_class_types
    (WORK CLASS read_wc WORK TYPE READ,
     WORK CLASS write_wc WORK TYPE WRITE,
     WORK CLASS ddl_wc WORK TYPE DDL,
     WORK CLASS call_wc WORK TYPE CALL,
     WORK CLASS load_wc WORK TYPE LOAD,
     WORK CLASS all_wc WORK TYPE ALL POSITION LAST)
```

Step 2: Enable the activities event monitor

Enable the event monitor for activities that was created in Exercise 1.

```
SET EVENT MONITOR DB2ACTIVITIES STATE 1
```

Step 3: Create a database work action set

If you want to perform a particular action on all activities of a specific type (such as applying a threshold or collecting activity information), use a database work action set.

Create a work action set at the database level that contains work actions for the specific work class representing the type of activities you want isolated. For this example, we want to collect activity data for all DDL, READ and LOAD activities that run on the system and we also want to stop any large read activity from running. For this exercise, a large read activity is any select statement that has an estimated cost (in timerons) of greater than 10000.

```
CREATE WORK ACTION SET db_was FOR DATABASE
   USING WORK CLASS SET  all_class_types
   (WORK ACTION collect_load_wa ON WORK CLASS load_wc
       COLLECT ACTIVITY DATA WITH DETAILS AND VALUES,
    WORK ACTION collect_ddl_wa ON WORK CLASS ddl_wc
       COLLECT ACTIVITY DATA WITH DETAILS AND VALUES,
    WORK ACTION collect_read_wa ON WORK CLASS read_wc
       COLLECT ACTIVITY DATA WITH DETAILS AND VALUES,
    WORK ACTION stop_large_read_wa on WORK CLASS read_wc
       WHEN ESTIMATEDSQLCOST > 10000 STOP EXECUTION )
```

Step 4: Run activities and view work action set statistics

Run the `work1.db2` and `work3.db2` scripts.

```
db2 –o –tvf work1.db2
db2 –o –tvf work3.db2
```

You can use the WLM_GET_WORK_ACTION_SET_STATS table function to access the work action set statistics in memory to get the number of times specific activity types have been run. Note that running the following query shows only the load_wc, read_wc and ddl_wc work classes since they are the only work classes that have an applicable work action. All the other activities are counted under the "*":

```
CONNECT TO SAMPLE

SELECT SUBSTR(WORK_ACTION_SET_NAME, 1, 12) AS WORK_ACTION_SET_NAME,
         SUBSTR(WORK_CLASS_NAME, 1, 12) AS WORK_CLASS_NAME,
         LAST_RESET,
         SUBSTR(CHAR(ACT_TOTAL), 1, 10) AS TOTAL_ACTS
FROM TABLE(WLM_GET_WORK_ACTION_SET_STATS('', -2)) AS WASSTATS
ORDER BY WORK_ACTION_SET_NAME, WORK_CLASS_NAME
```

The output will look something like:

```
WORK_ACTION_SET_NAME WORK_CLASS_NAME  LAST_RESET                 TOTAL_ACTS
-------------------- ---------------- -------------------------- ----------
DB_WAS               *                2007-08-15-19.02.47.305556 12
DB_WAS               DDL_WC           2007-08-15-19.02.47.305556 12
DB_WAS               LOAD_WC          2007-08-15-19.02.47.305556 1
DB_WAS               READ_WC          2007-08-15-19.02.47.305556 13

  4 record(s) selected.
```

Step 5: View the activity data collected

Information about every individual DDL, READ and LOAD activities was collected by the activities event monitor, due to the specification of the COLLECT ACTIVITY DATA work action that was applied to the ddl_wc, read_wc, and the load_wc work classes in step 3. The following are a couple of examples of how you might want to look at this activity information.

To get some basic information about the activities, you can simply query the activity event monitor table with a statement such as the following:

```
SELECT ACTIVITY_ID,
              SUBSTR(ACTIVITY_TYPE, 1, 8) AS ACTIVITY_TYPE,
              VARCHAR(APPL_ID, 30) AS APPL_ID,
              VARCHAR(APPL_NAME, 10) AS APPL_NAME
FROM ACTIVITY_DB2ACTIVITIES
```

The output will look something like:

```
ACTIVITY_ID          ACTIVITY_TYPE APPL_ID                        APPL_NAME
-------------------- ------------- ------------------------------ ----------
                   1 READ_DML      *LOCAL.karenam.070815192410    db2bp
                   1 READ_DML      *LOCAL.karenam.070815192418    db2bp
                   2 READ_DML      *LOCAL.karenam.070815192418    db2bp
                   3 READ_DML      *LOCAL.karenam.070815192418    db2bp
                   4 READ_DML      *LOCAL.karenam.070815192418    db2bp
                   1 DDL           *LOCAL.karenam.070815192418    db2bp
                   2 DDL           *LOCAL.karenam.070815192418    db2bp
                   3 DDL           *LOCAL.karenam.070815192418    db2bp
                   2 READ_DML      *LOCAL.karenam.070815192418    db2bp
                   1 READ_DML      *LOCAL.karenam.070815192418    db2bp
```

```
                 2 READ_DML      *LOCAL.karenam.070815192418    db2bp
                 3 READ_DML      *LOCAL.karenam.070815192418    db2bp
                 4 READ_DML      *LOCAL.karenam.070815192418    db2bp
                 6 LOAD          *LOCAL.karenam.070815192418    db2bp
                 1 DDL           *LOCAL.karenam.070815192418    db2bp
                 1 DDL           *LOCAL.karenam.070815192418    db2bp
                 2 DDL           *LOCAL.karenam.070815192418    db2bp
                 3 DDL           *LOCAL.karenam.070815192418    db2bp
                 4 DDL           *LOCAL.karenam.070815192418    db2bp
                 5 READ_DML      *LOCAL.karenam.070815192418    db2bp
                10 READ_DML      *LOCAL.karenam.070815192418    db2bp
                 1 DDL           *LOCAL.karenam.070815192418    db2bp
                 2 DDL           *LOCAL.karenam.070815192418    db2bp
                 3 DDL           *LOCAL.karenam.070815192418    db2bp
                 4 DDL           *LOCAL.karenam.070815192418    db2bp
                 1 READ_DML      *LOCAL.karenam.070815192426    db2bp

  26 record(s) selected.
```

To obtain additional information about each activity, such as activity text and what service class it ran under, you can perform a query similar to this one:

```
SELECT VARCHAR(A.APPL_NAME, 15) as APPL_NAME,
                 VARCHAR(A.TPMON_CLIENT_APP, 20) AS CLIENT_APP_NAME,
                 VARCHAR(A.APPL_ID, 30) as APPL_ID,
                 VARCHAR(A.SERVICE_SUPERCLASS_NAME, 20) as SUPER_CLASS,
                 VARCHAR(A.SERVICE_SUBCLASS_NAME, 20) as SUB_CLASS,
                 SQLCODE,
                 VARCHAR(S.STMT_TEXT, 300) AS STMT_TEXT
FROM ACTIVITY_DB2ACTIVITIES AS A, ACTIVITYSTMT_DB2ACTIVITIES AS S
WHERE A.APPL_ID = S.APPL_ID AND
                A.ACTIVITY_ID = S.ACTIVITY_ID AND
                A.UOW_ID = S.UOW_ID
```

The output will look something like:

```
APPL_NAME       CLIENT_APP_NAME      APPL_ID
SUPER_CLASS
         SUB_CLASS            SQLCODE     STMT_TEXT
--------------- -------------------- ------------------------------ ---------
---
-------- -------------------- ----------- -----------------------------------
---
-----------------------------------------------------------------------------
---
-----------------------------------------------------------------------------
---
-----------------------------------------------------------------------------
---
----------------------
db2bp           CLP wasdbsc.db2      *LOCAL.karenam.070815192410
SYSDEFAULTUS
ERCLASS  SYSDEFAULTSUBCLASS             0 SELECT DISTINCT CURRENT SQLID FROM
SYS
IBM.SYSTABLES

db2bp           CLP work1.db2        *LOCAL.karenam.070815192418
SYSDEFAULTUS
ERCLASS  SYSDEFAULTSUBCLASS             0 values(current client_applname)

      :
      :
db2bp           CLP work1.db2        *LOCAL.karenam.070815192418
SYSDEFAULTUS
ERCLASS  SYSDEFAULTSUBCLASS             0 drop procedure stp2
```

```
db2bp          CLP work3.db2       *LOCAL.karenam.070815192426
SYSDEFAULTUS
ERCLASS  SYSDEFAULTSUBCLASS        -4712 select count(*) from syscat.tables,
sy
scat.tables, syscat.tables, syscat.tables, syscat.tables, syscat.tables

      :
      :
```

Note that one of the activities has an SQLCODE of -4712. This indicates execution of the activity was stopped due to a threshold violation. The threshold defined for the stop_large_read_wa work action will prevent any SELECT statement with an estimated cost of greater than 10000 from executing.

Additional information: Load activities (not including load from a cursor) do not have an entry in the activity statement event monitor table (activitystmt_db2activities table) which explains why there is no record for the single load activity that is run by the `work1.db2` script in the output shown previously in the last query. The reason for this is that load activities are not SQL statements. For load from cursor activities, there is an entry for the cursor statement in the activity statement event monitor table because the cursor itself is a separate activity. There is an entry for all load activities in the activities event monitor table (activity_db2activities).

Step 6: Disable work actions

Before moving on to the service class work action set, drop the database work action set.

```
DROP WORK ACTION SET db_was
```

Additional information: Before dropping any concurrency threshold, that threshold must first be disabled. In this case, there are no work actions that represent a concurrency threshold but if there were, the only way to disable it would be by disabling the work action. A work action threshold cannot be manipulated through THRESHOLD SQL statements; they can be manipulated only through WORK ACTION SET SQL statements. Only work actions that represent concurrency thresholds need to be disabled before dropping the subsequent work action set. For this exercise, because there are no work actions that represent a concurrency threshold, there is no need to disable any of the work actions before dropping the work action set.

If you want to apply a particular action, such as a threshold, to all the activities of a certain type running in a service super class, you should consider using a service class work action set. You can create a mapping work action to map specific types of activities to a specific service subclass and then apply a threshold to that service subclass. The following steps demonstrate how service class work action sets might be used

Step 7: Create a service class to and create a workload

Create a service subclass under the work1_sc service super class that was created in Exercise 2 Step 2.

The service super class work1_sc is the service class that the activities will be mapped to through the workloads. The service subclass work1_sc_read is the service class that the read activities will be mapped to through the work action.

```
CREATE SERVICE CLASS work1_sc_read UNDER work1_sc
```

Create a workload so that all activities submitted by the `work3.db2` script will be mapped to work1_sc service super class. Note that activities from `work1.db2` are already being mapped to work1_sc from one of the previous exercises.

```
CREATE WORKLOAD work3_wl CURRENT CLIENT_APPLNAME('CLP work3.db2')
   SERVICE CLASS work1_sc
```

Step 8: Create a service class work action set

Create a work action set at the service class level that contains work actions that apply to the specific work classes representing the types of activities you want isolated. For this example, we want to collect activity data for all DDL, read, and load activities that run under the work1_sc service class and we also want to map read activities to a separate service subclass so that we can treat them differently; in this case, a threshold will be applied to the service subclass to stop any large SELECT statements from running.

```
CREATE WORK ACTION SET sc_was FOR SERVICE CLASS work1_sc
  USING WORK CLASS SET all_class_types (
    WORK ACTION collect_load_wa ON WORK CLASS load_wc
      COLLECT ACTIVITY DATA ON ALL MEMBERS WITH DETAILS AND VALUES,
    WORK ACTION collect_ddl_wa ON WORK CLASS ddl_wc
      COLLECT ACTIVITY DATA ON ALL MEMBERS WITH DETAILS AND VALUES,
   WORK ACTION collect_read_wa ON WORK CLASS read_wc
      COLLECT ACTIVITY DATA ON ALL MEMBERS WITH DETAILS AND VALUES,
   WORK ACTION map_read_wa on WORK CLASS read_wc
           MAP ACTIVITY TO work1_sc_read)
```

Step 9: Create a service class threshold

To get an effect similar to the stop_large_read_wa work action that prevented any large SELECT statements from running, create an ESTIMATEDSQLCOST threshold and apply it to the work1_sc_read service subclass.

```
CREATE THRESHOLD stop_large_activities FOR SERVICE CLASS work1_sc_read
              UNDER work1_sc
              ACTIVITIES ENFORCEMENT DATABASE
              WHEN ESTIMATEDSQLCOST >10000 STOP EXECUTION
```

Step 10: Clear the activity tables, reset the statistics, and run activities

Clear out all of the activity tables so that you can start afresh before running the script again. Then call the wlm_collect_stats() stored procedure to reset the statistics

```
DELETE FROM activity_db2activities
DELETE FROM activitystmt_db2activities
DELETE FROM activityvals_db2activities

CALL wlm_collect_stats()
```

Now, run `work1.db2` and `work3.db2` scripts once.

```
db2 –o –tvf work1.db2
db2 –o –tvf work3.db2
```

Note the SQL04712 error for activities that caused the threshold to be exceeded.

Step 11: View work action set statistics

Use the WLM_GET_WORK_ACTION_SET_STATS table function to access the work action set statistics in memory to get the number of times specific activity types have been run. Note that running the following query shows only the load_wc, ddl_wc, and the read_wc work classes since they are the only three work classes that have a work action applied to them. All the other activities end up being counted under "*":

```
CONNECT TO SAMPLE

SELECT SUBSTR(WORK_ACTION_SET_NAME, 1, 12) AS WORK_ACTION_SET_NAME,
               SUBSTR(CHAR(MEMBER), 1, 4) AS MEMB,
               SUBSTR(WORK_CLASS_NAME, 1, 12) AS WORK_CLASS_NAME, LAST_RESET,
               SUBSTR(CHAR(ACT_TOTAL), 1, 10) AS TOTAL_ACTS
FROM TABLE(WLM_GET_WORK_ACTION_SET_STATS('', -2)) AS WASSTATS
ORDER BY WORK_ACTION_SET_NAME, WORK_CLASS_NAME, MEMB
```

This time, output will look something such as the following:

```
WORK_ACTION_SET_NAME MEMB WORK_CLASS_NAME LAST_RESET                 TOTAL_ACTS
-------------------- ---- --------------- -------------------------- ----------
SC_WAS               0    *               2007-08-15-19.02.54.597999 12
SC_WAS               0    DDL_WC          2007-08-15-19.02.54.597999 12
SC_WAS               0    LOAD_WC         2007-08-15-19.02.54.597999 1
SC_WAS               0    READ_WC         2007-08-15-19.02.54.597999 12

  4 record(s) selected.
```

Step 12: View the activity data collected

Now query the activity tables again to get information about the individual activities. Note the service subclass that the activities were run under.

```
SELECT VARCHAR(A.APPL_NAME, 15) as APPL_NAME,
                 VARCHAR(A.TPMON_CLIENT_APP, 20) AS CLIENT_APP_NAME,
                 VARCHAR(A.APPL_ID, 30) as APPL_ID,
                 VARCHAR(A.SERVICE_SUPERCLASS_NAME, 20) as SUPER_CLASS,
                 VARCHAR(A.SERVICE_SUBCLASS_NAME, 20) as SUB_CLASS,
                 SQLCODE,
                 VARCHAR(S.STMT_TEXT, 300) AS STMT_TEXT
FROM ACTIVITY_DB2ACTIVITIES AS A, ACTIVITYSTMT_DB2ACTIVITIES AS S
WHERE A.APPL_ID = S.APPL_ID AND
                A.ACTIVITY_ID = S.ACTIVITY_ID AND
                A.UOW_ID = S.UOW_ID
```

The output will look something like:

```
APPL_NAME       CLIENT_APP_NAME      APPL_ID                        SUPER_CLASS
         SUB_CLASS            SQLCODE     STMT_TEXT
--------------- -------------------- ------------------------------ ------------
-------- -------------------- ----------- --------------------------------------
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
----------------------

db2bp           CLP work1.db2        *LOCAL.karenam.070815195555    WORK1_SC
         WORK1_SC_READ                  0 values(current client_applname)

db2bp           CLP work1.db2        *LOCAL.karenam.070815195555    WORK1_SC
         WORK1_SC_READ                  0 select * from org
:
:
db2bp           CLP work1.db2        *LOCAL.karenam.070815195555    WORK1_SC
         SYSDEFAULTSUBCLASS           0 drop procedure stp2

db2bp           CLP work3.db2        *LOCAL.karenam.070815195600    WORK1_SC
         WORK1_SC_READ              -4712 select count(*) from syscat.tables, sy
scat.tables, syscat.tables, syscat.tables, syscat.tables, syscat.tables
```

Note again, that one of the activities has a SQLCODE of -4712, this time because of the stop_large_activities service class threshold that was created in step 9 that was violated because the estimated cost for that select statement was too large. Also notice that all read activities are being run under the work1_sc_read service subclass.

Step 13: Reset for next exercise

Disable the even monitor, drop the service class threshold and drop the service class work action set.

```
SET EVENT MONITOR DB2ACTIVITIES STATE 0

DROP THRESHOLD STOP_LARGE_ACTIVITIES
ALTER WORK ACTION SET SC_WAS
 ALTER WORK ACTION COLLECT_LOAD_WA DISABLE
 ALTER WORK ACTION COLLECT_DDL_WA DISABLE
 ALTER WORK ACTION COLLECT_READ_WA DISABLE
 ALTER WORK ACTION MAP_READ_WA DISABLE;
DROP WORK ACTION SET SC_WAS
```

Clear out all of the activity tables so that you can start afresh, before running the script again.

```
DELETE FROM activity_db2activities
DELETE FROM activitystmt_db2activities
DELETE from activityvals_db2activities
```

Disable all of the workloads that have been created so that all activities will run under the default user workload and get mapped to the default service super class.

```
ALTER WORKLOAD work1_wl DISABLE
ALTER WORKLOAD work2_wl DISABLE
ALTER WORKLOAD work3_wl DISABLE
ALTER WORKLOAD workth_wl DISABLE
```

Call the wlm_collect_stats() stored procedure to reset the statistics.

```
CALL WLM_COLLECT_STATS()
```

Exercise 5: Using histograms for service classes

This exercise demonstrates how to use the COLLECT AGGREGATE ACTIVITY DATA BASE option on a service class to produce histograms of coordinator activity lifetimes, coordinator activity execution times, and coordinator activity queue times.

Estimated time: 25-30 minutes

These three histograms are useful for knowing more than just the average lifetime, execution time, or queue time of the activities run on the system, since they can be used to calculate standard deviations and can reveal outliers. For more information on histograms, see “Histograms in workload management” on page 253.

Histograms are accessed through the statistics event monitor. This exercise reuses the statistics event monitor created in Exercise 1 Step 1.

Additional Information: The statistics event monitor is a write-to-table event monitor and contains logical data groups. The first is the control logical data group, which every event monitor has, and then there are the logical data groups that are specific to the statistics event monitor type. The specific logical data groups are:

- histogrambin for histogram information
- qstats for threshold queue statistics
- scstats service class statistics
- wcstats for work class statistics
- wlstats for workload statistics

Step 1: Create views for viewing histogram statistics

Create several views to make querying the HISTOGRAMBIN_DB2STATISTICS table easier. The first view lists all of the histogram types available. This exercise reports just the three basic types:lifetime, execution time and queue time.

```
CREATE VIEW HISTOGRAMTYPES AS
  SELECT DISTINCT SUBSTR(HISTOGRAM_TYPE,1,24) AS HISTOGRAM_TYPE
  FROM HISTOGRAMBIN_DB2STATISTICS
```

A second view makes it easier to find out which service classes are having histograms collected for them. The HISTOGRAMBIN_DB2STATISTICS table identifies the service classes for which histograms are being collected using the service class ID. Joining this table with the SERVICECLASSES catalog table permits the service class information to be presented with the service super class name and service subclass name instead of the service class ID.

```
CREATE VIEW HISTOGRAMSERVICECLASSES AS
  SELECT DISTINCT SUBSTR(HISTOGRAM_TYPE,1,24) AS HISTOGRAM_TYPE,
         SUBSTR(PARENTSERVICECLASSNAME,1,24) AS SERVICE_SUPERCLASS,
         SUBSTR(SERVICECLASSNAME,1,24) AS SERVICE_SUBCLASS
  FROM HISTOGRAMBIN_DB2STATISTICS AS H,
       SYSCAT.SERVICECLASSES AS S
  WHERE H.SERVICE_CLASS_ID = S.SERVICECLASSID
```

The third view lists all of the times that a histogram of a given type was collected for a given service class. Such as the histogramserviceclasses view, it also joins the HISTOGRAMBIN_DB2STATISTICS table with the SERVICECLASSES catalog table. The difference is that it includes the STATISTICS_TIMESTAMP column as one of the columns in the view.

```
CREATE VIEW HISTOGRAMTIMES AS
  SELECT DISTINCT SUBSTR(HISTOGRAM_TYPE,1,24) AS HISTOGRAM_TYPE,
         SUBSTR(PARENTSERVICECLASSNAME,1,24) AS SERVICE_SUPERCLASS,
         SUBSTR(SERVICECLASSNAME,1,24) AS SERVICE_SUBCLASS,
         STATISTICS_TIMESTAMP AS TIMESTAMP
  FROM HISTOGRAMBIN_DB2STATISTICS AS H,
       SYSCAT.SERVICECLASSES AS S
  WHERE H.SERVICE_CLASS_ID = S.SERVICECLASSID
```

The fourth and final view will be used to show the histograms themselves. It also demonstrates something that one often needs to do when dealing with histograms, which is to aggregate them over time. This view shows the top of each bin and the number of activities that were counted towards each bin. For the three histograms in this exercise, the BIN_TOP field measures the number of milliseconds in the activity lifetime, execution time or queue time. When BIN_TOP is, say 3000 milliseconds and the BIN_TOP of the previous bin is 2000 milliseconds and the NUMBER_IN_BIN is ten for a lifetime histogram, you know that ten activities had a lifetime that was between 2 and 3 seconds.

```
CREATE VIEW HISTOGRAMS(HISTOGRAM_TYPE,
                       SERVICE_SUPERCLASS,
                       SERVICE_SUBCLASS,
                       BIN_TOP,
                       NUMBER_IN_BIN) AS
  SELECT DISTINCT SUBSTR(HISTOGRAM_TYPE,1,24) AS HISTOGRAM_TYPE,
         SUBSTR(PARENTSERVICECLASSNAME,1,24) AS SERVICE_SUPERCLASS,
         SUBSTR(SERVICECLASSNAME,1,24) AS SERVICE_SUBCLASS,
         TOP AS BIN_TOP,
         SUM(NUMBER_IN_BIN) AS NUMBER_IN_BIN
  FROM HISTOGRAMBIN_DB2STATISTICS AS H,
       SYSCAT.SERVICECLASSES AS S
  WHERE H.SERVICE_CLASS_ID = S.SERVICECLASSID
  GROUP BY HISTOGRAM_TYPE, PARENTSERVICECLASSNAME, SERVICECLASSNAME, TOP
```

Step 2: Turn on the collection of histograms

The activity lifetime, queue time, and execution time histograms are collected for a service subclass when the base collect aggregate activity data option is enabled for the subclass. Enable the base aggregate activity data collection for the default subclass under the default user super class using the COLLECT AGGREGATE ACTIVITY DATA clause.

Note that all activities will be run in the default user service class since all the user defined workloads were disabled at the end of the previous exercise.

```
ALTER SERVICE CLASS SYSDEFAULTSUBCLASS
  UNDER SYSDEFAULTUSERCLASS
  COLLECT AGGREGATE ACTIVITY DATA BASE
```

Step 3: Activate the statistics event monitor

Activate the statistics event monitor that was created earlier so that it may receive the aggregate data whenever it is collected.

```
SET EVENT MONITOR DB2STATISTICS STATE 1
```

Step 4: Run activities and send statistics to the statistics event monitor

Now some activities can be run. After the activities have finished, the WLM_COLLECT_STATS stored procedure is called to send the statistics (including the activity lifetime, execution time and queue time histograms for the default user service class) to the active statistics event monitor. These histograms contain data about all activities that executed in the default user service class since aggregate activity statistics were enabled. Calling this stored procedure also resets the statistics. To show changes in database activity over time, three collection intervals are created. In the first interval, run two scripts, `work1.db2` and `work2.db2`, and then collect and reset the statistics.

```
db2 -o -tvf work1.db2
db2 -o -tvf work2.db2

CONNECT TO SAMPLE

CALL WLM_COLLECT_STATS()
```

In the second interval, only run the `work1.db2` script once and then collect and reset the statistics.

```
db2 -o -tvf work1.db2

CONNECT TO SAMPLE

CALL WLM_COLLECT_STATS()
```

In the third interval, run `work1.db2` twice and run `work2.db2` script once and then collect and reset the statistics.

```
db2 -o -tvf work1.db2
db2 -o -tvf work2.db2
db2 -o -tvf work1.db2

CONNECT TO SAMPLE

CALL WLM_COLLECT_STATS()
```

Collecting data periodically such as this permits you to watch how work on your system changes over time.

Additional Information: Collecting data periodically does not need to be a manual operation. Using the WLM_COLLECT_INT database configuration parameter, one can set the interval in minutes after which statistics collection and reset automatically occurs.

Step 5: Query views to view statistics

Now that statistics have been collected, the views created earlier can be used to look at the statistics. The HISTOGRAMTYPES view just returns the types of histograms available.

```
SELECT * FROM HISTOGRAMTYPES

HISTOGRAM_TYPE
------------------------
CoordActExecTime
CoordActLifetime
CoordActQueueTime

  3 record(s) selected.
```

Since the BASE option was used when altering the service class, there are three histograms: lifetime, exectime and queuetime. The HISTOGRAMSERVICECLASSES view permits you to see the service classes for which a histogram was collected. The following example restricts the output to that of the CoordActLifetime histogram only. Since aggregate activity collection was only turned on for the default user service class's default subclass, only that class is shown when selecting from the HISTOGRAMSERVICECLASSES view.

```
SELECT * FROM HISTOGRAMSERVICECLASSES
  WHERE HISTOGRAM_TYPE = 'CoordActLifetime'
  ORDER BY SERVICE_SUPERCLASS, SERVICE_SUBCLASS

HISTOGRAM_TYPE          SERVICE_SUPERCLASS       SERVICE_SUBCLASS
------------------------ ------------------------ -----------------------
-
CoordActLifetime        SYSDEFAULTUSERCLASS      SYSDEFAULTSUBCLASS

  1 record(s) selected.
```

The HISTOGRAMTIMES view shows the times when histograms were collected. Since the WLM_COLLECT_STATS procedure was run three times, there are three timestamps for the lifetime histogram shown.

```
SELECT * FROM HISTOGRAMTIMES
  WHERE HISTOGRAM_TYPE = 'CoordActLifetime'
    AND SERVICE_SUPERCLASS = 'SYSDEFAULTUSERCLASS'
    AND SERVICE_SUBCLASS = 'SYSDEFAULTSUBCLASS'
  ORDER BY TIMESTAMP

HISTOGRAM_TYPE   SERVICE_SUPERCLASS  SERVICE_SUBCLASS   TIMESTAMP
---------------- ------------------- ------------------ -----------------
---------
CoordActLifetime SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 2007-08-05-
20.44.51.519380
CoordActLifetime SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 2007-08-05-
21.04.27.131281
CoordActLifetime SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 2007-08-05-
21.08.27.474168

  3 record(s) selected.
```

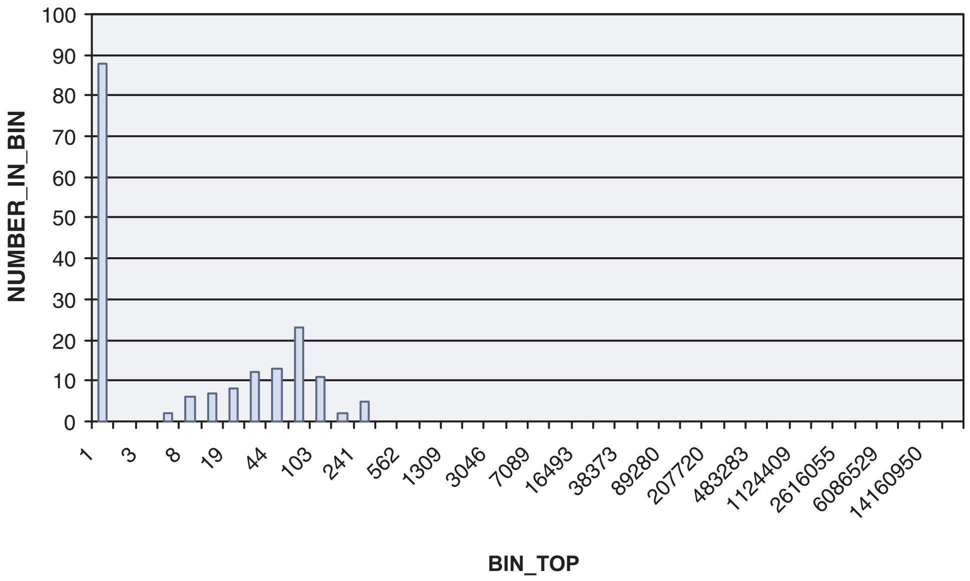
The last view, HISTOGRAMS, is for looking at the histograms themselves. Unlike the HISTOGRAMTIMES view that lists each collection interval as its own row, this view aggregates histogram data across multiple intervals to produce a single histogram of a given type for a given service class.

```
SELECT BIN_TOP, NUMBER_IN_BIN FROM HISTOGRAMS
  WHERE HISTOGRAM_TYPE = 'CoordActLifetime'
    AND SERVICE_SUPERCLASS = 'SYSDEFAULTUSERCLASS'
    AND SERVICE_SUBCLASS = 'SYSDEFAULTSUBCLASS'
  ORDER BY BIN_TOP

BIN_TOP              NUMBER_IN_BIN
-------------------- --------------------
                  -1                    0
                   1                   88
                   2                    0
                   3                    0
                   5                    2
                   8                    6
                  12                    7
                  19                    8
                  29                   12
                  44                   13
                  68                   23
                 103                   11
                 158                    2
                 241                    5
                 369                    0
                 562                    0
                 858                    0
                1309                    0
                1997                    0
                3046                    0
                4647                    0
                7089                    0
               10813                    0
               16493                    0
               25157                    0
               38373                    0
               58532                    0
               89280                    0
              136181                    0
              207720                    0
              316840                    0
              483283                    0
              737162                    0
             1124409                    0
             1715085                    0
             2616055                    0
```

```
            3990325                  0
            6086529                  0
            9283913                  0
           14160950                  0
           21600000                  0

  41 record(s) selected.
```

The output from the histograms can then be used as input into a graphing tool to generate a graph. The following diagram shows a graph that was created using a Ruby Graphing Library called Gruff Graphs.

Lifetime histogram for SYSDEFAULTUSERCLASS (CoordActLifetime):

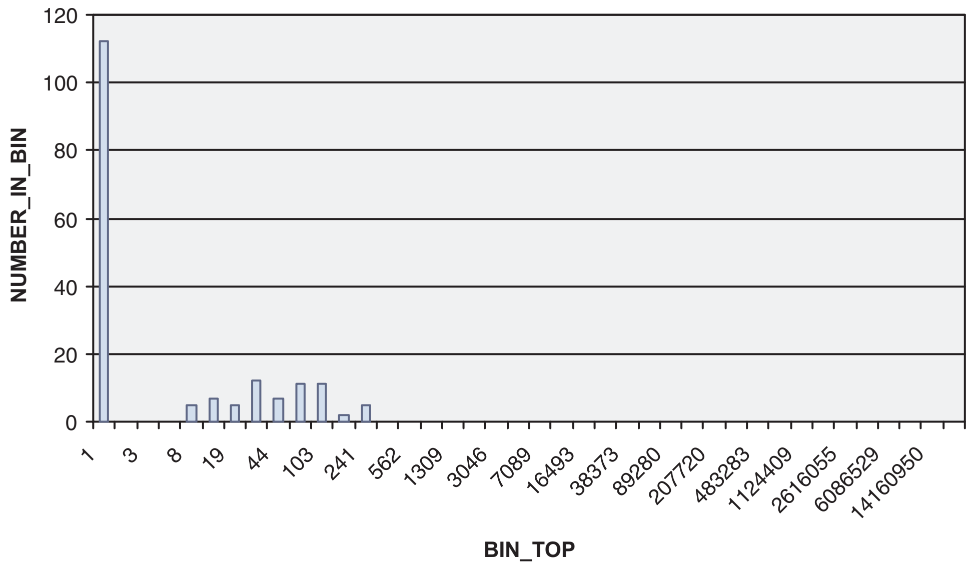


Running the query of this view, should produce output that will not be exactly the same as what is shown in the preceding lifetime histogram graph since activity lifetimes depend on the performance of the system. In the previous output, there are 41 bins and all of the largest bins are empty. At the top, there is a bin whose BIN_TOP is -1. This bin represents all of those activities whose lifetime was too large to fit in the histogram. Seeing a NUMBER_OF_BIN greater than zero when the BIN_TOP is -1 indicates that you should probably increase the high bin value of your histogram. In the previous output, the NUMBER_IN_BIN is 0, so there is no need to make such a change. A large number of activities, 88 in this case, were counted in the bin with a BIN_TOP of 1. This is the lowest bin and it means that 88 activities had a lifetime between 0 and 1 milliseconds. Another piece of information that can be extracted from the histogram is that, since the largest BIN_TOP for which there is a corresponding non-zero NUMBER_IN_BIN is 241, the largest lifetime of any activity in the workloads collected in this histogram was between 158 milliseconds and 241 milliseconds. The COORD_ACT_LIFETIME_TOP column in the SCSTATS_DB2STATISTICS table gives a more precise measurement of the lifetime of the activity with the largest lifetime.

The same query can be repeated with a histogram_type of CoordActExecTime instead of CoordActLifetime. The execution time histogram is expected to be similar but not identical to the lifetime histogram. The reason they are different, even when there is no queuing, is that execution time does not include initialization time or cursor idle time, while lifetime does.

```
SELECT BIN_TOP, NUMBER_IN_BIN FROM HISTOGRAMS
  WHERE HISTOGRAM_TYPE = 'CoordActExecTime'
    AND SERVICE_SUPERCLASS = 'SYSDEFAULTUSERCLASS'
    AND SERVICE_SUBCLASS = 'SYSDEFAULTSUBCLASS'
  ORDER BY BIN_TOP

BIN_TOP              NUMBER_IN_BIN
-------------------- --------------------
                  -1                    0
                   1                  112
                   2                    0
                   3                    0
                   5                    0
                   8                    5
                  12                    7
                  19                    5
                  29                   12
                  44                    7
                  68                   11
                 103                   11
                 158                    2
                 241                    5
                 369                    0
                 562                    0
                 858                    0
                1309                    0
                1997                    0
                3046                    0
                4647                    0
                7089                    0
               10813                    0
               16493                    0
               25157                    0
               38373                    0
               58532                    0
               89280                    0
              136181                    0
              207720                    0
              316840                    0
              483283                    0
              737162                    0
             1124409                    0
             1715085                    0
             2616055                    0
             3990325                    0
             6086529                    0
             9283913                    0
            14160950                    0
            21600000                    0

  41 record(s) selected.
```

Execution time histogram for SYSDEFAULTUSERCLASS (CoordActExecTime):



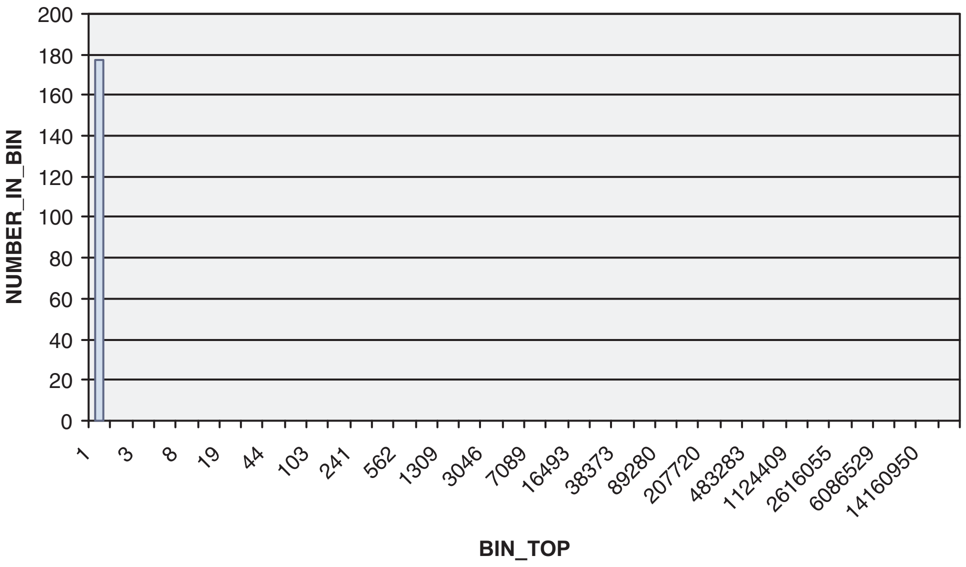
Once again, a large number of activities are counted in the first bin and the highest execution time of any activity is at most 241 milliseconds.

Finally, the HISTOGRAMS view will be used to look at the CoordActQueueTime histogram. This is the simplest histogram because there is no queuing, since no queuing thresholds were created or enabled in this exercise.

```
SELECT BIN_TOP, NUMBER_IN_BIN FROM HISTOGRAMS
  WHERE HISTOGRAM_TYPE = 'CoordActQueueTime'
    AND SERVICE_SUPERCLASS = 'SYSDEFAULTUSERCLASS'
    AND SERVICE_SUBCLASS = 'SYSDEFAULTSUBCLASS'
  ORDER BY BIN_TOP

BIN_TOP              NUMBER_IN_BIN
-------------------- --------------------
                  -1                    0
                   1                  177
                   2                    0
                   3                    0
                   5                    0
                   8                    0
                  12                    0
                  19                    0
                  29                    0
                  44                    0
                  68                    0
                 103                    0
                 158                    0
                 241                    0
                 369                    0
                 562                    0
                 858                    0
                1309                    0
                1997                    0
                3046                    0
                4647                    0
                7089                    0
               10813                    0
               16493                    0
               25157                    0
               38373                    0
               58532                    0
               89280                    0
              136181                    0
```

```
            207720                   0
            316840                   0
            483283                   0
            737162                   0
           1124409                   0
           1715085                   0
           2616055                   0
           3990325                   0
           6086529                   0
           9283913                   0
          14160950                   0
          21600000                   0

  41 record(s) selected.
```

Queue time histogram for SYSDEFAULTUSERCLASS (CoordActQueueTime):



Every activity was counted in the 0 to 1 millisecond bin because every activity spent zero milliseconds queuing.

The last several queries looked at activity lifetimes, execution times and queue times broken down into bins but aggregated across multiple intervals. The following query presents the same information from a different perspective. It shows averages instead of histograms and, rather than combining the intervals, it shows each interval individually. It also reports a count of the number of completed activities which shows how many activities completed in each interval. It uses the SCSTATS_DB2STATISTICS table instead of the HISTOGRAMBIN_DB2STATISTICS table.

```
SELECT STATISTICS_TIMESTAMP,
       COORD_ACT_LIFETIME_AVG AS LIFETIMEAVG,
       COORD_ACT_EXEC_TIME_AVG AS EXECTIMEAVG,
       COORD_ACT_QUEUE_TIME_AVG AS QUEUETIMEAVG,
       COORD_ACT_COMPLETED_TOTAL AS COMPLETED_TOTAL
FROM SCSTATS_DB2STATISTICS
WHERE SERVICE_SUPERCLASS_NAME = 'SYSDEFAULTUSERCLASS'
  AND SERVICE_SUBCLASS_NAME = 'SYSDEFAULTSUBCLASS'
ORDER BY STATISTICS_TIMESTAMP

STATISTICS_TIMESTAMP       LIFETIMEAVG EXECTIMEAVG QUEUETIMEAVG
COMPLETED_TOTAL
-------------------------- ----------- ----------- ------------ ---------
------
2007-08-07-14.07.44.511153         508         475            0
```

```
77
2007-08-07-14.07.46.537777         513        508           0
39
2007-08-07-14.07.51.882173         314        253           0
113

  3 record(s) selected.
```

The result shows that average lifetimes are slightly higher than average execution times for each interval and all three are just over a half a second or less. The average queue time, as expected, is zero. The counts of the number of completed activities in each interval is as expected because workloads 1 and 2 were run in the first interval which resulted in 77 activities collected, workload 1 ran alone in the second interval which resulted in 39 activities, and workload 1 ran twice and workload 2 ran once in the third interval, which resulted in 113 activities.

Step 6: Reset for the next exercise

The final step is to turn off collection of aggregate activities on the default user service class and drop the views and delete the information in the statistics tables.

```
ALTER SERVICE CLASS SYSDEFAULTSUBCLASS
  UNDER SYSDEFAULTUSERCLASS
  COLLECT AGGREGATE ACTIVITY DATA NONE

DROP VIEW histograms
DROP VIEW histogramtimes
DROP VIEW histogramserviceclasses
DROP VIEW histogramtypes

SET EVENT MONITOR DB2STATISTICS STATE 0

DELETE FROM HISTOGRAMBIN_DB2STATISTICS
DELETE FROM SCSTATS_DB2STATISTICS
```

Exercise 6: Investigating delays with WLM table functions

This exercise demonstrates how you can determine the cause of an application slow down with the DB2 WLM monitoring facilities.

Estimated time: 10-15 minutes

The DB2 WLM monitoring facilities provide information and statistics for work in a database. Once the cause of a slow-down is identified, you can remedy the situation.

Step 1: Run activities

Two applications are used in this exercise, `app1.db2` and `app2.db2`. Both applications perform DML operations on the SAMPLE database. Run the `app1.db2` script in one window followed immediately by the `app2.db2` script in a second window.

```
db2 –tvf app1.db2
db2 –tvf app2.db2
```

Step 2: View currently active workload occurrences

The `app2.db2` script should now be hanging. From a third window, issue table function WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES to find the states of all applications running on the database. For this example, you can think of a workload occurrence as the same as an application. This table function shows information for all workload occurrences in a service class. Since we want to see all workload occurrences in the database, we use wildcards represented by '' as *service_superclass_name* and *service_subclass_name* input parameters.

```
CONNECT TO SAMPLE

SELECT INTEGER(APPLICATION_HANDLE) APPL_HANDLE,
   VARCHAR(CLIENT_APPLNAME, 15) AS APPL_NAME,
   VARCHAR(SYSTEM_AUTH_ID, 20) AS USER_ID
   FROM TABLE
   (WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES('', '', -2))
```

The output will look something such as the following:

```
APPL_HANDLE APPL_NAME       USER_ID
----------- --------------- --------------------
         12 CLP app1.db2    DB2USR1
         17 CLP app2.db2    DB2USR1
         18 -               DB2USR1
         19 -               DB2USR1

  4 record(s) selected.
```

From the output, we can tell that the application handle for `app2.db2` is 17.

Step 3: Find the agent for the application

To find out what the agents for `app2.db2` are doing use the WLM_GET_SERVICE_CLASS_AGENTS table function. This table function shows information on agents working in a service class. Since we want to see the agents working for application handle 17, we specify this in the application_handle input parameter. For this example, we are not interested in agents for a particular service class, so we specify wildcards for the service_superclass_name and service_subclass_name input parameters.

```
SELECT INTEGER(APPLICATION_HANDLE) AS APPL_HANDLE,
   UOW_ID, ACTIVITY_ID,
   VARCHAR(AGENT_TYPE, 15) AS AGENT_TYPE,
   VARCHAR(AGENT_STATE, 10) AS AGENT_STATE,
   VARCHAR(EVENT_TYPE, 10) AS EVENT_TYPE,
   VARCHAR(EVENT_OBJECT, 10) AS EVENT_OBJ,
   VARCHAR(EVENT_STATE, 10) AS EVENT_STATE
FROM TABLE
   (WLM_GET_SERVICE_CLASS_AGENTS('', '', 17, -2))
```

The output will look something like

```
APPL_HANDLE UOW_ID      ACTIVITY_ID AGENT_TYPE      AGENT_STATE EVENT_TYPE
EVENT_OBJ  EVENT_STATE
----------- ----------- ----------- --------------- ----------- ----------
---------- -----------
         17           1           2 COORDINATOR     ACTIVE      ACQUIRE
LOCK       IDLE
  1 record(s) selected.
```

From the output, you can see that the coordinator agent for application 17 is idle and waiting to acquire a lock. This is the reason why `app2.db2` appears to be hanging.

Step 4: Find the problem application and resolve the problem

Now that we know why the application is hanging, we can remedy the situation. We know the application is waiting on a lock. To find out which lock this application is waiting on and which application is holding the lock, we can use the db2pd tool. First, we need to find out the current transaction number for our hanging application: Issue db2pd –transactions for application handle 17.

```
db2pd -db sample -transactions app=17
```

The output will look something such as the following:

```
Address            AppHandl [nod-index]  TranHdl    Locks      State
Tflag      Tflag2     Firstlsn       Lastlsn        LogSpace
SpaceReserved   TID            AxRegCnt   GXID

0x07000000302A7080 17       [000-00017] 7          5          READ
0x00000000 0x00000000 0x000000000000 0x000000000000 0
0               0x000000000AC3 1          0
```

From the output, we can tell that application 17 has transaction handle 7. We can now find which locks this transaction is waiting on by issuing the db2pd –locks command for transaction handle 7.

```
db2pd -db sample -locks 7 wait
```

The output will look something such as the following:

```
Address            TranHdl    Lockname                   Type       Mode Sts
Owner      Dur HoldCount  Att  ReleaseFlg
0x07000000304013F0 7          00020010000000000640002D52 Row        .NS  W
2          1   0          0x00 0x00000002
```

The output shows that the application is waiting on a row lock. The owner of the lock has transaction handle 2. This transaction is holding the lock and causing our hang. The final step is to determine the corresponding application handle for transaction handle 2. Issue db2pd –transactions command for transaction handle 2.

```
db2pd -db sample -transactions 2
```

The output will look something such as the following:

```
Address            AppHandl [nod-index] TranHdl    Locks      State
Tflag      Tflag2     Firstlsn       Lastlsn        LogSpace
SpaceReserved   TID            AxRegCnt   GXID
0x07000000302A2080 12       [000-00012] 2          6          WRITE
0x00000000 0x00000000 0x000002EE000C 0x000002EE005E 232
396             0x000000000ABB 1          0
```

From the output, we can see that transaction handle 2 corresponds to application handle 12. Referring back to the results from table function WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES, you can see that application 12 refers to `app1.db2`. This application is holding a row lock that is needed by `app2.db2`. To make `app2.db2` proceed, you may commit, rollback or terminate the unit of work or process from the window running `app1.db2`. Alternatively, you may also force off `app1.db2` by issuing FORCE APPLICATION on application handle 12.

```
db2 force application (12)
```

Additional Information: Another way to diagnose hanging applications due to lock contention is to use the SNAPSHOT_LOCKWAIT monitor table function. This table function provides information on lock holders and waiters. To use this table function, the DFT_MON_LOCK monitor switch configuration parameter must be turned on before the database is started. This switch affects all databases on an instance.

Exercise 7: Cancelling an ongoing activity

This exercise demonstrates how to cancel an activity that is currently active using the WLM_CANCEL_ACTIVITY procedure.

Estimated time: 5-10 minutes

Step 1: Issue a long running query

From a CLP window, run the following script that issues a long running query

```
db2 -tvf longquery.db2
```

Step 2: Get the application handle

From another CLP window, call the WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES to get the application handle, unit of work ID and activity ID of the cursor activity.

```
SELECT T.APPLICATION_HANDLE, T.UOW_ID, T.ACTIVITY_ID, T.ACTIVITY_TYPE
FROM SYSIBMADM.APPLICATIONS A,
     TABLE(WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES
            (CAST(NULL AS BIGINT), -2)) T
     WHERE (A.AGENT_ID = T.APPLICATION_HANDLE) AND
           (A.COORD_MEMBER = T.COORD_MEMBER) AND
           (A.MEMBER = T.MEMBER) AND
           (T.MEMBER = T.COORD_MEMBER) AND
           (A.TPMON_CLIENT_APP = 'CLP longquery.db2')
```

By joining the result of the table function with the APPLICATIONS administrative view, we can find the cursor activity that is run from within `longquery.db2`. The output would look something such as the following:

```
APPLICATION_HANDLE   UOW_ID      ACTIVITY_ID ACTIVITY_TYPE
-------------------- ----------- ----------- ----------------------------
----
                 267           1           1 READ_DML

  1 record(s) selected.
```

Step 3: Cancel the activity

From the same CLP window, call the WLM_CANCEL_ACTIVITY stored procedure to cancel the cursor activity obtained previously, using the application handle, unit of work ID, and activity ID obtained from the previous step:

```
CONNECT TO SAMPLE

CALL WLM_CANCEL_ACTIVITY (267, 1, 1)

CONNECT RESET
```

Note that in your case, the application handle, unit of work ID, and activity ID will be different.

In the first CLP window, you will see the following output returned by the long running query issued by `longquery.db2`.

```
SQL4725N  The activity has been cancelled. SQLSTATE=57014
```

Exercise 8: Discovering what types of activities are running on your system

This exercise demonstrates how you can use the DB2 workload management monitoring table functions and work action sets to discover what types of activities are running on your system.

Estimated time: 15-20 minutes

You might want to know the number of large activities or load utilities that are being run concurrently on your system, for example. Understanding the types of work being run on the system is important as different types of work will have different resource requirements and impacts on system performance.

Step 1: Determining the number of activities of each type that are running on your system

Before starting, you might want to show the number of activities of a certain type that are currently running by using the WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES table function:

```
CONNECT TO SAMPLE

SELECT ACTIVITY_TYPE,
     COUNT(*) AS NUMBER_RUNNING
     FROM TABLE (
     WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES(CAST(NULL AS BIGINT), -2)) AS T
GROUP BY ACTIVITY_TYPE
```

The output from this query will look something like:

```
ACTIVITY_TYPE                  NUMBER_RUNNING
------------------------------ -----------------------
READ_DML                        1
```

To get information about the different types of activities that have run on your system over a given period of time, you can use work class sets and work actions.

Step 2: Create a database work action set with count activity work actions

To count the number of times an activity of a specific type has been run over a period of time, a work action set needs to be created. In this example, because we are interested in the activities that are run on the entire system, the work action set will be created at the database level and is associated with the all_class_types work class set that was created in Exercise 4 Step 1. This work class set contains work classes for all types of recognized activities. If we were only interested in the activities being run in a specific service class, we would create a work action set at the service class level. For this example, we are also interested in the information for all types of activities so that the work action set contains a COUNT ACTIVITY work action for each work class in the all_class_types work class set.

```
CREATE WORK ACTION SET work1_was FOR DATABASE
   USING WORK CLASS SET all_class_types
    (WORK ACTION count_read_wa ON WORK CLASS read_wc COUNT ACTIVITY,
    WORK ACTION count_write_wa ON WORK CLASS write_wc COUNT ACTIVITY,
    WORK ACTION count_ddl_wa ON WORK CLASS ddl_wc COUNT ACTIVITY,
    WORK ACTION count_call_wa ON WORK CLASS call_wc COUNT ACTIVITY,
    WORK ACTION count_load_wa ON WORK CLASS load_wc COUNT ACTIVITY,
    WORK ACTION count_all_wa on WORK CLASS all_wc COUNT ACTIVITY)
```

Additional information: Each time an activity corresponding to a work class has one or more work actions applied to it, a counter for the work class is incremented by one. The COUNT ACTIVITY work action provides an efficient way to ensure that the counter is updated. If you do not want to perform any other action on an activity other than counting the number of activities of that type that have been run, the COUNT ACTIVITY work action is the best approach.

Step 3: Run some activities

Run the `work1.db2` script once.

```
db2 –tvf work1.db2
```

Step 4: View work action set statistics

You can use the WLM_GET_WORK_ACTION_SET_STATS table function to access the work action set statistics in memory to get the number of times specific activity types have been run. For example, the following query will tell you the number of activities that were assigned to each of the work classes in the work class set that has a work action associated with it:

```
CONNECT TO SAMPLE

SELECT SUBSTR(WORK_ACTION_SET_NAME, 1, 12) AS WORK_ACTION_SET_NAME,
              SUBSTR(WORK_CLASS_NAME, 1, 12) AS WORK_CLASS_NAME,
              LAST_RESET,
              SUBSTR(CHAR(ACT_TOTAL), 1, 12) AS TOTAL_ACTS
FROM TABLE(WLM_GET_WORK_ACTION_SET_STATS('', -2)) AS WASSTATS
ORDER BY WORK_ACTION_SET_NAME, WORK_CLASS_NAME, PART
```

Additional Information: The blank included with the statement means that result is not to be restricted by the argument (in this example, we want the information for all of the work action sets). The value of the last argument, member, is the wildcard character -2, which means that data from all database members is to be returned.

The output from this query will look something like the following where "*" represents all activities that do not fall into any of the defined work classes or that fall into work classes with no work actions.

```
WORK_ACTION_SET_NAME WORK_CLASS_NAME LAST_RESET
TOTAL_ACTS
-------------------- --------------- -------------------------- ---------
-
WORK1_WAS            *               2007-08-14-13.55.30.725886 0
WORK1_WAS            ALL_WC          2007-08-14-13.55.30.725886 2
WORK1_WAS            CALL_WC         2007-08-14-13.55.30.725886 4
WORK1_WAS            DDL_WC          2007-08-14-13.55.30.725886 12
WORK1_WAS            LOAD_WC         2007-08-14-13.55.30.725886 1
WORK1_WAS            READ_WC         2007-08-14-13.55.30.725886 12
WORK1_WAS            WRITE_WC        2007-08-14-13.55.30.725886 6

  7 record(s) selected.
```

Step 5: Differentiate activities by more than their type and other attributes

You can separate out activities by more than just their types. For example, you might want to know how many large queries are being run.

Alter the work class set to add a new read work class that will represent large queries. For this example, a large query is any query that has a cardinality greater than 40.

```
ALTER WORK CLASS SET all_class_types
   ADD WORK CLASS large_wc WORK TYPE READ FOR CARDINALITY FROM 41 POSITION AT 1
```

Additional Information: Note that we positioned this work class at position 1. If the POSITION AT clause is not specified, the work class is positioned at the bottom of the work class set. When deciding which work class an activity belongs to, the work classes are checked in the order they are positioned and the first work class whose attributes match the activities attributes is the class that the activity gets assigned to. In this case, if the large_wc were positioned at the end of the list, the large activities would have been assigned to the read_wc since it was positioned ahead of large_wc.

Alter the work action set to add a COUNT ACTIVITY work action and apply it to the new work class.

```
ALTER WORK ACTION SET work1_was
    ADD WORK ACTION count_large_reads ON WORK CLASS large_wc COUNT ACTIVITY
```

Step 6: Reset the statistics and run some activities

Call the WLM_COLLECT_STATS stored procedure to reset the statistics that are stored in memory so that you are starting fresh and when you chose to query that workload management statistical information that is stored in memory, it will contain information for the activities that have been run from this point on.

```
CALL WLM_COLLECT_STATS()
```

Run the `work1.db2` script once.

```
db2 –tvf work1.db2
```

Step 7: View work action set statistics

Use the WLM_GET_WORK_ACTION_SET_STATS table function again to access the work action set statistics in memory to get the number of times specific activity types have been run.

```
CONNECT TO SAMPLE

SELECT SUBSTR(WORK_ACTION_SET_NAME, 1, 12) AS WORK_ACTION_SET_NAME,
       SUBSTR(CHAR(MEMBER), 1, 4) AS MEMB,
       SUBSTR(WORK_CLASS_NAME, 1, 12) AS WORK_CLASS_NAME,
       LAST_RESET,
       SUBSTR(CHAR(ACT_TOTAL), 1, 12) AS TOTAL_ACTS
FROM TABLE(WLM_GET_WORK_ACTION_SET_STATS('', -2)) AS WASSTATS
ORDER BY WORK_ACTION_SET_NAME, WORK_CLASS_NAME, MEMB
```

The output will look something such as the following:

```
WORK_ACTION_SET_NAME MEMB WORK_CLASS_NAME LAST_RESET
TOTAL_ACTS
-------------------- ---- --------------- -------------------------- ----
------
```

```
WORK1_WAS           0    *               2007-08-14-13.55.35.650685 0
WORK1_WAS           0    ALL_WC          2007-08-14-13.55.35.650685 2
WORK1_WAS           0    CALL_WC         2007-08-14-13.55.35.650685 4
WORK1_WAS           0    DDL_WC          2007-08-14-13.55.35.650685 12
WORK1_WAS           0    LARGE_WC        2007-08-14-13.55.35.650685 4
WORK1_WAS           0    LOAD_WC         2007-08-14-13.55.35.650685 1
WORK1_WAS           0    READ_WC         2007-08-14-13.55.35.650685 8
WORK1_WAS           0    WRITE_WC        2007-08-14-13.55.35.650685 6

  8 record(s) selected.
```

Note that this time four of the activities from the script are considered large activities.

Step 8: Reset for the next exercise

Drop the work action set:

```
ALTER WORK ACTION SET WORK1_WAS
 ALTER WORK ACTION COUNT_READ_WA DISABLE
 ALTER WORK ACTION COUNT_WRITE_WA DISABLE
 ALTER WORK ACTION COUNT_DDL_WA DISABLE
 ALTER WORK ACTION COUNT_CALL_WA DISABLE
 ALTER WORK ACTION COUNT_LOAD_WA DISABLE
 ALTER WORK ACTION COUNT_ALL_WA DISABLE
 ALTER WORK ACTION COUNT_LARGE_READS DISABLE;
ALTER WORK ACTION SET WORK1_WAS DISABLE;
DROP WORK ACTION SET WORK1_WAS;
```

Exercise 9: Capturing detailed information about an executing activity

This exercise demonstrates how you can use the WLM_CAPTURE_ACTIVITY_IN_PROGRESS procedure to capture detailed information about a currently executing activity for later historical analysis.

Estimated time: 5-10 minutes

Activity information you capture is sent to the active event monitor for activities. Previous tasks showed how the COLLECT ACTIVITY DATA clause is used for workloads, service classes, work actions and thresholds to capture detailed activity information. This clause needs to be specified in advance before an activity begins executing and information is sent to the activities event monitor when the activity completes. The WLM_CAPTURE_ACTIVITY_IN_PROGRESS procedure permits you to capture information reactively when you notice a problem with an activity already in progress. When this procedure is used, information about an activity is sent to the activities event monitor immediately. Both basic and statement activity information are collected, but not input data.

Step 1: Enable activities event monitor

Enable the existing event monitor for activities you created in Exercise 1.

```
CONNECT TO SAMPLE

SET EVENT MONITOR DB2ACTIVITIES STATE 1
```

Step 2: Issue a long running query

From the CLP, run the following script that issues a long running query with a problematic cursor:

```
db2 -tvf longquery.db2
```

Step 3: Get the application handle

From a second CLP window, call WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES to obtain the application handle, unit of work ID and activity ID for the activity. By joining the result of the table function with the APPLICATIONS administrative view, you can find the cursor activity that is run from within `longquery.db2`.

```
CONNECT TO SAMPLE

SELECT T.APPLICATION_HANDLE, T.UOW_ID, T.ACTIVITY_ID, T.ACTIVITY_TYPE
FROM SYSIBMADM.APPLICATIONS A,
     TABLE(WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES
         (CAST(NULL AS BIGINT), -2)) T
WHERE (A.AGENT_ID = T.APPLICATION_HANDLE) AND
         (A.COORD_MEMBER = T.COORD_MEMBER) AND
         (A.MEMBER = T.MEMBER) AND
         (T.MEMBER = T.COORD_MEMBER) AND
         (A.TPMON_CLIENT_APP = 'CLP longquery.db2')
```

The output looks such as the following:

```
APPLICATION_HANDLE   UOW_ID      ACTIVITY_ID ACTIVITY_TYPE
-------------------- ----------- ----------- ----------------------------
----
                 267           1           1 READ_DML

1 record(s) selected.
```

Step 4: Capture information about the activity

From the same CLP window, call the WLM_CAPTURE_ACTIVITY_IN_PROGRESS stored procedure using the application handle, unit of work ID, and activity ID obtained from the previous step:

```
CONNECT TO SAMPLE

CALL WLM_CAPTURE_ACTIVITY_IN_PROGRESS (267, 1, 1)

CONNECT RESET
```

This step sends information about the activity to the active event monitor for activities. Note that in your case, the application handle, unit of work ID, and activity ID you specify may be different.

Step 5: View the activity information

Look at the information that was collected for the activity using a statement such as the following:

```
SELECT VARCHAR(A.APPL_NAME, 15) as APPL_NAME,
     VARCHAR(A.TPMON_CLIENT_APP, 20) AS CLIENT_APP_NAME,
     VARCHAR(A.APPL_ID, 30) as APPL_ID,
     A.ACTIVITY_ID,
     A.UOW_ID,
     A.PARTIAL_RECORD,
     A.TIME_STARTED,
     A.TIME_COMPLETED,
     VARCHAR(S.STMT_TEXT, 300) AS STMT_TEXT
FROM ACTIVITY_DB2ACTIVITIES AS A,
     ACTIVITYSTMT_DB2ACTIVITIES AS S
WHERE A.APPL_ID = S.APPL_ID AND
     A.ACTIVITY_ID = S.ACTIVITY_ID AND
     A.UOW_ID = S.UOW_ID
```

The output looks something such as this:

```
APPL_NAME       CLIENT_APP_NAME      APPL_ID
ACTIVITY_ID          UOW_ID      PARTIAL_RECORD TIME_STARTED
TIME_COMPLETED             STMT_TEXT
--------------- -------------------- ------------------------------ -----
--------------- ----------- -------------- -------------------------- ---
----------------------- -----------------------------------------------
-----------------------------------------------------------------------
-----------------------------------------------------------------------
-----------------------------------------------------------------------
--------------------------------
db2bp           CLP longquery.db2    *LOCAL.swalkty.070928151408
1          1              1 2007-09-28-11.14.09.334636 0000-00-00-
00.00.00.000000 SELECT COUNT(*) FROM SYSCAT.TABLES, SYSCAT.TABLES,
SYSCAT.TABLES, SYSCAT.TABLES, SYSCAT.TABLES
```

Note: Activities that are captured using the WLM_CAPTURE_ACTIVITY_IN_PROGRESS procedure contain somewhat less information than if the COLLECT ACTIVITY DATA clause were used, because the activity is captured before it has completed execution. In particular, fields such as the completion timestamp (which shows only zeros) and the sqlcode do not apply. You can determine if an activity was collected using the WLM_CAPTURE_ACTIVITY_IN_PROGRESS procedure by looking at the PARTIAL_RECORD column in the ACTIVITY table. If the PARTIAL_RECORD column has a value of 1 (as shown in the previous output), activity information was collected using WLM_CAPTURE_ACTIVITY_IN_PROGRESS. If the PARTIAL_RECORD column has a value of 0, activity information was collected after completion with the COLLECT ACTIVITY DATA clause.

Exercise 10: Generating historical data and reports

This exercise demonstrates how to use the WLM Historical Analysis Tool sample.

Estimated time: 20-25 minutes

DB2 database products include Perl sample scripts that provide information captured by the WLM activities event monitor for historical analysis. You can review or even modify these scripts to produce additional historical analysis reports to suit your needs. The perl scripts are:

- wlmhist.pl: generates historical data
- wlmhistrep.pl: produces reports from the historical data.

Step 1: Create the explain tables

In order to generate some historical data, the explain tables must exist under the schema of the user running the tool. To create the explain tables, go to the /sqllib/misc directory and run the following:

```
db2 CONNECT TO SAMPLE

db2 –tvf EXPLAIN.DDL
```

Step 2: Alter the service class to collect activity data

Enable activity collection by specifying the COLLECT ACTIVITY DATA clause on the WLM object of interest. For this exercise, we want to generate historical data for activities run in the default service subclass of the default user service super class:

```
ALTER SERVICE CLASS SYSDEFAULTSUBCLASS UNDER SYSDEFAULTUSERCLASS
       COLLECT ACTIVITY DATA ON COORDINATOR WITH DETAILS
```

Step 3: Enable the activities event monitor

Since the activities event monitor was created in Exercise 1 Step 1, enable it now if it is not enabled already.

```
SET EVENT MONITOR DB2ACTIVITIES STATE 1
```

Step 4: Run some activities

Run some activities so that activity data is collected to generate historical data on.

```
db2 –tvf work1.db2
db2 –tvf work2.db2
```

Step 5: Disable the event monitor for activities

It is highly recommended that you turn off the event monitor for activities before generating historical data. If you do not do this, any DML activities that are run as a result of the historical data generator may also be captured and put into the DB2 event monitor activity tables, thereby dramatically increasing the number of actual activities for which activity data is generated.

```
CONNECT TO SAMPLE

SET EVENT MONITOR DB2ACTIVITIES STATE 0
```

Step 6: Generate historical data

Run the historical data generator script, wlmhist.pl, to generate historical data for activities that are captured in the activities event monitor tables. The format is as follows:

```
wlmhist.pl dbname user password [fromTime toTime workloadid
        serviceClassName serviceSubclassName activityTable activityStmtTable]
```

Use a dash (-) to bypass any optional parameters.

Additional Information: The historical data generator (wlmhist.pl) script will generate only historical data for DML. If you have previously run the historical data generator (wlmhist.pl) script once or more, it is recommended that, before running it again, you clear the activityTable and activityStmtTable tables in order to avoid duplicating data. If you choose not to clear these two tables, be sure to use the fromTime and toTime input parameters to ensure you do not generate historical data for activities that have already had data generated for them.

For this exercise, generate historical data for all activities that have been captured in the activities event monitor.

```
Perl wlmhist.pl sample db2inst1 password
```

You may notice some errors similar to the following:

```
Error running explain [IBM][CLI Driver][DB2/LINUXX8664] SQL0418N  A
statement contains a use of a parameter marker that is not valid. SQLSTATE=42610
 for statement VALUES (TABLE_SCHEMA(:H00002 , :H00003   )) INTO :H00007

DBD::DB2::db do failed: [IBM][CLI Driver][DB2/LINUXX8664] SQL0418N  A
statement
contains a use of a parameter marker that is not valid. SQLSTATE=42610
```

When generating historical data, explain is run on the actual statement. In some cases, explain cannot be run on some statements with parameter markers and an error is returned. Any activity that shows such an error will not have historical data generated for it.

Once the tool has completed generating historical data, it will tell you how many activities it has successfully generated historical data for.

Step 7: Generate historical data reports

Run the historical data report script wlmhistrep.pl to generate reports based on the data that was generated in step 1. The format is as follows:

```
wlmhistrep.pl dbAlias userId passwd [outputFile report schemaName fromTime toTime submitter]
```

Use a dash (-) to bypass optional parameters.

The **report** parameter can be any combination from the following letters:

- A: Tables hit
- B: Tables not hit
- C: Indexes hit
- D: Indexes not hit
- E: Submitters

If the **userId** parameter you specify is not the same as what was used to run the wlmhist.pl script when the wlmhist table was created, you must specify the correct schemaName. The **fromTime** and **toTime** parameters must be specified in timestamp format (for example 2007-06-06-17.00.00).

For this exercise, generate reports for tables hit and indexes not hit:

```
Perl wlmhistrep.pl sample db2inst1 password - AD
```

The output will look something such as the following:

```
                TABLES HIT REPORT FOR DATABASE sample
              _______________________________________________________


TABLE NAME                     TABLE SCHEMA        % HITS        TOTAL HITS
______________________         __________________  _____________ ____________

EMPLOYEE                        KARENAM             7.14285714            2
INVENTORY                       KARENAM            14.28571429            4

ORG                             KARENAM            28.57142857            8
SALES                           KARENAM            14.28571429            4
SYSROUTINES                     SYSIBM              7.14285714            2
SYSTABLES                       SYSIBM             21.42857143            6
SYSTABLESPACES                  SYSIBM              7.14285714            2


             INDEXES NOT HIT REPORT FOR DATABASE sample
            ___________________________________________________________


TABLE NAME         TABLE SCHEMA    INDEX NAME         INDEX SCHEMA    INDEX TYPE
__________________ _______________ __________________ _______________ __________
EXPLAIN_ARGUMENT   KARENAM         ARG_I1             KARENAM         REG
HMON_ATM_INFO      SYSTOOLS        ATM_UNIQ           SYSTOOLS        REG
CUSTOMER           KARENAM         CUST_CID_XMLIDX    KARENAM         XVIL
CUSTOMER           KARENAM         CUST_NAME_XMLIDX   KARENAM         XVIL
CUSTOMER          KARENAM        CUST_PHONES_XMLIDX KARENAM         XVIL
CUSTOMER          KARENAM        CUST_PHONET_XMLIDX KARENAM         XVIL
EXPLAIN_DIAGNOSTIC KARENAM       EXP_DIAG_DAT_I1    KARENAM         REG
HMON_COLLECTION   SYSTOOLS       HI_OBJ_UNIQ        SYSTOOLS        REG
ADVISE_INDEX      KARENAM        IDX_I1             KARENAM         REG
ADVISE_INDEX      KARENAM        IDX_I2             KARENAM         REG
SYSATTRIBUTES     SYSIBM         INDATTRIBUTES01    SYSIBM          REG
SYSATTRIBUTES     SYSIBM         INDATTRIBUTES02    SYSIBM          REG
:
:
```

Step 8: Reset for the next exercise

Disable activity collection for the default service subclass of the default user service super class, and clean up the activity tables.

```
ALTER SERVICE CLASS SYSDEFAULTSUBCLASS UNDER SYSDEFAULTUSERCLASS
       COLLECT ACTIVITY DATA NONE

DELETE FROM ACTIVITY_DB2ACTIVITIES
DELETE FROM ACTIVITYSTMT_DB2ACTIVITIES
```

Exercise 11: Using extended aggregates for service classes

This exercise demonstrates how to use the COLLECT AGGREGATE ACTIVITY DATA EXTENDED option on a service class to produce histograms of coordinator activity inter-arrival times and estimated costs.

Estimated time: 25-30 minutes

The inter-arrival time is the time between the arrival of one activity into the system and the arrival of the next activity. The estimated cost of an activity is the estimated system resources that will be used in the execution of the activity and it only applies to DML activities. An inter-arrival time histogram can be useful for correlating with a lifetime histogram or other lifetime statistics for determining whether a change in lifetime statistics was the result of a change in the arrival rate of the workload versus being the result of a change in the complexity of the workload (more complex queries) or a change in the system. The estimated cost histogram can be useful for correlating with the inter-arrival time and lifetime histograms to see whether a change in the lifetime histogram could be due to a change in the complexity of the workload load (more complex queries with higher estimated costs being submitted), due to a change in the arrival rate of activities (determined from the inter-arrival time distribution) or due to a change in the system itself, such as the introduction of a new threshold, a change in the priority given to a service class, or a change in hardware.

For more information on histograms, see “Histograms in workload management” on page 253.

Histograms are accessed through the statistics event monitor. This exercise reuses the statistics event monitor created in Exercise 1 Step 1.

Step 1: Create views for viewing histogram statistics

Create several views to make querying the HISTOGRAMBIN_DB2STATISTICS table easier. The first view lists all of the histogram types available. In this exercise, it reports just the three basic types: lifetime, execution time and queue time.

```
CREATE VIEW HISTOGRAMTYPES AS
  SELECT DISTINCT SUBSTR(HISTOGRAM_TYPE,1,24) HISTOGRAM_TYPE
  FROM HISTOGRAMBIN_DB2STATISTICS
```

A second view makes it easier to find out what service classes are having histograms collected for them. The HISTOGRAMBIN_DB2STATISTICS table reports the service class for which the histogram is being collected by giving the service class ID. Joining this table with the SERVICECLASSES catalog table will permit the service class information to be presented with the service super class name and service subclass name instead of the service class ID.

```
CREATE VIEW HISTOGRAMSERVICECLASSES AS
  SELECT DISTINCT SUBSTR(HISTOGRAM_TYPE,1,24) HISTOGRAM_TYPE,
         SUBSTR(PARENTSERVICECLASSNAME,1,24) SERVICE_SUPERCLASS,
         SUBSTR(SERVICECLASSNAME,1,24) SERVICE_SUBCLASS
  FROM HISTOGRAMBIN_DB2STATISTICS H,
       SYSCAT.SERVICECLASSES S
  WHERE H.SERVICE_CLASS_ID = S.SERVICECLASSID
```

The third view lists all of the times that a histogram of a given type was collected for a given service class. Such as the HISTOGRAMSERVICECLASSES view, it joins the HISTOGRAMBIN_DB2STATISTICS table with the SERVICECLASSES catalog table. The difference is in the STATISTICS_TIMESTAMP column which is included as one of the columns in this view.

```
CREATE VIEW HISTOGRAMTIMES AS
  SELECT DISTINCT SUBSTR(HISTOGRAM_TYPE,1,24) HISTOGRAM_TYPE,
         SUBSTR(PARENTSERVICECLASSNAME,1,24) SERVICE_SUPERCLASS,
         SUBSTR(SERVICECLASSNAME,1,24) SERVICE_SUBCLASS,
         STATISTICS_TIMESTAMP TIMESTAMP
  FROM HISTOGRAMBIN_DB2STATISTICS H,
       SYSCAT.SERVICECLASSES S
  WHERE H.SERVICE_CLASS_ID = S.SERVICECLASSID
```

The fourth and final view will be used to show the histograms themselves. It also demonstrates a common task when dealing with histograms, which is to aggregate them over time. This view shows the top of each bin and the number of activities that were counted towards each bin. Of the two following histograms, the BIN_TOP field measures the number of milliseconds in the activity inter-arrival time and the number of timerons in the estimated cost. When BIN_TOP is, 3000 milliseconds and the BIN_TOP of the previous bin is 2000 milliseconds and the NUMBER_IN_BIN is ten for an inter-arrival time histogram you know that there were ten activities which each arrived into the system between 2 and 3 seconds after the arrival of the previous activity, for example.

```
CREATE VIEW HISTOGRAMS(HISTOGRAM_TYPE, SERVICE_SUPERCLASS,
  SERVICE_SUBCLASS, BIN_TOP, NUMBER_IN_BIN) AS
  SELECT DISTINCT SUBSTR(HISTOGRAM_TYPE,1,24) HISTOGRAM_TYPE,
         SUBSTR(PARENTSERVICECLASSNAME,1,24) SERVICE_SUPERCLASS,
         SUBSTR(SERVICECLASSNAME,1,24) SERVICE_SUBCLASS,
         TOP AS BIN_TOP,
         SUM(NUMBER_IN_BIN) AS NUMBER_IN_BIN
  FROM HISTOGRAMBIN_DB2STATISTICS H,
       SYSCAT.SERVICECLASSES S
  WHERE H.SERVICE_CLASS_ID = S.SERVICECLASSID
  GROUP BY HISTOGRAM_TYPE, PARENTSERVICECLASSNAME, SERVICECLASSNAME, TOP
```

Step 2: Turn on collection of histograms

Turning on the collection of histograms is done for the default user service class by altering its default subclass to collect aggregate activity data with the EXTENDED option. This provides both the three histograms available in the BASE option (lifetime, execution time, and queue time) and the two histograms available only when using the EXTENDED option (inter-arrival time and estimated cost).

```
ALTER SERVICE CLASS SYSDEFAULTSUBCLASS UNDER SYSDEFAULTUSERCLASS
   COLLECT AGGREGATE ACTIVITY DATA EXTENDED
```

Step 3: Activate statistics event monitor

If not already active, activate the event monitor that was created earlier so that it can receive aggregate data whenever it is collected.

```
SET EVENT MONITOR DB2STATISTICS STATE 1
```

Step 4: Run activities and send statistics to statistics event monitor

First run some activities; after the activities have finished the WLM_COLLECT_STATS stored procedure is called to send the service class statistics to the active statistics event monitor (including the activity lifetime, execution time, queue time, inter-arrival time and estimated cost histograms for the default user service class). These histograms contain data about all activities that executed in the default user service class since aggregate activity statistics were enabled. Calling the stored procedure also resets the statistics. To show changes in database activity over time, three collection intervals are created.

In the first interval, run two scripts, `work1.db2` and `work2.db2`, then collect and reset the statistics.

```
db2 -o- -tvf work1.db2
db2 -o- -tvf work2.db2

CONNECT TO SAMPLE

CALL WLM_COLLECT_STATS
```

In the second interval, run only the `work1.db2` script once, then collect and reset the statistics.

```
db2 -o- -tvf work1.db2

CONNECT TO SAMPLE

CALL WLM_COLLECT_STATS
```

In the third interval, run the `work1.db2` script twice and the `work2.db2` script once, then collect and reset the statistics.

```
db2 -o- -tvf work1.db2
db2 -o- -tvf work2.db2
db2 -o- -tvf work1.db2

CONNECT TO SAMPLE

CALL WLM_COLLECT_STATS
```

Collecting data periodically such as this permits you to watch how work on your system changes over time.

Additional Information: Collecting data periodically does not need to be a manual operation. Using the WLM_COLLECT_INT database configuration parameter, you can set the interval in minutes after which statistics collection and reset occurs.

Step 5: Query views to view statistics

Now that statistics have been collected, the views created earlier can be used to look at the statistics. The HISTOGRAMTYPES view just returns the types of histograms available.

```
SELECT * FROM HISTOGRAMTYPES

HISTOGRAM_TYPE
------------------------
CoordActEstCost
CoordActExecTime
CoordActInterArrivalTime
CoordActLifetime
CoordActQueueTime

  3 record(s) selected.
```

Since the EXTENDED option was used when altering the service class, there are five histograms.

The HISTOGRAMSERVICECLASSES view permits you to see the service classes for which a histogram was collected. The following example restricts the output to that of the CoordActInterArrivalTime histogram only. Since aggregate activity collection was turned on only for the default user service class's default subclass, only that class is shown when selecting from the HISTOGRAMSERVICECLASSES view.

```
SELECT * FROM HISTOGRAMSERVICECLASSES
  WHERE HISTOGRAM_TYPE = 'CoordActInterArrivalTime'
  ORDER BY SERVICE_SUPERCLASS, SERVICE_SUBCLASS

HISTOGRAM_TYPE           SERVICE_SUPERCLASS       SERVICE_SUBCLASS
------------------------ ------------------------ -----------------------
-
CoordActInterArrivalTime SYSDEFAULTUSERCLASS      SYSDEFAULTSUBCLASS

  1 record(s) selected.
```

The HISTOGRAMTIMES view shows the times when histograms were collected. Since the WLM_COLLECT_STATS procedure was run three times, there are three timestamps for the inter-arrival time histogram shown.

```
SELECT * FROM HISTOGRAMTIMES
  WHERE HISTOGRAM_TYPE = 'CoordActInterArrivalTime'
    AND SERVICE_SUPERCLASS = 'SYSDEFAULTUSERCLASS'
    AND SERVICE_SUBCLASS = 'SYSDEFAULTSUBCLASS'
  ORDER BY TIMESTAMP

HISTOGRAM_TYPE           SERVICE_SUPERCLASS       SERVICE_SUBCLASS
TIMESTAMP
------------------------ ------------------------ -----------------------
- --------------------------
CoordActInterArrivalTime SYSDEFAULTUSERCLASS      SYSDEFAULTSUBCLASS
2007-08-08-13.41.38.870298
CoordActInterArrivalTime SYSDEFAULTUSERCLASS      SYSDEFAULTSUBCLASS
2007-08-08-13.41.42.802855
CoordActInterArrivalTime SYSDEFAULTUSERCLASS      SYSDEFAULTSUBCLASS
2007-08-08-13.41.53.577835
```

The last view, HISTOGRAMS, is for looking at the histograms themselves. Unlike the HISTOGRAMTIMES view that lists each collection interval as its own row, this view aggregates histogram data across multiple intervals to produce a single histogram of a given type for a given service class.

```
SELECT BIN_TOP, NUMBER_IN_BIN FROM HISTOGRAMS
  WHERE HISTOGRAM_TYPE = 'CoordActInterArrivalTime'
    AND SERVICE_SUPERCLASS = 'SYSDEFAULTUSERCLASS'
    AND SERVICE_SUBCLASS = 'SYSDEFAULTSUBCLASS'
  ORDER BY BIN_TOP

BIN_TOP              NUMBER_IN_BIN
-------------------- --------------------
                  -1                    0
                   1                   10
                   2                    6
                   3                    7
                   5                   14
                   8                    7
                  12                   32
                  19                    2
                  29                    9
                  44                   24
                  68                   11
                 103                    8
                 158                    8
                 241                    9
                 369                    1
                 562                   10
                 858                    5
                1309                    5
                1997                    0
                3046                    0
                4647                    0
                7089                    0
               10813                    2
               16493                    2
               25157                    0
               38373                    0
               58532                    0
               89280                    0
              136181                    0
              207720                    0
              316840                    0
              483283                    0
              737162                    0
             1124409                    0
             1715085                    0
             2616055                    0
             3990325                    0
             6086529                    0
             9283913                    0
            14160950                    0
            21600000                    0

  41 record(s) selected.
```

Running this query produces output than will not be exactly the same as what is shown in the preceding example since activity inter-arrival times depend on the performance of the system. In the previous output, there are 41 bins and all of the largest bins are empty. At the top, there is a bin whose BIN_TOP is -1. This bin represents all of those activities whose inter-arrival time was too large to fit in the histogram. Seeing a NUMBER_OF_BIN greater than zero when the BIN_TOP is -1 indicates that you should probably increase the high bin value of your histogram. In the previous output, the NUMBER_IN_BIN is 0, so there is no need to make such a change. The majority of activities arrived less than 1309 milliseconds apart from each other. Four activities arrived between 7089 milliseconds and 16493 milliseconds apart.

The same query can be repeated with a histogram_type of CoordActEstCost instead of CoordActInterArrivalTime.

```
SELECT BIN_TOP, NUMBER_IN_BIN FROM HISTOGRAMS
  WHERE HISTOGRAM_TYPE = 'CoordActEstCost'
    AND SERVICE_SUPERCLASS = 'SYSDEFAULTUSERCLASS'
    AND SERVICE_SUBCLASS = 'SYSDEFAULTSUBCLASS'
  ORDER BY BIN_TOP

BIN_TOP              NUMBER_IN_BIN
-------------------- --------------------
                  -1                    0
                   1                   39
                   2                    0
                   3                    0
                   5                    0
                   8                   30
                  12                    0
                  19                   30
                  29                    0
                  44                    0
                  68                    0
                 103                    0
                 158                    0
                 241                    0
                 369                    0
                 562                    0
                 858                    0
                1309                    0
                1997                    0
                3046                    0
                4647                    0
                7089                    0
               10813                    0
               16493                    0
               25157                    0
               38373                    0
               58532                    0
               89280                    0
              136181                    0
              207720                    0
              316840                    0
              483283                    0
              737162                    0
             1124409                    0
             1715085                    0
             2616055                    0
             3990325                    0
             6086529                    0
             9283913                    0
            14160950                    0
            21600000                    0

  41 record(s) selected.
```

A histogram such as this is typical for a small workload. With a small workload, there is not much variation in the size of activities, so there are only three different bins that had activities counted towards them. Slightly more than 60% of the activities had a cost estimate between 5 and 19 timerons, with the rest having cost estimates of less than 1 timeron.

Step 6: Reset for other exercises

The final step is to turn off collection of aggregate activities on the default user service class, to drop the views and to delete the information in the statistics tables.

```
ALTER SERVICE CLASS SYSDEFAULTSUBCLASS UNDER SYSDEFAULTUSERCLASS
   COLLECT AGGREGATE ACTIVITY DATA NONE

DROP VIEW HISTOGRAMS
DROP VIEW HISTOGRAMTIMES
DROP VIEW HISTOGRAMSERVICECLASSES
DROP VIEW HISTOGRAMTYPES

SET EVENT MONITOR DB2STATISTICS STATE 0

DELETE FROM HISTOGRAMBIN_DB2STATISTICS
DELETE FROM SCSTATS_DB2STATISTICS
```

Chapter 7. Workload management scenarios

Workload management sample application

Comprehensive workload management features have been integrated into your DB2 data server with DB2 workload management, giving you finer control over activities, resources and performance, and deeper insight into how your system is running. A workload management sample application is now available on developerWorks®.

The workload management sample application demonstrates how you can use DB2 workload management features to achieve the following objectives:

Protect the system from runaway queries
: Runaway queries are costly and cause poor performance. The workload management sample application identifies queries with the potential to become runaway queries, and then stops these queries from running after they have violated a specified threshold.

Limit concurrent resource consumption by individual applications
: The sample application shows how to use DB2 workload management features to prevent applications that submit large amounts of concurrent work from negatively affecting the performance of other applications.

Achieve a specific response time
: Workload management features permit you to achieve a specific response time objective of the form: "transaction X from application Y shall complete within 1 second in 90% of cases," regardless of what other activity is running concurrently on the system. The sample application will demonstrate how to achieve a response time objective.

Consistent response time for short queries
: Queries that typically have a response time of less than 1 second should have a relatively consistent response time regardless of what other workloads are running on the system. The sample application uses the query execution time histogram to monitor consistency.

Protect the system during periods of peak demand
: Workload management policy features protect the system from capacity overload during bursts of peak demand by queuing work once the system is sufficiently loaded.

Enable concurrent batch extract, transform, and load (ETL) processing and user queries
: Workload management features permit you to run ETL jobs (like loading data into tables) while controlling the performance impact for users running queries concurrently.

To obtain the sample application, see Workload management sample on developerWorks.

Scenario: Investigating a workload-related system slowdown

If you notice a system slowdown (for example, some applications take much longer to complete than expected) and are unsure whether the problem is related to the configuration of the workloads, you can use table function data to investigate and, if necessary, correct the problem.

First, create a query that aggregates data across service classes and database members using data from the WLM_GET_SERVICE_SUBCLASS_STATS table function. Set the first and second arguments to empty strings and the third argument to -2 to indicate that data is to be gathered for all service classes on all database members.

Your query might resemble the following one:

```
SELECT SUBSTR(SERVICE_SUPERCLASS_NAME,1,19) AS SUPERCLASS_NAME,
       SUBSTR(SERVICE_SUBCLASS_NAME,1,18) AS SUBCLASS_NAME,
       SUBSTR(CHAR(SUM(COORD_ACT_COMPLETED_TOTAL)),1,13) AS ACTSCOMPLETED,
       SUBSTR(CHAR(SUM(COORD_ACT_ABORTED_TOTAL)),1,11) AS ACTSABORTED,
       SUBSTR(CHAR(MAX(CONCURRENT_ACT_TOP)),1,6) AS ACTSHW,
       CAST(CASE WHEN SUM(COORD_ACT_COMPLETED_TOTAL) = 0 THEN 0
                 ELSE SUM(COORD_ACT_COMPLETED_TOTAL * COORD_ACT_LIFETIME_AVG)
                 / SUM(COORD_ACT_COMPLETED_TOTAL) END / 1000 AS DECIMAL(9,3))
       AS ACTAVGLIFETIME
FROM TABLE(WLM_GET_SERVICE_SUBCLASS_STATS('', '', -2)) AS SCSTATS
GROUP BY SERVICE_SUPERCLASS_NAME, SERVICE_SUBCLASS_NAME
ORDER BY SUPERCLASS_NAME, SUBCLASS_NAME
```

```
SUPERCLASS_NAME     SUBCLASS_NAME      ACTSCOMPLETED ACTSABORTED ACTSHW ACTAVGLIFETIME
------------------- ------------------ ------------- ----------- ------ --------------
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 20            0           1               3.750
SUP1                SUB1               40            0           8               7.223
```

In the preceding example data, the SUB1 service subclass in the SUP1 service superclass is running more simultaneous activities than usual. To investigate further, you might want to examine the statistics for workloads that map to this service class. Your query might resemble the following one:

```
SELECT SUBSTR(WLSTATS.WORKLOAD_NAME,1,22) AS WL_NAME,
       SUBSTR(CHAR(WLSTATS.MEMBER),1,4) AS MEMB,
       CONCURRENT_WLO_TOP AS WLO_HIGH_WTRMRK,
       CONCURRENT_WLO_ACT_TOP AS WLO_ACT_HIGH_WTRMRK
FROM TABLE(WLM_GET_WORKLOAD_STATS('', -2)) AS WLSTATS,
     TABLE(WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES('', '', -2)) AS SCWLOS
WHERE WLSTATS.WORKLOAD_NAME = SCWLOS.WORKLOAD_NAME
AND SCWLOS.SERVICE_SUPERCLASS_NAME = 'SUP1'
AND SCWLOS.SERVICE_SUBCLASS_NAME = 'SUB1'
ORDER BY WL_NAME, MEMB;

WL_NAME                MEMB WLO_HIGH_WTRMRK WLO_ACT_HIGH_WTRMRK
---------------------- ---- --------------- -------------------
LYNNSALES                 0               2                   8
LYNNSALES                 1               0                   0
SYSDEFAULTUSERWORKLOAD    0               1                   1
SYSDEFAULTUSERWORKLOAD    1               0                   0
```

The output shows that an application in the LYNNSALES workload submitted 8 activities concurrently. Consider adding a threshold to restrict concurrency of coordinator activities for each workload occurrence.

Scenario: Aggregation of activity metrics across child activities

Each row in an activity event monitor contains information and monitor metrics describing the execution of a specific activity. Included in the activity information are the **parent_uow_id** and **parent_activity_id** monitor elements. These monitor elements are nonzero if the activity is a child of some other activity (nested) and the elements identify the parent activity.

Using recursive SQL, it is possible to aggregate the monitor metrics in the activity event monitor across all child activities to their parent activity. Viewing the aggregated metrics for the parent is useful in identifying which parts of a stored procedure may benefit from tuning. For example, if a stored procedure P1 calls stored procedures P2 and P3, the aggregated metrics might show that 90% of the CPU usage during a call to P1 occurs during the processing of statements in the nested procedure P3. As a result, you can focus your investigation accordingly.

You can use the following as an example of how to obtain aggregates of nested metrics from an activity event monitor.

Note: The @ character is used as a statement termination character in this example. The following statements can be copied to a file (for example, `test.clp`) and executed using `db2 -td@ -f` *filename*, as shown in the following example command:

```
db2 -td@ -f test.clp
```

For the purpose of this example, suppose the following tables and stored procedures exist:

```
CREATE TABLE T1 (ONE INT)@

DROP PROCEDURE TEST.P1@
DROP PROCEDURE TEST.P2@
DROP PROCEDURE TEST.P3@
DROP PROCEDURE TEST.P4@

CREATE PROCEDURE TEST.P4()
LANGUAGE SQL
BEGIN
  INSERT INTO T1 VALUES(5);
  INSERT INTO T1 VALUES(6);
  INSERT INTO T1 VALUES(7);
END@

CREATE PROCEDURE TEST.P3()
LANGUAGE SQL
BEGIN
  DECLARE V INTEGER;

  INSERT INTO T1 VALUES(1);
  CALL TEST.P4();
  SELECT COUNT(*) INTO V FROM T1;
END@

CREATE PROCEDURE TEST.P2()
LANGUAGE SQL
BEGIN
  INSERT INTO T1 VALUES(2);
  INSERT INTO T1 VALUES(3);
END@

CREATE PROCEDURE TEST.P1()
LANGUAGE SQL
```

```
BEGIN
  CALL TEST.P3();
  CALL TEST.P2();
  INSERT INTO T1 VALUES(4);
END@
```

Procedure

1. Create an activity event monitor and enable activity capture. In this example, activity capture is enabled for the current connection using the WLM_SET_CONN_ENV procedure. Execute the TEST.P1 procedure using the same connection and then disable the activity event monitor. Activity information will be captured for the TEST.P1 procedure and all of its child activities.

   ```
   CREATE EVENT MONITOR A FOR ACTIVITIES WRITE TO TABLE@
   SET EVENT MONITOR A STATE 1@

   CALL WLM_SET_CONN_ENV(NULL, '<collectactdata>WITH DETAILS</collectactdata>
   <collectactpartition>ALL</collectactpartition>')@

   CALL TEST.P1()@

   SET EVENT MONITOR A STATE 0@

   CALL WLM_SET_CONN_ENV(NULL, '<collectactdata>NONE</collectactdata>')@
   ```
2. Execute the following query to display the captured statements, along with their parent identification information, individual CPU consumption, and aggregate CPU consumption. The aggregate CPU consumption is recursively summed across all child activities. This query can be easily extended to support any of the monitoring metrics captured by the activity event monitor.

   Note: To improve readability, only CPU consumption is reported here.

```
WITH ACT( APPL_ID,
          UOW_ID,
          ACTIVITY_ID,
          PARENT_UOW_ID,
          PARENT_ACTIVITY_ID,
          CPU )
  AS ( SELECT APPL_ID,
              UOW_ID,
              ACTIVITY_ID,
              MAX(PARENT_UOW_ID),
              MAX(PARENT_ACTIVITY_ID),
              SUM(METRICS.TOTAL_CPU_TIME)
        FROM ACTIVITY_A AS A,
            XMLTABLE (XMLNAMESPACES( DEFAULT 'http://www.ibm.com/xmlns/prod/db2/mon'),
                '$actmetrics/activity_metrics' PASSING XMLPARSE(DOCUMENT A.DETAILS_XML) as "actmetrics"
                COLUMNS
                  TOTAL_CPU_TIME BIGINT PATH 'total_cpu_time' ) AS METRICS
        WHERE A.PARTIAL_RECORD = 0
        GROUP BY APPL_ID,
                UOW_ID,
                ACTIVITY_ID ),
    TMP( BASE_APPL_ID,
          BASE_UOW_ID,
          BASE_ACTIVITY_ID,
          APPL_ID,
          UOW_ID,
          ACTIVITY_ID,
          PARENT_UOW_ID,
          PARENT_ACTIVITY_ID,
          CPU,
          LEVEL )
  AS ( SELECT APPL_ID,
```

```
              UOW_ID,
              ACTIVITY_ID,
              APPL_ID,
              UOW_ID,
              ACTIVITY_ID,
              PARENT_UOW_ID,
              PARENT_ACTIVITY_ID,
              CPU,
              1
        FROM ACT
      UNION ALL
        SELECT T.BASE_APPL_ID,
              T.BASE_UOW_ID,
              T.BASE_ACTIVITY_ID,
              A.APPL_ID,
              A.UOW_ID,
              A.ACTIVITY_ID,
              A.PARENT_UOW_ID,
              A.PARENT_ACTIVITY_ID,
              A.CPU,
              T.LEVEL + 1
        FROM ACT AS A, TMP AS T
        WHERE A.APPL_ID = T.APPL_ID AND
              A.PARENT_UOW_ID = T.UOW_ID AND
              A.PARENT_ACTIVITY_ID = T.ACTIVITY_ID AND
              T.LEVEL < 128 ),
    AGG( APPL_ID,
          UOW_ID,
          ACTIVITY_ID,
          CPU )
  AS ( SELECT BASE_APPL_ID,
              BASE_UOW_ID,
              BASE_ACTIVITY_ID,
              SUM(CPU)
        FROM TMP
        GROUP BY BASE_APPL_ID,
                BASE_UOW_ID,
                BASE_ACTIVITY_ID )
SELECT
      A.UOW_ID,
      A.ACTIVITY_ID,
      A.PARENT_UOW_ID,
      A.PARENT_ACTIVITY_ID,
      A.CPU AS STMT_CPU,
      B.CPU AS AGG_CPU,
      SUBSTR(CONCAT(REPEAT('  ',C.STMT_NEST_LEVEL),
              C.STMT_TEXT),
              1, 30) AS STMT_TEXT
FROM ACT AS A,
    AGG AS B,
    ACTIVITYSTMT_A AS C,
    ACTIVITY_A AS D
WHERE A.APPL_ID = B.APPL_ID AND
      A.UOW_ID = B.UOW_ID AND
      A.ACTIVITY_ID = B.ACTIVITY_ID AND
      D.COORD_PARTITION_NUM = D.PARTITION_NUMBER AND
      A.APPL_ID = C.APPL_ID AND
      A.UOW_ID = C.UOW_ID AND
      A.ACTIVITY_ID = C.ACTIVITY_ID AND
      A.APPL_ID = D.APPL_ID AND
      A.UOW_ID = D.UOW_ID AND
      A.ACTIVITY_ID = D.ACTIVITY_ID AND
      D.PARTIAL_RECORD = 0
ORDER BY D.TIME_CREATED ASC@
```

This query produces the following output. The STMT_CPU column reports the CPU consumption for the statement without including CPU usage of any child activities. The AGG_CPU column reports the aggregate CPU consumption for the activity and all of its children.

Note: If queries execute too quickly to be measurable, STMT_CPU and AGG_CPU might be zero.

```
UOW_ID      ACTIVITY_ID          PARENT_UOW_ID PARENT_ACTIVITY_ID   STMT_CPU             AGG_CPU              STMT_TEXT
----------- -------------------- ------------- -------------------- -------------------- -------------------- -------------------------------
        576                    1             0                    0                 5353                84064 CALL TEST.P1()
        576                    2           576                    1                 7444                52043 CALL TEST.P3()
        576                    3           576                    2                 1869                 1869 INSERT INTO T1 VALUES(1)
        576                    4           576                    2                11727                26935 CALL TEST.P4()
        576                    5           576                    4                 2017                 2017 INSERT INTO T1 VALUES(5)
        576                    6           576                    4                 6602                 6602 INSERT INTO T1 VALUES(6)
        576                    7           576                    4                 6589                 6589 INSERT INTO T1 VALUES(7)
        576                    8           576                    2                15795                15795 SELECT COUNT(*) INTO :HV00
        576                    9           576                    1                11727                20314 CALL TEST.P2()
        576                   10           576                    9                 1941                 1941 INSERT INTO T1 VALUES(2)
        576                   11           576                    9                 6646                 6646 INSERT INTO T1 VALUES(3)
        576                   12           576                    1                 6354                 6354 INSERT INTO T1 VALUES(4)

  12 record(s) selected.
```

Scenario: Identifying activities that are taking too long to complete

Workload management table functions simplify the task of identifying a specific activity inside the data server and, if necessary, canceling it without having to end the entire application.

Identifying an activity that is taking too long to complete

Following is an example of identifying a long-running query. Assume that a user from the Sales department who is running the SalesReport application complains that the application is taking too long to complete.

After identifying the application handle, use the WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES table function to look up all activities currently running in this application. For example, if the application handle is 1, your query might resemble the following one:

```
SELECT SUBSTR(CHAR(COORD_MEMBER),1,5) AS COORD,
       SUBSTR(CHAR(MEMBER),1,4) AS MEMB,
       SUBSTR(CHAR(UOW_ID),1,5) AS UOWID,
       SUBSTR(CHAR(ACTIVITY_ID),1,5) AS ACTID,
       SUBSTR(CHAR(PARENT_UOW_ID),1,8) AS PARUOWID,
       SUBSTR(CHAR(PARENT_ACTIVITY_ID),1,8) AS PARACTID,
       SUBSTR(ACTIVITY_TYPE,1,8) AS ACTTYPE,
       SUBSTR(CHAR(NESTING_LEVEL),1,7) AS NESTING
   FROM TABLE(WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES(1, -2))
       AS WLOACTS
   ORDER BY MEMB, UOWID, ACTID

COORD MEMB UOWID ACTID PARUOWID PARACTID ACTTYPE NESTING
----- ---- ----- ----- -------- -------- -------- -------
    0    0     2     3        -        -     CALL       0
    0    0     2     5        2        3 READ_DML       1
```

The activity is identified as having a unit of work ID of 2 and an activity ID of 5. You can then use the WLM_GET_SERVICE_CLASS_AGENTS table function to discover what the agents that work on this activity are doing:

```
SELECT APPLICATION_HANDLE, UOW_ID, ACTIVITY_ID,
       SUBSTR(REQUEST_TYPE,1,8) AS REQUEST_TYPE,
       SUBSTR(EVENT_TYPE,1,8) AS EVENT_TYPE,
       SUBSTR(EVENT_OBJECT,1,8) AS EVENT_OBJECT
```

```
   FROM TABLE(WLM_GET_SERVICE_CLASS_AGENTS('', '', CAST(NULL AS BIGINT),-2))
       AS AGENTS
   WHERE APPLICATION_HANDLE = 1
   AND UOW_ID = 2
   AND ACTIVITY_ID = 5
```

For example, the activity might be queued, executing, or waiting on a lock. If the activity were queued, the result would be:

```
APPLICATION_HANDLE UOW_ID ACTIVITY_ID REQUEST_TYPE EVENT_TYPE EVENT_OBJECT
------------------ ------ ----------- ------------ ---------- ------------
                 1      2           5         OPEN       WAIT    WLM_QUEUE
```

If the activity were executing, the result would be:

```
APPLICATION_HANDLE UOW_ID ACTIVITY_ID REQUEST_TYPE EVENT_TYPE EVENT_OBJECT
------------------ ------ ----------- ------------ ---------- ------------
                 1      2           5          OPEN   PROCESS      REQUEST
```

If the activity were waiting on a lock, the result would be:

```
APPLICATION_HANDLE UOW_ID ACTIVITY_ID REQUEST_TYPE EVENT_TYPE EVENT_OBJECT
------------------ ------ ----------- ------------ ---------- ------------
                 1      2           5         OPEN    ACQUIRE         LOCK
```

When you know what the activity is doing, you can proceed appropriately:

- If the activity is queued, if the user indicates that the query is taking so long that they no longer care about the results, or you think the query is consuming too many resources, you can cancel it.
- If the activity is important and it is queued, consider cancelling some other less important work that is currently running (reducing the concurrency so that activities leave queue), or maybe the user will be satisfied to know that work is not hanging and is just waiting for chance to run.
- If the activity is waiting for a lock, you can use the snapshot monitor to investigate which locks the application is waiting for.
- If the activity is waiting for a lock held by lower priority activity, consider cancelling that activity.

You might also find it useful to know the DML statement that activity 5 is running. Assuming that you have an active activities event monitor, you can run the WLM_CAPTURE_ACTIVITY_IN_PROGRESS procedure to capture information about the DML statement and other information about activity 5 while it is running. Unlike the statement event monitor, the WLM_CAPTURE_ACTIVITY_IN_PROGRESS procedure permits you to capture information about a specific query, as opposed to every statement running at the time. You can also obtain the statement text by using MON_GET_ACTIVITY_DETAILS.

If you decide that you must cancel the activity, you can use the WLM_CANCEL_ACTIVITY routine to cancel the activity without having to end the application that issued it:

```
CALL WLM_CANCEL_ACTIVITY (1, 2, 5)
```

The application that issued the activity receives an SQL4725N error. Any application that handles negative SQL codes is able to handle this SQL code.

Identifying an activity hang caused by lock contention

Assume that you have a situation in which a user is complaining about an application that is taking too long. Also assume that you have either the application name or the authorization ID of the long-running application. With this information, you can use the **LIST APPLICATIONS** command to obtain the application handle. Assuming that application handle returned by the **LIST APPLICATIONS** command is 2, you can use the WLM_GET_SERVICE_CLASS_AGENTS table function to determine which agents are working on this activity. Your query might resemble the following one:

```
SELECT SUBSTR(CHAR(APPLICATION_HANDLE),1,7) AS APPHANDLE,
       SUBSTR(CHAR(MEMBER),1,4) AS MEMB,
       SUBSTR(CHAR(AGENT_TID),1,9) AS AGENT_TID,
       SUBSTR(AGENT_TYPE,1,11) AS AGENTTYPE,
       SUBSTR(EVENT_OBJECT,1,11) AS EVENTOBJECT,
       SUBSTR(REQUEST_TYPE,1,7) AS REQTYPE,
       SUBSTR(CHAR(UOW_ID),1,6) AS UOW_ID,
       SUBSTR(CHAR(ACTIVITY_ID),1,6) AS ACT_ID
   FROM TABLE(WLM_GET_SERVICE_CLASS_AGENTS('', '', 2, -2)) AS SCDETAILS
   ORDER BY APPHANDLE, MEMB, AGENT_TID

APPHANDLE MEMB AGENT_TID AGENTTYPE   EVENTOBJECT  REQTYPE UOW_ID ACT_ID
--------- ---- --------- ----------- -----------  ------- ------ ------
2         0    1         COORDINATOR REQUEST      OPEN    2      1
2         1    3         SUBAGENT    LOCK         -       2      1
```

The results indicate that agent 1 is waiting on a remote response. Looking at the agent on the remote member that is working on the same activity, the EVENTOBJECT field indicates that the agent is waiting to obtain a lock.

The next step is to determine who owns the lock. You can obtain this information by turning on the monitor switches and using the snapshot monitor table function, as shown in the following example:

```
SELECT AGENT_ID AS WAITING_FOR_LOCK,
       SUBSTR(APPL_ID_HOLDING_LK,1,40) AS HOLDING_LOCK,
       CAST(LOCK_MODE_REQUESTED AS SMALLINT) AS WANTED,
       CAST(LOCK_MODE AS SMALLINT) AS HELD
   FROM TABLE(SNAPSHOT_LOCKWAIT('SAMPLE',-1)) AS SLW

WAITING_FOR_LOCK     HOLDING_LOCK                             WANTED HELD
-------------------- ---------------------------------------- ------ ------
                   2 *LOCAL.DB2.060131021547                       9      5
```

You can also determine the lock owner by using the following sequence of commands:

```
db2pd -db *database alias* -locks
db2pd –db *database alias* -transactions
```

If you want to cancel the long-running activity, you can use the WLM_CANCEL_ACTIVITY procedure. If the successful completion of the long-running application is more important than the successful completion of the lock-owning application, you can force the lock-owning application.

Scenario: How to cancel activities queued for more than an hour

Using the example scripts described here, you can create a procedure to cancel activities that have been queued for more than an hour. In addition, an example script is provided that can be used to schedule the queued-activity-cancelling procedure to run every 10 minutes using the DB2 Administrative Task Scheduler.

The queued-activity-cancelling procedure also captures information about the cancelled activities (if an activity event monitor is active), and maintains a small history table of cancelled activities. Both of these informational components are optional and comments in the example script indicate where to comment out the components, if they are not required.

The statements contained in the example procedure are themselves activities and subject to threshold control (depending on how thresholds are configured on your system). Consider running the example queued-activity-cancelling procedure in a service class that does not have any queuing thresholds applied.

1. Copy the following example script, that creates the procedure to cancel activities queued for more than 1 hour, into a file you have created (for example, a file named `x.clp`):

```
-- Simple history table to track cancelled
-- activities

CREATE TABLE SAMPLE.CANCELED_ACTIVITIES(
   APPLICATION_HANDLE BIGINT,
   UOW_ID BIGINT,
   ACTIVITY_ID BIGINT )@

-- Cancel any activities that have been queued
-- for more than 1 hour

CREATE PROCEDURE SAMPLE.CANCEL_QUEUED_ACTIVITIES()
  LANGUAGE SQL
  BEGIN
     DECLARE APPHANDLE   BIGINT;
     DECLARE UOWID       BIGINT;
     DECLARE ACTIVITYID  BIGINT;
     DECLARE QUEUETIME   BIGINT;
     DECLARE AT_END      INT DEFAULT 0;

     DECLARE QUEUEDAPPS CURSOR WITH HOLD FOR SELECT APPLICATION_HANDLE,
         UOW_ID, ACTIVITY_ID
         FROM TABLE(WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES(NULL,-2)) AS T
         WHERE ACTIVITY_STATE = 'QUEUED' AND LOCAL_START_TIME IS NULL;

     DECLARE QTIMECUR CURSOR FOR SELECT TIMESTAMPDIFF(8, CHAR
         (CURRENT TIMESTAMP - TIMESTAMP(VALUE)))
         FROM TABLE(WLM_GET_ACTIVITY_DETAILS(APPHANDLE ,
         UOWID ,  ACTIVITYID , -2)) AS T WHERE NAME = 'ENTRY_TIME';

     DECLARE CONTINUE HANDLER FOR NOT FOUND
        SET AT_END = 1;

     -- Ignore errors for activity not found and activity event
     -- monitor does not exist.
     DECLARE CONTINUE HANDLER FOR SQLSTATE '5U035', SQLSTATE '01H53'
        BEGIN
        END;

     -- Find all activities that are queued by WLM
     -- thresholds where (ACTIVITY_STATE = 'QUEUED')
     OPEN QUEUEDAPPS;
     FETCH QUEUEDAPPS INTO APPHANDLE, UOWID, ACTIVITYID;

     WHILE AT_END = 0 DO

     -- Now use activity entry time to estimate the time spend queued.
     -- Queuing occurs before an activity begins execution, so queue
     -- time is approximated using current time - entry time
        OPEN QTIMECUR;
        FETCH QTIMECUR INTO QUEUETIME;
        CLOSE QTIMECUR;

        IF ( QUEUETIME >= 1 ) THEN

     -- Optional: Insert a record into a table to record the
     -- cancellation of the statement (for monitoring purposes, to
     -- understand how many statements were cancelled). Modify this
     -- insert as required to capture more info such as the name of
     -- the application that submitted the cancelled query. Comment out
     -- these 2 lines if the monitoring is not important to you.
        INSERT INTO SAMPLE.CANCELED_ACTIVITIES VALUES ( APPHANDLE,
                       UOWID, ACTIVITYID );

     -- Optional: Send details about activity to any activity activities
     -- event monitor before cancelling. Comment out
     -- this line if you don't care about the details of the
     -- statements that were cancelled
        CALL WLM_CAPTURE_ACTIVITY_IN_PROGRESS( APPHANDLE, UOWID,
            ACTIVITYID );

     -- Cancel the activity
        CALL WLM_CANCEL_ACTIVITY( APPHANDLE, UOWID, ACTIVITYID );

     -- Explicit commit, required for the insert statement above. The
     -- admin task scheduler will not perform a commit. Comment out this
     -- line if the insert statement is removed.
        COMMIT;

        END IF;

        FETCH QUEUEDAPPS INTO APPHANDLE, UOWID, ACTIVITYID;

     END WHILE;

     CLOSE QUEUEDAPPS;

  END@
```

2. Create the queued-activity-cancelling procedure by executing script `x.clp` using the following command:

   ```
   db2 -td@ -f x.clp
   ```

3. Execute the queued-activity-cancelling procedure by issuing the following command:

   ```
   db2 "call sample.cancel_queued_activities()"
   ```

   Any activities that have been queued for more than 1 hour will be cancelled.

4. The following example script schedules the queued-activity-cancelling procedure to run every 10 minutes using the DB2 Administrative Task Scheduler. Copy the example script into a file you have created (for example, a file named `y.clp`):

   ```
   ---------------------------------------
   -- Enable DB2 Admin Task Scheduler if
   -- not already enabled.
   ---------------------------------------

   !db2set DB2_ATS_ENABLE=YES@

   ---------------------------------------
   -- Create SYSTOOLSPACE tablespace.
   -- Enable if SYSTOOLSPACE does not already
   -- exist on your database.
   ---------------------------------------

   -- CREATE TABLESPACE SYSTOOLSPACE IN IBMCATGROUP MANAGED BY AUTOMATIC STORAGE
   -- EXTENTSIZE 4@
   ```

```
---------------------------------------
-- Add a task to automatically cancel
-- activities that have been queued
-- for more than 1 hour. Task is scheduled
-- to run every 10 minutes. Adjust the
-- schedule as necessary using the
-- schedule input parameter (specified in
-- cron format).
---------------------------------------

CALL SYSPROC.ADMIN_TASK_ADD(
   'CANCEL ACTIVITIES QUEUED FOR MORE 1 HOUR',
   NULL,
   NULL,
   NULL,
   '*/10 * * * *',
   'SAMPLE',
   'CANCEL_QUEUED_ACTIVITIES',
   NULL,
   NULL,
   NULL )@
```

5. Schedule the queued-activity-cancelling procedure to run every 10 minutes by executing script `y.clp` using the following command:

   ```
   db2 -td@ -f y.clp
   ```

Scenario: Identifying activities with low estimated cost and high runtime

The following example shows how you can use work classes, work action sets, thresholds, and activity collection to identify activities that have a low estimated cost but a high runtime. This situation could indicate that the estimated cost (in timerons) is inaccurate because of out-of-date table and index statistics.

The first step is to create a work class set with a work class that will be used to identify activities with a low estimated cost. For example:

```
CREATE WORK CLASS SET WCS1
(WORK CLASS SMALLDML WORK TYPE DML FOR TIMERONCOST FROM 0 TO 500)
```

Then, you would create a database work action set with a work action that applies an activity-total-time threshold to the SMALLDML work class. The threshold action is CONTINUE and the COLLECT ACTIVITY DATA option is specified so that an activity that violates the threshold is sent to the activities event monitor on completion:

```
CREATE WORK ACTION SET WAS1 FOR DATABASE USING WORK CLASS SET WCS1
(WORK ACTION WA1 ON WORK CLASS SMALLDML WHEN ACTIVITYTOTALTIME > 15 MINUTES
COLLECT ACTIVITY DATA WITH DETAILS CONTINUE)
```

Finally, you would create and activate a threshold violations event monitor and an activities event monitor:

```
CREATE EVENT MONITOR THVIOLATIONS FOR THRESHOLD VIOLATIONS WRITE TO TABLE
SET EVENT MONITOR THVIOLATIONS STATE 1

CREATE EVENT MONITOR DB2ACTIVITIES FOR ACTIVITIES WRITE TO TABLE
SET EVENT MONITOR DB2ACTIVITIES STATE 1
```

Now when a DML activity with an estimated cost of less than 500 timerons runs for greater than 15 minutes, a threshold violation record is written to the THVIOLATIONS event monitor (indicating that the total time threshold was violated), and details about the DML activity are collected when the activity completes and sent to the DB2ACTIVITIES event monitor. You can use the information collected about the activity in the DB2ACTIVITIES event monitor to investigate further. For example, you can run the EXPLAIN statement on the query and examine the access plan. You should also consider the system load and queuing at the time the activity was collected, as a long lifetime can be a result of insufficient system resources or the activity being queued. The long lifetime does not necessarily indicate out-of-date statistics.

Scenario: Cancelling all activities being executed in a service subclass

The following is an example of a stored procedure that can be used to cancel all currently executing activities in a particular service subclass.

To create the CANCELALL procedure, execute the following steps:

1. Copy the following CREATE PROCEDURE statement to a file (for example, `cancelall.ddl`):

   ```
   CREATE PROCEDURE CANCELALL ( IN INSCID BIGINT )
           SPECIFIC CANCELALL
           LANGUAGE SQL
   BEGIN
      DECLARE SQLSTATE CHAR(5) DEFAULT '00000';
      DECLARE APPHNDL BIGINT;
      DECLARE UOWID INTEGER;
      DECLARE ACTIVITYID INTEGER;

      DECLARE C1 CURSOR FOR  (SELECT APPLICATION_HANDLE,
           UOW_ID, ACTIVITY_ID
           FROM TABLE(SYSPROC.WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES
                                                    ( NULL, -2 ))
           AS T WHERE T.SERVICE_CLASS_ID = INSCID);

      DECLARE CONTINUE HANDLER FOR SQLEXCEPTION
        BEGIN
        END;
      OPEN C1;

      FETCH_LOOP:
        LOOP

      FETCH C1 INTO APPHNDL, UOWID, ACTIVITYID;

      IF (SQLSTATE <> '00000')
      THEN LEAVE FETCH_LOOP;
      END IF;

      CALL WLM_CANCEL_ACTIVITY( APPHNDL, UOWID, ACTIVITYID );

      END LOOP FETCH_LOOP;

   END@
   ```

2. Run the following CLP command:

   ```
   db2 -td@ -f cancelall.ddl
   ```

After the procedure has been created, execute the procedure (for example, cancelling all activities in the service subclass which has ID = 15) using the following statement:

```
CALL CANCELALL( 15 )
```

Note: The CANCELALL procedure must be run in a different service subclass from the target that is passed as input, otherwise the procedure will cancel itself.

Scenario: Disconnecting all applications either mapped to or executing activities in a service class

The following is an example of a stored procedure that can be used to disconnect (force) all applications that are either mapped to a particular service class or currently executing activities in a particular service class.

To create the FORCEALLINSC procedure, execute the following steps:

1. Copy the following CREATE PROCEDURE statement to a file (for example, `forceall.ddl`):

```
CREATE PROCEDURE FORCEALLINSC ( IN INSCID BIGINT )
        SPECIFIC FORCEALLINSC
        LANGUAGE SQL
BEGIN
   DECLARE SQLSTATE CHAR(5) DEFAULT '00000';
   DECLARE APPHNDL BIGINT;
   DECLARE UOWID INTEGER;
   DECLARE ACTIVITYID INTEGER;

   DECLARE C1 CURSOR FOR  (SELECT APPLICATION_HANDLE
        FROM TABLE(SYSPROC.WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES
                                                     ( NULL, -2 ))
        AS T WHERE T.SERVICE_CLASS_ID = INSCID);


   DECLARE C2 CURSOR FOR  (SELECT APPLICATION_HANDLE
        FROM TABLE(SYSPROC.WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES
                                                     (NULL,NULL, -2 ))
        AS T, SYSCAT.SERVICECLASSES AS S
        WHERE T.SERVICE_SUPERCLASS_NAME = S.PARENTSERVICECLASSNAME AND
        T.SERVICE_SUBCLASS_NAME = S.SERVICECLASSNAME AND
        S.SERVICECLASSID = INSCID);

   DECLARE CONTINUE HANDLER FOR SQLEXCEPTION
     BEGIN
     END;

-- First force any applications that have an activity running in
-- the specified service class

   OPEN C1;

   FETCH_LOOP:
     LOOP

   FETCH C1 INTO APPHNDL;

   IF (SQLSTATE <> '00000')
   THEN LEAVE FETCH_LOOP;
   END IF;

   CALL ADMIN_CMD( 'FORCE APPLICATION (' || CHAR(APPHNDL) || ')' );

   END LOOP FETCH_LOOP;

-- Now force any connections that are mapped to the service class, but which
-- don't currently have any activities running

   OPEN C2;
```

```
FETCH_LOOP2:
  LOOP

FETCH C2 INTO APPHNDL;

IF (SQLSTATE <> '00000')
THEN LEAVE FETCH_LOOP2;
END IF;

CALL ADMIN_CMD( 'FORCE APPLICATION (' || CHAR(APPHNDL) || ')' );

END LOOP FETCH_LOOP2;

END@
```

2. Run the following CLP command:

```
db2 -td@ -f forceall.ddl
```

After the procedure has been created, execute the procedure (for example, disconnecting all applications that are either mapped to or currently executing activities in a particular service class with ID = 15) using the following statement:

```
CALL FORCEALLINSC( 15 )
```

Note: The FORCEALLINSC procedure must be run in a different service class from the target that is passed as input, otherwise the procedure will cancel itself.

Scenario: Tuning a DB2 workload management configuration when capacity planning data is available

If you performed capacity planning, you should have information about the types of users and their expected response times. You can use this information to construct, determine the effectiveness of, and tune your DB2 workload management configuration.

Assume that you performed capacity planning and that the data in the following table represents the results of this exercise for work types and response time goals:

Table 63. Results of capacity planning

Type of work	Application	Goal	Importance	Expected throughput
Order entry	`orderentryapp.exe`	Obtain an average response time < 1 second	High	10 000 (both inserts and updates) per day
Business intelligence queries	`businessobjects.exe`	Obtain an average response time < 10 seconds	High	100 queries per day
Batch processing	`batchapp.exe`	Maximize throughput	Low	5000 updates per day
Other	All other applications	Best effort	Low	100 activities per day

Based on the data in the preceding table, you might create three service classes (ORDER_ENTRY_SC, BI_QUERIES_SC, and BATCH_SC) and three workloads (ORDER_ENTRY_WL, BI_QUERIES_WL, and BATCH_WL) to assign work to the service classes. After creating the service classes and workloads, you might create a statistics event monitor to collect aggregate activity information, such as the activity lifetime histogram for each service class. Assume that the data in the following table compares the average daily count of activities in each service class (computed from the activity lifetime histogram) with the volumes that were predicted in the capacity planning exercise:

Table 64. Activities each day

Service class	Predicted activities per day	Actual activities per day
ORDER_ENTRY_SC	10 000	9700
BI_QUERIES_SC	100	115
BATCH_SC	5000	5412
SYSDEFAULTUSERCLASS	100	85

The observed data indicates that the capacity planning estimates were accurate. The data in the following table compares the average activity lifetimes (obtained from the activity lifetime histogram) with the response time goals determined during capacity planning and shows that activities in the BI_QUERIES_SC service class are not meeting their response time objectives.

Table 65. Response times

Service class	Response time goal	Actual average lifetime
ORDER_ENTRY_SC	< 1 second	0.8 seconds
BI_QUERIES_SC	< 10 seconds	30 seconds
BATCH_SC		2 seconds
SYSDEFAULTUSERCLASS		10 minutes

With DB2 workload management, you can use different approaches when addressing the problem of the business intelligence queries not meeting their response time goals:

- Limiting the concurrency of lower-importance service classes
- Allowing the operating system workload manager to provide less processor resource to less-important service classes
- Modifying the agent and I/O prefetcher priorities for the service classes
- Using any combination of the previous three approaches

Assume that processor time is the resource that is causing the business intelligence queries to fail to meet their goals. Also assume that you use the operating system workload manager to give the SYSDEFAULTUSERCLASS service class less processor resources than other service classes. You can then capture aggregate activity information over a period of days to observe whether the changes to the CPU allocation provide the results that you expect. The data in the following table shows another comparison between response time goals and actual average lifetimes computed from the histograms after you made the operating system workload manager changes. All service classes are now meeting their response time objectives and, because of the processor time reallocation, activities in the SYSDEFAULTUSERCLASS service class have had their response times doubled.

Table 66. Response times after reconfiguration

Service class	Response time goal	Actual average lifetime
ORDER_ENTRY_SC	< 1 second	0.6 seconds
BI_QUERIES_SC	< 10 seconds	9.5 seconds
BATCH_SC		1.5 seconds

Table 66. Response times after reconfiguration (continued)

Service class	Response time goal	Actual average lifetime
SYSDEFAULTUSERCLASS		20 minutes

Scenario: Tuning a DB2 workload management configuration when capacity planning information is unavailable

You can use the DB2 workload management tools to help design, monitor, and tune a workload management configuration even if you do not have capacity analysis data to use for designing the configuration.

Assume that you do not initially know which workloads and service classes to create because either you do not have full knowledge of the workload on the system or you do not yet know which workloads are required for stable execution results. Also assume that you know that some applications have response time requirements but that you do not yet know how many other applications are competing for resources with such time-critical applications. You can use the workload management monitoring capabilities to determine this.

To set up a DB2 workload management configuration using monitoring data as the foundation:

1. Classify those applications that you know are important. You must isolate these applications and give them an appropriate portion of the system resources.
2. For the rest of the workload, collect statistics for the largest activities in the workload because these activities have the greatest impact on a per-activity basis on the system.
3. Analyze the activity information that you collected in step 2.
4. Repeat steps 1 through 3 on that portion of the workload that is still unclassified. Repeat this step until you know that the remaining unclassified work is not worth classification.

The sections that follow provide information about how to perform these steps.

Step 1. Isolate those applications that are known to be important and give them an appropriate portion of resources

Assume that you have two important business intelligence applications, `BI1` and `BI2` and that you need to minimize the response times for these applications. You can create workloads for these two applications and map them to a service class called MOSTIMPORTANT for which you can assign system resources.

On the AIX operating system, you use the AIX Workload Manager to create a service class called MOSTIMPORTANT, and give this service class a guaranteed set of resources.

On the DB2 data server, you create the required service classes and workloads:

```
CREATE SERVICE CLASS MOSTIMPORTANT OUTBOUND CORRELATOR 'MOSTIMPORTANT'
CREATE WORKLOAD BI1WORKLOAD APPLNAME ('BI1') SERVICE CLASS MOSTIMPORTANT
CREATE WORKLOAD BI2WORKLOAD APPLNAME ('BI2') SERVICE CLASS MOSTIMPORTANT
```

For the purposes of this example, assume that even after you account for the known applications, a significant portion of the system workload is unaccounted for. You therefore need to better understand and possibly control this workload.

Step 2. For the remaining unclassified workload, collect statistics for the largest activities in the workload

A long-running activity has a greater individual impact on the system than a short-running activity has because the long-running activity occupies system resources for a longer period of time. However, collecting information about a long-running activity imposes no greater overhead than would be imposed by collecting information on a short-running activity. As a result, the best way to collect information on the largest proportion of the workload is to collect information on the longest-running activities first.

Start collecting activity information by first deciding on an activity lifetime above which you collect activity information. You can simplify this task by choosing a portion of the unclassified activities to be collected, such as 30%, and then observing the activity lifetime histogram for these activities. Allow the system to run so that the statistics are updated, then run the WLM_COLLECT_STATS procedure to send the statistics to an active statistics event monitor.

Use the following query to obtain the activity lifetime histogram for the SYSDEFAULTUSERCLASS service class as a table that represents the proportion of the total activities that fell into each lifetime range. This query is written assuming that the database does not have multiple members.

```
WITH TOTAL AS (
SELECT PARENTSERVICECLASSNAME,
       SERVICECLASSNAME,
       HIST.HISTOGRAM_TYPE,
       SUM(NUMBER_IN_BIN) AS NUMBER_IN_BIN
FROM HISTOGRAMBIN_DB2STATISTICS AS HIST,
     SYSCAT.SERVICECLASSES SC
WHERE
     HIST.SERVICE_CLASS_ID = SC.SERVICECLASSID
     AND HIST.TOP >= 0
     AND SC.PARENTSERVICECLASSNAME = 'SYSDEFAULTUSERCLASS'
     AND SC.SERVICECLASSNAME = 'SYSDEFAULTSUBCLASS'
     AND HIST.HISTOGRAM_TYPE = 'CoordActLifetime'
GROUP BY PARENTSERVICECLASSNAME, SERVICECLASSNAME, HISTOGRAM_TYPE)
SELECT CAST(CAST(TOP AS DOUBLE) / 60000 AS DECIMAL(14,3)) AS TOP_IN_MINUTES,
     CAST(100 * CAST(SUM(HIST.NUMBER_IN_BIN) AS DOUBLE) / TOTAL.NUMBER_IN_BIN AS DECIMAL(4,2))
     AS PERCENT_IN_BIN
FROM HISTOGRAMBIN_DB2STATISTICS AS HIST,
     SYSCAT.SERVICECLASSES SC,
     TOTAL
WHERE HIST.SERVICE_CLASS_ID = SC.SERVICECLASSID
      AND HIST.TOP >= 0
      AND TOTAL.NUMBER_IN_BIN > 0
      AND SC.PARENTSERVICECLASSNAME = 'SYSDEFAULTUSERCLASS'
      AND SC.SERVICECLASSNAME = 'SYSDEFAULTSUBCLASS'
      AND HIST.HISTOGRAM_TYPE = 'CoordActLifetime'
      AND TOTAL.PARENTSERVICECLASSNAME = SC.PARENTSERVICECLASSNAME
      AND TOTAL.SERVICECLASSNAME = SC.SERVICECLASSNAME
      AND TOTAL.HISTOGRAM_TYPE = HIST.HISTOGRAM_TYPE
GROUP BY TOP, SC.PARENTSERVICECLASSNAME, SC.SERVICECLASSNAME, HIST.HISTOGRAM_TYPE, TOTAL.NUMBER_IN_BIN;


TOP_IN_MINUTES   PERCENT_IN_BIN
---------------- --------------
           0.000           0.00
           0.000           0.00
           0.000           0.00
           0.000           0.00
           0.000           0.00
           0.000           0.00
     0.000          0.00
     0.000          0.00
     0.000          0.00
     0.001          0.00
     0.001          0.00
     0.002          0.00
     0.004          0.00
     0.006          0.00
     0.009          0.00
     0.014          0.00
     0.021          0.00
     0.033          0.00
     0.050          0.00
     0.077          0.00
     0.118          0.00
     0.180          0.00
     0.274          0.00
     0.419          0.00
     0.639          0.00
     0.975          0.00
     1.488          0.00
     2.269          0.00
     3.462          0.00
     5.280          0.00
     8.054          0.00
    12.286          0.00
    18.740          0.00
    28.584         10.00
    43.600         15.00
    66.505         45.00
   101.442         23.00
   154.731          5.00
   236.015          2.00
   360.000          0.00
```

The following figure shows the results of the preceding query plotted as a graph:

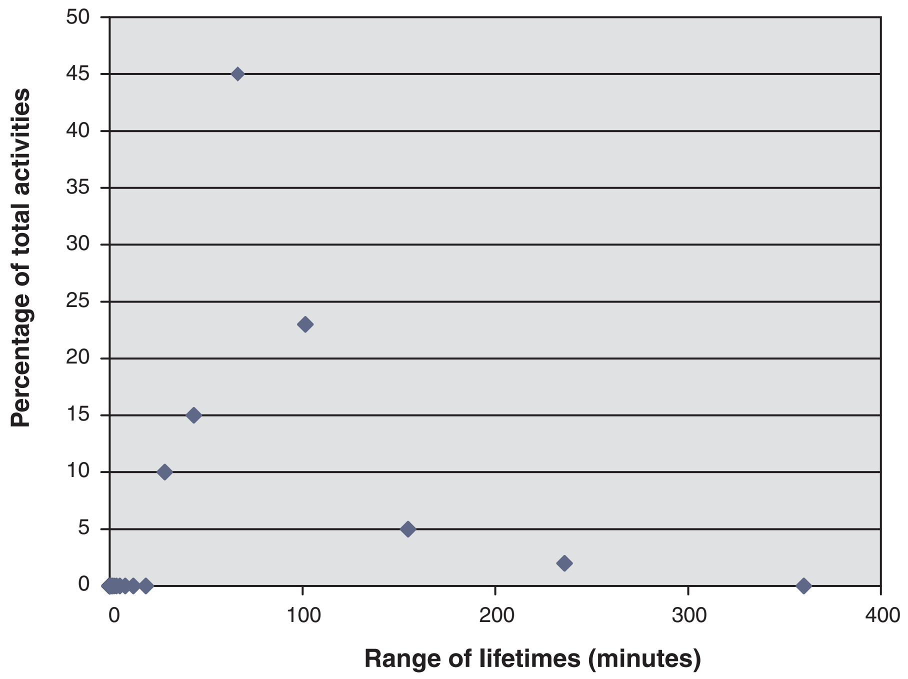


Figure 56. Activity lifetime histogram of unclassified activities

In this example, 30% of the activities fall into the 101 minutes or greater lifetime range. To capture information about these activities, create an activity lifetime threshold of 100 minutes with the CONTINUE and COLLECT ACTIVITY DATA options as shown in the following example. If this threshold is violated, activity information is sent to an active activities event monitor.

```
CREATE THRESHOLD COLLECTLONGESTRUNNING30PERCENT
FOR SERVICE CLASS SYSDEFAULTSUBCLASS UNDER SYSDEFAULTUSERCLASS
ACTIVITIES ENFORCEMENT DATABASE ENABLE
WHEN ACTIVITYTOTALTIME > 100 MINUTES COLLECT ACTIVITY DATA CONTINUE
```

Allow the system to run so that data is collected.

Assuming that the overhead of collecting information on 30% of the longest-running activities is acceptable, you can let the data collection continue for a few hours or a few days. You can use the collected data to determine which users and applications produce the longest running of the 30% of the DML activities that are still unclassified. These activities might include some that are time critical. You might uncover some surprises, such as low-priority applications that run significant numbers of large activities. When you finish collecting and analyzing the data, you can drop the threshold.

Step 3. Analyze the information about activities collected in the previous step

You can analyze the information you collected about activities in the previous step according to the application that submitted them. You might specify the following query:

```
SELECT SUBSTR (APPL_NAME, 1,16) APPLICATION_NAME,
       AVG(TIMESTAMPDIFF(4, CHAR(TIME_COMPLETED – TIME_CREATED)))
       AS AVG_LIFETIME_MINUTES
       COUNT(*) AS ACTIVITY_COUNT
FROM ACTIVITY_DB2ACTIVITIES
GROUP BY APPL_NAME
ORDER BY APPL_NAME

APPLICATION_NAME AVG_LIFETIME_MINUTES ACTIVITY_COUNT
================ ==================== ==============
MOSTLYSMALL1                      120             21
MOSTLYSMALL2                      110             15
UNIMPORTANTAPP                    150          10213
```

An analysis of the activities according to the submitting application shows that a large number of the longest-running activities were submitted by the UNIMPORTANTAPP application, which is a relatively unimportant application. You can use a workload to isolate this application from the other unclassified applications and map it to a service class called BESTEFFORT, which receives resources only when all other activities have their resource needs met.

According to the preceding results, the remaining applications in the default service class appear to submit few large activities. You might find it worthwhile to repeat the process of collecting activities executing in the default service class without restricting the collection to long-running activities.

Step 4. Repeat steps 1 to 3 on that portion of the workload that is still unclassified until the remaining unclassified work is not worth classification

Now that you have the two important applications running in the MOSTIMPORTANT service class and the unimportant application running in the BESTEFFORT service class, much less work is running in the default user service class. In this situation, it might be inexpensive to collect information about every activity in this service class. Alternatively, you might not need to further subdivide the work and can stop here. Assume that you want to collect information about the remaining activities, in case the remaining workload contains surprises. You can accomplish this task by setting COLLECT ACTIVITY DATA for the default user service class and creating an activities event monitor:

```
ALTER SERVICE CLASS SYSDEFAULTSUBCLASS UNDER SYSDEFAULTUSERCLASS
COLLECT ACTIVITY DATA ON COORDINATOR WITHOUT DETAILS
```

Allow the system to run so that data is collected. You can analyze the results as in step 3.

```
SELECT SUBSTR (APPL_NAME,1,16) APPLICATION_NAME,
       AVG(TIMESTAMPDIFF(4, CHAR(TIME_COMPLETED – TIME_CREATED)))
       AS AVG_LIFETIME_MINUTES
       COUNT(*) AS ACTIVITY_COUNT
FROM ACTIVITY_DB2ACTIVITIES
GROUP BY APPL_NAME
ORDER BY APPL_NAME

APPLICATION_NAME AVG_LIFETIME_MINUTES ACTIVITY_COUNT
================ ==================== ==============
MOSTLYSMALL1                        5           1501
MOSTLYSMALL2                        7            124
ONLYSMALL                           2          10123
```

The results show that the ONLYSMALL application produces the majority of the unclassified activities. Because this application was not included in the results when you collected information about the largest activities, you can assume that ONLYSMALL did not produce any large queries during the period of data collection.

Chapter 8. Reference

Procedures and table functions

WLM_CANCEL_ACTIVITY - Cancel an activity

This procedure cancels a given activity. If the cancel takes place, an error message will be returned to the application that submitted the activity that was cancelled.

Syntax

```
►►—WLM_CANCEL_ACTIVITY—(—application_handle—,—uow_id—,—activity_id—)—————►◄
```

The schema is SYSPROC.

Procedure parameters

application_handle
An input argument of type BIGINT that specifies the application handle whose activity is to be cancelled. If the argument is null, no activity will be found and an SQL4702N with SQLSTATE 5U035 is returned.

uow_id
An input argument of type INTEGER that specifies the unit of work ID of the activity that is to be cancelled. If the argument is null, no activity will be found and an SQL4702N with SQLSTATE 5U035 is returned.

activity_id
An input argument of type INTEGER that specifies the activity ID which uniquely identifies the activity within the unit of work that is to be cancelled. If the argument is null, no activity will be found and an SQL4702N with SQLSTATE 5U035 is returned.

Authorization

One of the following authorities is required to execute the routine:

- EXECUTE privilege on the routine
- DATAACCESS authority
- DBADM authority
- SQLADM authority
- WLMADM authority

Default PUBLIC privilege

None

Example

An administrator can use the WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES table function to find the application handle, unit of work ID and activity ID of an activity. To cancel an activity with application handle 1, unit of work ID 2 and activity ID 3:

```
CALL WLM_CANCEL_ACTIVITY(1, 2, 3)
```

Usage notes

- If no activity can be found, an SQL4702N with SQLSTATE 5U035 is returned.
- If the activity cannot be cancelled because it not in the correct state (not initialized), an SQL4703N (reason code 1) with SQLSTATE 5U016 is returned.
- If the activity is successfully cancelled, an SQL4725N with SQLSTATE 57014 is returned to the cancelled application.
- If, at the time of the cancel, the coordinator is processing a request for a different activity or is idle, the activity is placed into CANCEL_PENDING state and will be cancelled when the coordinator processes the next request.

WLM_CAPTURE_ACTIVITY_IN_PROGRESS - Collect activity information for activities event monitor

The WLM_CAPTURE_ACTIVITY_IN_PROGRESS procedure gathers information about a specified activity and writes the information to the active activities event monitor.

When you apply this procedure to an activity with child activities, the procedure recursively generates a record for each child activity. This information is collected and sent when you call the procedure; the procedure does not wait until the parent activity completes execution. The record of the activity in the event monitor is marked as a partial record.

Syntax

```
►►—WLM_CAPTURE_ACTIVITY_IN_PROGRESS—(—application_handle—,——————————————————►

►—uow_id—,—activity_id—)——————————————————————————————————————————————————►◄
```

The schema is SYSPROC.

Procedure parameters

If you do not specify all of the following parameters, no activity is found, and SQL4702N with SQLSTATE 5U035 is returned.

application_handle
: An input argument of type BIGINT that specifies the handle of the application whose activity information is to be captured.

uow_id
: An input argument of type INTEGER that specifies the unit of work ID of the activity whose information is to be captured.

activity_id
: An input argument of type INTEGER that specifies the activity ID that uniquely identifies the activity within the unit of work whose information is to be captured.

Authorization

One of the following authorities is required to execute the routine:

- EXECUTE privilege on the routine

- DATAACCESS authority
- DBADM authority
- SQLADM authority
- WLMADM authority

Default PUBLIC privilege

None

Example

Assume that a user complains that stored procedure MYSCHEMA.MYSLOWSTP seems to be running more slowly than usual. The administrator wants to investigate the cause of the slowdown. Investigating while the stored procedure is running is not practical, so the administrator decides to capture information about the stored procedure activity and all of the activities nested within it.

An event monitor for DB2 activities named DB2ACTIVITIES has been activated. The administrator uses the WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES function to obtain the application handle, unit of work ID and activity ID for the call of this stored procedure. Assuming that the activity is identified by an application handle of 1, a unit of work ID of 2 and an activity ID of 3, the administrator can now issue the call to WLM_CAPTURE_ACTIVITY_IN_PROGRESS as follows:

```
CALL WLM_CAPTURE_ACTIVITY_IN_PROGRESS(1,2,3)
```

After the procedure is completed, the administrator can use the following table function to find out where the activity spent its time. The function retrieves the information from the DB2ACTIVITIES event monitor.

```
CREATE FUNCTION SHOWCAPTUREDACTIVITY(APPHNDL BIGINT,
                                    UOWID INTEGER,
                                    ACTIVITYID INTEGER)
 RETURNS TABLE (UOW_ID INTEGER, ACTIVITY_ID INTEGER, STMT_TEXT VARCHAR(40),
   LIFE_TIME DOUBLE)
 LANGUAGE SQL
 READS SQL DATA
 NO EXTERNAL ACTION
 DETERMINISTIC
 RETURN WITH RAH (LEVEL, APPL_ID, PARENT_UOW_ID, PARENT_ACTIVITY_ID,
         UOW_ID, ACTIVITY_ID, STMT_TEXT, ACT_EXEC_TIME) AS
 (SELECT 1, ROOT.APPL_ID, ROOT.PARENT_UOW_ID,
         ROOT.PARENT_ACTIVITY_ID, ROOT.UOW_ID, ROOT.ACTIVITY_ID,
         ROOTSTMT.STMT_TEXT, ACT_EXEC_TIME
  FROM ACTIVITY_DB2ACTIVITIES ROOT, ACTIVITYSTMT_DB2ACTIVITIES ROOTSTMT
  WHERE ROOT.APPL_ID = ROOTSTMT.APPL_ID AND ROOT.AGENT_ID = APPHNDL
    AND ROOT.UOW_ID = ROOTSTMT.UOW_ID AND ROOT.UOW_ID = UOWID
    AND ROOT.ACTIVITY_ID = ROOTSTMT.ACTIVITY_ID AND ROOT.ACTIVITY_ID = ACTIVITYID
 UNION ALL
  SELECT PARENT.LEVEL +1, CHILD.APPL_ID, CHILD.PARENT_UOW_ID,
         CHILD.PARENT_ACTIVITY_ID, CHILD.UOW_ID,
         CHILD.ACTIVITY_ID, CHILDSTMT.STMT_TEXT, CHILD.ACT_EXEC_TIME
  FROM RAH PARENT, ACTIVITY_DB2ACTIVITIES CHILD,
       ACTIVITYSTMT_DB2ACTIVITIES CHILDSTMT
  WHERE PARENT.APPL_ID = CHILD.APPL_ID AND
        CHILD.APPL_ID = CHILDSTMT.APPL_ID AND
        PARENT.UOW_ID = CHILD.PARENT_UOW_ID AND
        CHILD.UOW_ID = CHILDSTMT.UOW_ID AND
        PARENT.ACTIVITY_ID = CHILD.PARENT_ACTIVITY_ID AND
        CHILD.ACTIVITY_ID = CHILDSTMT.ACTIVITY_ID AND
        PARENT.LEVEL < 64
  )
SELECT UOW_ID, ACTIVITY_ID, SUBSTR(STMT_TEXT,1,40),
                ACT_EXEC_TIME AS
                LIFE_TIME
FROM RAH
```

The following sample query uses the table function:

```
  SELECT * FROM TABLE(SHOWCAPTUREDACTIVITY(1, 2, 3))
    AS ACTS ORDER BY UOW_ID, ACTIVITY_ID
```

Usage notes

If there is no active activities event monitor, an SQL1633W with SQLSTATE 01H53 is returned.

Activity information is collected only on the coordinator member for the activity.

WLM_COLLECT_STATS - Collect and reset workload management statistics

The WLM_COLLECT_STATS procedure gathers statistics for service classes, workloads, work classes, and threshold queues and writes them to the statistics event monitor. The procedure also resets the statistics for service classes, workloads, work classes, and threshold queues. If there is no active statistics event monitor, the procedure only resets the statistics.

Syntax

```
►►──WLM_COLLECT_STATS──(──┬────────────────────────────────┬──)──────────────►◄
                          └─wait──,──statistics_timestamp──┘
```

The schema is SYSPROC.

Procedure parameters

wait
: An optional input argument of type CHAR that specifies whether this procedure returns immediately after initiating a statistics collection and reset. If 'Y' is specified, then the procedure will not return until all statistics have been written and flushed to the statistics event monitor tables. Otherwise, the procedure will return immediately after initiating a statistics collection and reset.

statistics_timestamp
: An optional output argument of type TIMESTAMP that returns the timestamp value for the beginning of the statistics collection.

Authorization

One of the following authorities is required to execute the routine:
- EXECUTE privilege on the routine
- DATAACCESS authority
- DBADM authority
- SQLADM authority
- WLMADM authority

Default PUBLIC privilege

None

Examples

Example 1: Call WLM_COLLECT_STATS to initiate statistics collection and reset.

```
CALL WLM_COLLECT_STATS()
```

The following is an example of output from this query.

```
Return Status = 0
```

Example 2: Call WLM_COLLECT_STATS to collect and reset statistics, but not return until data has been written to statistics event monitor tables

```
CALL WLM_COLLECT_STATS('Y', ::collect_timestamp)
```

The following is an example of output from this query.

```
Return Status = 0
```

Example 3: Call WLM_COLLECT_STATS to collect and reset statistics while another call is in progress.

```
CALL WLM_COLLECT_STATS()
```

The following is an example of output from this query.

```
SQL1632W The collect and reset statistics request was ignored because
another collect and reset statistics request is already in progress.
```

Usage notes

The WLM_COLLECT_STATS procedure performs the same collection operation (send statistics to the active statistics event monitor) and reset operation that occur automatically on the interval defined by the **wlm_collect_int** database configuration parameter.

If you call the procedure while another collection and reset request is in progress (for example, while another invocation of the procedure is running or automatic collection is occurring), SQL1632W with SQLSTATE 01H53 is returned, and your new request is ignored.

In asynchronous mode, the WLM_COLLECT_STATS procedure only starts the collection and reset process. The procedure might return to the caller before all statistics have been written to the active statistics event monitor. Depending on how quickly the statistics collection and reset occur, the call to the WLM_COLLECT_STATS procedure (which is itself an activity) is counted in the statistics for either the prior collection interval or the new collection interval that has just started.

In synchronous mode, the WLM_COLLECT_STATS procedure does not return until the statistics collection is complete and all statistics are written to the tables of any active statistics event monitors. The timestamp at which the statistics collection began is returned via the *statistics_timestamp* output parameter.

WLM_GET_ACTIVITY_DETAILS - Return detailed information about a specific activity

This function returns detailed information about a specific activity identified by its application handle, unit of work ID, and activity ID. This information includes details about any thresholds that the activity has violated.

Note: This table function has been deprecated and replaced by the MON_GET_ACTIVITY_DETAILS table function.

This function returns basic statistics of one or more service subclasses.

Syntax

```
►►──WLM_GET_ACTIVITY_DETAILS──(──application_handle──,──uow_id──,──────────────►

►─activity_id──,──member──)──────────────────────────────────────────────────►◄
```

The schema is SYSPROC.

Table function parameters

application_handle
: An input argument of type BIGINT that specifies a valid application handle. If the argument is null, no rows are returned from this function. If the argument is null, an SQL171N error is returned.

uow_id
: An input argument of type INTEGER that specifies a valid unit of work identifier unique within the application. If the argument is null, no rows are returned from this function. If the argument is null, an SQL171N error is returned.

activity_id
: An input argument of type INTEGER that specifies a valid activity ID unique within the unit of work. If the argument is null, no rows are returned from this function. If the argument is null, an SQL171N error is returned.

member
: An input argument of type INTEGER that specifies a valid member number in the same instance as the currently connected database when calling this function. Specify `-1` for the current database member, or `-2` for all database members. If a null value is specified, `-1` is set implicitly.

Authorization

One of the following authorities is required to execute the routine:
- EXECUTE privilege on the routine
- DATAACCESS authority
- DBADM authority
- SQLADM authority
- WLMADM authority

Default PUBLIC privilege

None

Example

Detailed information about an individual activity can be obtained by using the WLM_GET_ACTIVITY_DETAILS table function. This table function returns activity information as name-value pairs for each member. This example is restricted to showing only an eleven member subset of the name-value pairs for each member for an activity identified by an application handle of 1, a unit of work ID of 1 and an activity ID of 5. For a complete list of name-value pairs, see Table 68 on page 368 and Table 69 on page 369.

```
  SELECT SUBSTR(CHAR(DBPARTITIONNUM),1,4) AS PART,
         SUBSTR(NAME, 1, 20) AS NAME,
         SUBSTR(VALUE, 1, 30) AS VALUE
  FROM TABLE(WLM_GET_ACTIVITY_DETAILS(1, 1, 5, -2)) AS ACTDETAIL
  WHERE NAME IN ('APPLICATION_HANDLE',
               'COORD_PARTITION_NUM',
               'LOCAL_START_TIME',
               'UOW_ID',
               'ACTIVITY_ID',
               'PARENT_UOW_ID',
               'PARENT_ACTIVITY_ID',
               'ACTIVITY_TYPE',
               'NESTING_LEVEL',
               'INVOCATION_ID',
               'ROUTINE_ID')
  ORDER BY PART
```

The following is an example of output from this query.

```
PART NAME                 VALUE
---- -------------------- ------------------------------
0    APPLICATION_HANDLE   1
0    COORD_PARTITION_NUM  0
0    LOCAL_START_TIME     2005-11-25-18.52.49.343000
0    UOW_ID               1
0    ACTIVITY_ID          5
0    PARENT_UOW_ID        1
0    PARENT_ACTIVITY_ID   3
0    ACTIVITY_TYPE        READ_DML
0    NESTING_LEVEL        0
0    INVOCATION_ID        1
0    ROUTINE_ID           0
1    APPLICATION_HANDLE   1
1    COORD_PARTITION_NUM  0
1    LOCAL_START_TIME     2005-11-25-18.52.49.598000
1    UOW_ID               1
1    ACTIVITY_ID          5
1    PARENT_UOW_ID
1    PARENT_ACTIVITY_ID
1    ACTIVITY_TYPE        READ_DML
1    NESTING_LEVEL        0
1    INVOCATION_ID        1
1    ROUTINE_ID           0
```

Usage note

An ACTIVITY_STATE of QUEUED means that the coordinator activity has made a RPC to the catalog member to obtain threshold tickets and has not yet received a response. Seeing this state might indicate that the activity has been queued by WLM or, over short periods of time, might just indicate that the activity is in the process of obtaining its tickets. To obtain a more accurate picture of whether or not the activity is really being queued, one can determine which agent is working on the activity (using the WLM_GET_SERVICE_CLASS_AGENTS table function) and find out whether this agent's event_object at the catalog member has a value of WLM_QUEUE.

Information returned

Table 67. Information returned for WLM_GET_ACTIVITY_DETAILS

Column Name	Data Type	Description
DBPARTITIONNUM	SMALLINT	dbpartitionnum - Database partition number monitor element
NAME	VARCHAR(256)	Element name. See Table 68 and Table 69 on page 369 for possible values.
VALUE	VARCHAR(1024)	Element values. See Table 68 and Table 69 on page 369 for possible values.

Table 68. Elements returned

Element Name	Description
ACTIVITY_ID	activity_id - Activity ID monitor element
ACTIVITY_STATE	activity_state - Activity state monitor element
ACTIVITY_TYPE	activity_type - Activity type monitor element
APPLICATION_HANDLE	application_handle - Application handle monitor element
COORD_PARTITION_NUM	coord_partition_num - Coordinator partition number monitor element
DATABASE_WORK_ACTION_SET_ID	If this activity has been mapped to a work action set that has been applied to the database, this column contains the ID of the work action set. This column contains 0 if the activity has not been mapped to a work action set that has been applied to the database.
DATABASE_WORK_CLASS_ID	If this activity has been mapped to a work action set that has been applied to the database, this column contains the ID of the work class of this activity. This column contains 0 if the activity has not been mapped to a work action set that has been applied to the database.
EFFECTIVE_ISOLATION	effective_isolation - Effective isolation monitor element
EFFECTIVE_LOCK_TIMEOUT	effective_lock_timeout - Effective lock timeout monitor element
EFFECTIVE_QUERY_DEGREE	effective_query_degree - Effective query degree monitor element
ENTRY_TIME	entry_time - Entry time monitor element
INVOCATION_ID	invocation_id - Invocation ID monitor element
LAST_REFERENCE_TIME	last_reference_time - Last reference time monitor element
LOCAL_START_TIME	local_start_time - Local start time monitor element
NESTING_LEVEL	nesting_level - Nesting level monitor element
PACKAGE_NAME	package_name - Package name monitor element
PACKAGE_SCHEMA	package_schema - Package schema monitor element
PACKAGE_VERSION_ID	package_version_id - Package version monitor element
PARENT_ACTIVITY_ID	parent_activity_id - Parent activity ID monitor element

Table 68. Elements returned (continued)

Element Name	Description
PARENT_UOW_ID	Unique unit of work identifier within an application. Refers to the original unit of work this activity's parent activity started in. Returns an empty string if the activity has no parent activity or when at a remote member.
QUERY_COST_ESTIMATE	query_cost_estimate - Query cost estimate monitor element
ROUTINE_ID	routine_id - Routine ID monitor element
ROWS_FETCHED	rows_fetched - Rows fetched monitor element
ROWS_MODIFIED	rows_modified - Rows modified monitor element
SECTION_NUMBER	section_number - Section number monitor element
SERVICE_CLASS_ID	service_class_id - Service class ID monitor element
SERVICE_CLASS_WORK_ACTION_SET_ID	If this activity has been mapped to a work action set that has been applied to a service class, this column contains the ID of the work action set. This column contains `0` if the activity has not been mapped to a work action set that has been applied to a service class.
SERVICE_CLASS_WORK_CLASS_ID	If this activity has been mapped to a work action set that has been applied to a service class, this column contains the ID of the work class of this activity. This column contains `0` if the activity has not been mapped to a work action set that has been applied to a service class.
STMT_PKG_CACHE_ID	stmt_pkgcache_id - Statement package cache identifier monitor element
STMT_TEXT	stmt_text - SQL statement text monitor element
SYSTEM_CPU_TIME	system_cpu_time - System CPU time monitor element
UOW_ID	uow_id - Unit of work ID monitor element
USER_CPU_TIME	user_cpu_time - User CPU time monitor element
UTILITY_ID	utility_id - Utility ID monitor element

Important: The WLM_GET_ACTIVITY_DETAILS table function shows only the thresholds that are currently being applied to an activity.

The following elements are returned only if the corresponding thresholds apply to the activity.

Table 69. Elements returned if applicable

Element Name	Description
ACTIVITYTOTALTIME_THRESHOLD_ID	activitytotaltime_threshold_id - Activity total time threshold ID monitor element
ACTIVITYTOTALTIME_THRESHOLD_VALUE	activitytotaltime_threshold_value - Activity total time threshold value monitor element
ACTIVITYTOTALTIME_THRESHOLD_VIOLATED	activitytotaltime_threshold_violated - Activity total time threshold violated monitor element
CONCURRENTDBCOORDACTIVITIES_DB _THRESHOLD_ID	concurrentdbcoordactivities_db_threshold_id - Concurrent database coordinator activities database threshold ID monitor element

Table 69. Elements returned if applicable (continued)

Element Name	Description
CONCURRENTDBCOORDACTIVITIES_DB _THRESHOLD_QUEUED	concurrentdbcoordactivities_db_threshold_queued - Concurrent database coordinator activities database threshold queued monitor element
CONCURRENTDBCOORDACTIVITIES_DB _THRESHOLD_VALUE	concurrentdbcoordactivities_db_threshold_value - Concurrent database coordinator activities database threshold value monitor element
CONCURRENTDBCOORDACTIVITIES_DB _THRESHOLD_VIOLATED	concurrentdbcoordactivities_db_threshold_violated - Concurrent database coordinator activities database threshold violated monitor element
CONCURRENTDBCOORDACTIVITIES_SUBCLASS _THRESHOLD_ID	concurrentdbcoordactivities_subclass_threshold_id - Concurrent database coordinator activities service subclass threshold ID monitor element
CONCURRENTDBCOORDACTIVITIES_SUBCLASS _THRESHOLD_QUEUED	'Yes' indicates that the activity was queued by the CONCURRENTDBCOORDACTIVITIES_SUBCLASS threshold. 'No' indicates that the activity was not queued.
CONCURRENTDBCOORDACTIVITIES_SUBCLASS _THRESHOLD_VALUE	concurrentdbcoordactivities_subclass _threshold_value - Concurrent database coordinator activities service subclass threshold value monitor element
CONCURRENTDBCOORDACTIVITIES_SUBCLASS _THRESHOLD_VIOLATED	'Yes' indicates that the activity violated the CONCURRENTDBCOORDACTIVITIES_SUBCLASS threshold. 'No' indicates that the activity has not yet violated the threshold.
CONCURRENTDBCOORDACTIVITIES_SUPERCLASS _THRESHOLD_ID	The ID of the CONCURRENTDBCOORDACTIVITIES _SUPERCLASS threshold that was applied to the activity.
CONCURRENTDBCOORDACTIVITIES_SUPERCLASS _THRESHOLD_QUEUED	'Yes' indicates that the activity was queued by the CONCURRENTDBCOORDACTIVITIES _SUPERCLASS threshold. 'No' indicates that the activity was not queued.
CONCURRENTDBCOORDACTIVITIES_SUPERCLASS _THRESHOLD_VALUE	The upper bound of the CONCURRENTDBCOORDACTIVITIES _SUPERCLASS threshold that was applied to the activity.
CONCURRENTDBCOORDACTIVITIES_SUPERCLASS _THRESHOLD_VIOLATED	'Yes' indicates that the activity violated the CONCURRENTDBCOORDACTIVITIES _SUPERCLASS threshold. 'No' indicates that the activity has not yet violated the threshold.
CONCURRENTDBCOORDACTIVITIES_WORK_ACTION_SET _THRESHOLD_ID	The ID of the CONCURRENTDBCOORDACTIVITIES_WORK _ACTION_SET threshold that was applied to the activity.
CONCURRENTDBCOORDACTIVITIES_WORK_ACTION_SET _THRESHOLD_QUEUED	'Yes' indicates that the activity was queued by the CONCURRENTDBCOORDACTIVITIES _WORK_ACTION_SET threshold. 'No' indicates that the activity was not queued.
CONCURRENTDBCOORDACTIVITIES_WORK_ACTION_SET _THRESHOLD_VALUE	The upper bound of the CONCURRENTDBCOORDACTIVITIES_WORK _ACTION_SET threshold that was applied to the activity.

Table 69. Elements returned if applicable (continued)

Element Name	Description
CONCURRENTDBCOORDACTIVITIES_WORK_ACTION_SET _THRESHOLD_VIOLATED	'Yes' indicates that the activity violated the CONCURRENTDBCOORDACTIVITIES_WORK _ACTION_SET threshold. 'No' indicates that the activity has not yet violated the threshold.
CONCURRENTWORKLOADACTIVITIES _THRESHOLD_ID	The ID of the CONCURRENTWORKLOADACTIVITIES threshold that was applied to the activity.
CONCURRENTWORKLOADACTIVITIES _THRESHOLD_VALUE	The upper bound of the CONCURRENTWORKLOADACTIVITIES threshold that was applied to the activity.
CONCURRENTWORKLOADACTIVITIES _THRESHOLD_VIOLATED	'Yes' indicates that the activity violated the CONCURRENTWORKLOADACTIVITIES threshold. 'No' indicates that the activity has not yet violated the threshold.
ESTIMATEDSQLCOST_THRESHOLD_ID	estimatedsqlcost_threshold_id - Estimated SQL cost threshold ID monitor element
ESTIMATEDSQLCOST_THRESHOLD_VALUE	estimatedsqlcost_threshold_value - Estimated SQL cost threshold value monitor element
ESTIMATEDSQLCOST_THRESHOLD_VIOLATED	estimatedsqlcost_threshold_violated - Estimated SQL cost threshold violated monitor element
SQLROWSRETURNED_THRESHOLD_ID	sqlrowsreturned_threshold_id - SQL rows read returned threshold ID monitor element
SQLROWSRETURNED_THRESHOLD_VALUE	sqlrowsreturned_threshold_value - SQL rows read returned threshold value monitor element
SQLROWSRETURNED_THRESHOLD_VIOLATED	sqlrowsreturned_threshold_violated - SQL rows read returned threshold violated monitor element
SQLTEMPSPACE_THRESHOLD_ID	sqltempspace_threshold_id - SQL temporary space threshold ID monitor element
SQLTEMPSPACE_THRESHOLD_VALUE	sqltempspace_threshold_value - SQL temporary space threshold value monitor element
SQLTEMPSPACE_THRESHOLD_VIOLATED	sqltempspace_threshold_violated - SQL temporary space threshold violated monitor element

WLM_GET_QUEUE_STATS table function - Return threshold queue statistics

The WLM_GET_QUEUE_STATS function returns basic statistics for one or more threshold queues on all active members. This function returns one row of statistics for each threshold queue.

Syntax

```
►►──WLM_GET_QUEUE_STATS──(──threshold_predicate──,──threshold_domain──,──────────►

►─threshold_name──,──threshold_id──)─────────────────────────────────────────────►◄
```

The schema is SYSPROC.

Table function parameters

`threshold_predicate`
An input argument of type VARCHAR(27) that specifies a threshold predicate. The possible values are as follows:

CONCDBC	Concurrent database coordinator activities threshold
DBCONN	Total database member connections threshold
SCCONN	Total service class member connections threshold

If the argument is null or an empty string, data is returned for all thresholds that meet the other criteria.

The *threshold_predicate* values match those of the THRESHOLDPREDICATE column in the SYSCAT.THRESHOLDS view.

`threshold_domain`
An input argument of type VARCHAR(18) that specifies a threshold domain. The possible values are as follows:

DB	Database
SB	Service subclass
SP	Service superclass
WA	Work action set

If the argument is null or an empty string, data is returned for all thresholds that meet the other criteria.

The *threshold_domain* values match those of the DOMAIN column in the SYSCAT.THRESHOLDS view.

`threshold_name`
An input argument of type VARCHAR(128) that specifies a threshold name. If the argument is null or an empty string, data is returned for all thresholds that meet the other criteria. The *threshold_name* values match those of the THRESHOLDNAME column in the SYSCAT.THRESHOLDS view.

`threshold_id`
An input argument of type INTEGER that specifies a threshold ID. If the argument is null or `-1`, data is returned for all thresholds that meet the other criteria. The *threshold_id* values match those of the THRESHOLDID column in the SYSCAT.THRESHOLDS view.

Authorization

One of the following authorities is required to execute the routine:
- EXECUTE privilege on the routine
- DATAACCESS authority
- DBADM authority
- SQLADM authority
- WLMADM authority

Default PUBLIC privilege

None

Example

The following query displays the basic statistics for all the queues on a system, across all members:

```
SELECT substr(THRESHOLD_NAME, 1, 6) THRESHNAME,
     THRESHOLD_PREDICATE,
     THRESHOLD_DOMAIN,
     MEMBER MEMB,
     QUEUE_SIZE_TOP,
     QUEUE_TIME_TOTAL,
     QUEUE_ASSIGNMENTS_TOTAL QUEUE_ASSIGN
FROM table(WLM_GET_QUEUE_STATS('', '', '', -1)) as QSTATS
```

Sample output is as follows:

```
THRESHNAME THRESHOLD_PREDICATE         THRESHOLD_DOMAIN   ...
---------- --------------------------- ------------------ ...
LIMIT1     CONCDBC                     DB                 ...
LIMIT2     SCCONN                      SP                 ...
LIMIT3     DBCONN                      DB                 ...

... MEMB QUEUE_SIZE_TOP QUEUE_TIME_TOTAL QUEUE_ASSIGN
... ---- -------------- ---------------- ------------
... 0                12          1238540          734
... 0                 4           741249           24
... 0                 7           412785          128
```

Usage note

The function does not aggregate data across queues (on a member) or across members (for one or more queues). However, you can use SQL queries to aggregate data, as shown in the previous example.

Information returned

Table 70. Information returned for WLM_GET_QUEUE_STATS

Column name	Data type	Description
THRESHOLD_PREDICATE	VARCHAR(27)	threshold_predicate - Threshold predicate monitor element
THRESHOLD_DOMAIN	VARCHAR(18)	threshold_domain - Threshold domain monitor element
THRESHOLD_NAME	VARCHAR(128)	threshold_name - Threshold name monitor element
THRESHOLD_ID	INTEGER	thresholdid - Threshold ID monitor element
DBPARTITIONNUM	SMALLINT	dbpartitionnum - Database partition number monitor element
SERVICE_SUPERCLASS_NAME	VARCHAR(128)	service_superclass_name - Service superclass name monitor element
SERVICE_SUBCLASS_NAME	VARCHAR(128)	service_subclass_name - Service subclass name monitor element
WORK_ACTION_SET_NAME	VARCHAR(128)	work_action_set_name - Work action set name monitor element

Table 70. Information returned for WLM_GET_QUEUE_STATS (continued)

Column name	Data type	Description
WORK_CLASS_NAME	VARCHAR(128)	work_class_name - Work class name monitor element
WORKLOAD_NAME	VARCHAR(128)	workload_name - Workload name monitor element
LAST_RESET	TIMESTAMP	last_reset - Last Reset Timestamp monitor element
QUEUE_SIZE_TOP	INTEGER	queue_size_top - Queue size top monitor element
QUEUE_TIME_TOTAL	BIGINT	queue_time_total - Queue time total monitor element
QUEUE_ASSIGNMENTS_TOTAL	BIGINT	queue_assignments_total - Queue assignments total monitor element
QUEUE_SIZE_CURRENT	INTEGER	Number of connections or activities in the queue.
QUEUE_TIME_LATEST	BIGINT	Time spent in the queue by the last connection or activity to leave the queue. Units are milliseconds.
QUEUE_EXIT_TIME_LATEST	TIMESTAMP	Time that the last connection or activity left the queue.
THRESHOLD_CURRENT_CONCURRENCY	INTEGER	Number of connections or activities that are currently running according to the threshold.
THRESHOLD_MAX_CONCURRENCY	INTEGER	Maximum number of connections or activities that the threshold allows to be concurrently running.
MEMBER	SMALLINT	member - Database member monitor element

WLM_GET_SERVICE_CLASS_AGENTS table function - list agents running in a service class

The WLM_GET_SERVICE_CLASS_AGENTS function returns the list of agents, fenced mode processes (db2fmp processes), and system entities on a specified member that are running in a specified service class or on behalf of a specified application. The system entities are non-agent threads and processes, such as page cleaners and prefetchers.

Refer to Table 71 on page 377 for a complete list of information that can be returned.

Syntax

```
►►—WLM_GET_SERVICE_CLASS_AGENTS—(—service_superclass_name—,——————————————►

►—service_subclass_name—,—application_handle—,—member—)——————————————————►◄
```

The schema is SYSPROC.

Table function parameters

service_superclass_name
: An input argument of type VARCHAR(128) that specifies the name of a service superclass in the currently connected database. If the argument is null or an empty string, data is retrieved for all the superclasses in the database.

service_subclass_name
: An input argument of type VARCHAR(128) that refers to a specific subclass within a superclass. If the argument is null or an empty string, data is retrieved for all the subclasses in the database.

application_handle
: An input argument of type BIGINT that specifies the application handle for which agent information is to be returned. If the argument is null, data is retrieved for all applications in the database. An application handle of 0 returns the system entities only.

member
: An input argument of type INTEGER that specifies the member number in the same instance as the currently connected database. Specify -1 for the current database member, or -2 for all database members. If a null value is specified, -1 is set implicitly.

Authorization

One of the following authorities is required to execute the routine:
- EXECUTE privilege on the routine
- DATAACCESS authority
- DBADM authority
- SQLADM authority
- WLMADM authority

Default PUBLIC privilege

None

Example 1

The following query returns a list of agents that are associated with application handle 1 for all database members. You can determine the application handle by using the **LIST APPLICATIONS** command or the WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES table function.

```
SELECT SUBSTR(CHAR(APPLICATION_HANDLE),1,7) AS APPHANDLE,
  SUBSTR(CHAR(MEMBER),1,4) AS MEMB,
  SUBSTR(CHAR(AGENT_TID),1,9) AS AGENT_TID,
  SUBSTR(AGENT_TYPE,1,11) AS AGENTTYPE,
  SUBSTR(AGENT_STATE,1,10) AS AGENTSTATE,
  SUBSTR(REQUEST_TYPE,1,12) AS REQTYPE,
  SUBSTR(CHAR(UOW_ID),1,6) AS UOW_ID,
  SUBSTR(CHAR(ACTIVITY_ID),1,6) AS ACT_ID
FROM TABLE(WLM_GET_SERVICE_CLASS_AGENTS(CAST(NULL AS VARCHAR(128)),
  CAST(NULL AS VARCHAR(128)), 1, -2)) AS SCDETAILS
ORDER BY APPHANDLE, MEMB, AGENT_TID
```

Sample output is as follows:

```
APPHANDLE MEMB AGENT_TID AGENTTYPE   AGENTSTATE REQTYPE       UOW_ID ACT_ID
--------- ---- --------- ----------- ---------- ------------- ------ ------
1         0    3         COORDINATOR ACTIVE     FETCH         1      5
1         0    4         SUBAGENT    ACTIVE     SUBSECTION:1  1      5
1         1    2         SUBAGENT    ACTIVE     SUBSECTION:2  1      5
```

The output shows a coordinator agent and a subagent on member 0 and a subagent on member 1 operating on behalf of an activity with UOW ID 1 and activity ID 5. The `AGENTTYPE` column with a value of `COORDINATOR` has a value of `FETCH` for the `REQTYPE` column (which indicates the main or initial request type). This means that the type of request is a fetch request for the coordinator agent.

Example 2

The following query determines which lock an agent is waiting on:

```
 db2 select event_object, event_type, event_state, varchar(event_object_name, 30)
   as event_object_name
   from table(WLM_GET_SERVICE_CLASS_AGENTS('','',cast(NULL as bigint), -1)) as t
```

Sample output is as follows:

```
EVENT_OBJECT    EVENT_TYPE        EVENT_STATE         EVENT_OBJECT_NAME
--------------- ----------------- ------------------- --------------------------
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         WAIT              IDLE                -
LOCK            ACQUIRE           IDLE                02000500000000000000000054
ROUTINE         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -

  21 record(s) selected.
```

Using the same query at a later time shows that the WLM threshold has queued an agent:

```
EVENT_OBJECT    EVENT_TYPE        EVENT_STATE         EVENT_OBJECT_NAME
--------------- ----------------- ------------------- --------------------------
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
WLM_QUEUE       WAIT              IDLE                MYCONCDBCOORDTH
ROUTINE         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST         PROCESS           EXECUTING           -
REQUEST        PROCESS          EXECUTING          -
REQUEST        PROCESS          EXECUTING          -
REQUEST        PROCESS          EXECUTING          -
REQUEST        PROCESS          EXECUTING          -
REQUEST        PROCESS          EXECUTING          -
REQUEST        PROCESS          EXECUTING          -
REQUEST        PROCESS          EXECUTING          -
REQUEST        PROCESS          EXECUTING          -

  21 record(s) selected.
```

Usage note

The parameters are, in effect, ANDed together. That is, if you specify conflicting input parameters, such as a service superclass SUP_A and a subclass SUB_B such that SUB_B is not a subclass of SUP_A, no rows are returned.

Information returned

Table 71. Information returned by WLM_GET_SERVICE_CLASS_AGENTS

Column name	Data type	Description
SERVICE_SUPERCLASS_NAME	VARCHAR (128)	service_superclass_name - Service superclass name monitor element
SERVICE_SUBCLASS_NAME	VARCHAR (128)	service_subclass_name - Service subclass name monitor element
APPLICATION_HANDLE	BIGINT	application_handle - Application handle monitor element
DBPARTITIONNUM	SMALLINT	dbpartitionnum - Database partition number monitor element
ENTITY	VARCHAR (32)	One of the following values: • If the type of entity is an agent, the value is db2agent. • If the type of entity is a fenced mode process, the value is db2fmp (*pid*) where *pid* is the process ID of the fenced mode process. • Otherwise, the value is the name of the system entity.
WORKLOAD_NAME	VARCHAR (128)	workload_name - Workload name monitor element
WORKLOAD_OCCURRENCE_ID	INTEGER	workload_occurrence_id - Workload occurrence identifier monitor element
UOW_ID	INTEGER	uow_id - Unit of work ID monitor element
ACTIVITY_ID	INTEGER	activity_id - Activity ID monitor element
PARENT_UOW_ID	INTEGER	parent_uow_id - Parent unit of work ID monitor element
PARENT_ACTIVITY_ID	INTEGER	parent_activity_id - Parent activity ID monitor element
AGENT_TID	BIGINT	agent_tid - Agent thread ID monitor element
AGENT_TYPE	VARCHAR (32)	Agent type. The agent types are as follows: • COORDINATOR • OTHER • PDBSUBAGENT • SMPSUBAGENT If the value is COORDINATOR, the agent ID might change in concentrator environments.
SMP_COORDINATOR	INTEGER	Indication of whether the agent is an SMP coordinator: 1 for yes and 0 for no.

Table 71. Information returned by WLM_GET_SERVICE_CLASS_AGENTS (continued)

Column name	**Data type**	**Description**
AGENT_SUBTYPE	VARCHAR (32)	Agent subtype. The possible subtypes are as follows: • DSS • OTHER • RPC • SMP
AGENT_STATE	VARCHAR (32)	Indication of whether an agent is associated or active. The possible values are: • ASSOCIATED • ACTIVE
EVENT_TYPE	VARCHAR (32)	Type of event last processed by this agent. The possible values are as follows: • ACQUIRE • PROCESS • WAIT See Table 72 on page 381 for more information about possible values for this column.
EVENT_OBJECT	VARCHAR (32)	Object of the event last processed by this agent. The possible values are as follows: • COMPRESSION_DICTIONARY_BUILD • IMPLICIT_REBIND • INDEX_RECREATE • LOCK • LOCK_ESCALATION • QP_QUEUE • REMOTE_REQUEST • REQUEST • ROUTINE • WLM_QUEUE See Table 72 on page 381 for more information about possible values for this column.
EVENT_STATE	VARCHAR (32)	State of the event last processed by this agent. The possible values are as follows: • EXECUTING • IDLE See Table 72 on page 381 for more information about possible values for this column.
REQUEST_ID	VARCHAR (64)	Request ID. This value is unique only in combination with the value of *application_handle*. You can use this combination to distinguish between one request that is taking a long time and multiple requests; for example, to distinguish between one long fetch and multiple fetches.

Table 71. Information returned by WLM_GET_SERVICE_CLASS_AGENTS (continued)

Column name	Data type	Description
REQUEST_TYPE	VARCHAR (32)	Type of request. The possible values are as follows: • For coordinator agents: – CLOSE – COMMIT – COMPILE – DESCRIBE – EXCSQLSET – EXECIMMD – EXECUTE – FETCH – INTERNAL *number*, where *number* is the value of the internal constant – OPEN – PREPARE – REBIND – REDISTRIBUTE – REORG – ROLLBACK – RUNSTATS • For subagents with an AGENT_SUBTYPE of DSS or SMP: – If the subsection number is nonzero, the subsection number in the form SUBSECTION:*subsection number*; otherwise, returns NULL.

Table 71. Information returned by WLM_GET_SERVICE_CLASS_AGENTS (continued)

Column name	**Data type**	**Description**
REQUEST_TYPE (continued)	VARCHAR (32)	• For subagents with an AGENT_SUBTYPE of RPC: – ABP – CATALOG – INTERNAL – REORG – RUNSTATS – WLM • For subagents with a SUBTYPE of OTHER: – ABP – APP_RBSVPT – APP_RELSVPT – BACKUP – CLOSE – EXTERNAL_RBSVPT – EVMON – FORCE – FORCE_ALL – INTERNAL *number*, where *number* is the value of the internal constant – INTERRUPT – NOOP (if there is no request) – QP – REDISTRIBUTE – STMT_RBSVPT – STOP_USING – UPDATE_DBM_CFG – WLM
NESTING_LEVEL	INTEGER	nesting_level - Nesting level monitor element
INVOCATION_ID	INTEGER	invocation_id - Invocation ID monitor element
ROUTINE_ID	INTEGER	routine_id - Routine ID monitor element
EVENT_OBJECT_NAME	VARCHAR (1024)	Event object name. If the value of EVENT_OBJECT is LOCK, the value of this column is the name of the lock that the agent is waiting on. If the value of EVENT_OBJECT is WLM_QUEUE, the value of the column is the name of the WLM threshold that the agent is queued on. Otherwise, the value is NULL.
APPLICATION_NAME	VARCHAR (128)	appl_name - Application name
APPLICATION_ID	VARCHAR (128)	appl_id - Application ID
CLIENT_PID	BIGINT	client_pid - Client process ID
SESSION_AUTH_ID	VARCHAR (128)	session_auth_id - Session authorization ID
REQUEST_START_TIME	TIMESTAMP	Time that the agent started processing the request on which it is currently working

Table 71. Information returned by WLM_GET_SERVICE_CLASS_AGENTS (continued)

Column name	Data type	Description
AGENT_STATE_LAST _UPDATE_TIME	TIMESTAMP	The last time that the event, being processed by the agent, was changed. The event currently processed by the agent is identified by the EVENT_TYPE, EVENT_OBJECT, and EVENT_STATE columns.
EXECUTABLE_ID	VARCHAR (32) FOR BIT DATA	executable_id - Executable ID monitor element
MEMBER	SMALLINT	member - Database member monitor element

Note: The possible combinations of EVENT_STATE, EVENT_TYPE, EVENT_OBJECT and EVENT_OBJECT_NAME column values are listed in the following table.

Table 72. Possible combinations for EVENT_STATE, EVENT_TYPE, EVENT_OBJECT and EVENT_OBJECT_NAME column values

Event description	EVENT_STATE value	EVENT_TYPE value	EVENT_OBJECT value	EVENT_OBJECT_ NAME value
Acquire lock	IDLE	ACQUIRE	LOCK	Lock name
Escalate lock	EXECUTING	PROCESS	LOCK_ESCALATION	NULL
Process request	EXECUTING	PROCESS	REQUEST	NULL
Wait for a new request	IDLE	WAIT	REQUEST	NULL
Wait for a request to be processed at a remote member	IDLE	WAIT	REMOTE_REQUEST	NULL
Wait on a WLM threshold queue	IDLE	WAIT	WLM_QUEUE	Threshold name
Process a routine	EXECUTING	PROCESS	ROUTINE	NULL
Re-create an index	EXECUTING	PROCESS	INDEX_RECREATE	NULL
Build compression dictionary	EXECUTING	PROCESS	COMP_DICT_BLD	NULL
Implicit rebind	EXECUTING	PROCESS	IMPLICIT_REBIND	NULL

WLM_GET_SERVICE_CLASS _WORKLOAD_OCCURRENCES - list workload occurrences

The WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES function returns the list of all workload occurrences running in a specified service class on a particular member. A workload occurrence is a specific database connection whose attributes match the definition of a workload and hence is associated with or assigned to the workload.

Refer to Table 73 on page 383 for a complete list of information that can be returned.

Syntax

```
►►──WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES──(──service_superclass_name──,──────────►
►─service_subclass_name─,─member─)──────────────────────────────────────►◄
```

The schema is SYSPROC.

Table function parameters

service_superclass_name
: An input argument of type VARCHAR(128) that specifies the name of a service superclass in the currently connected database. If the argument is null or an empty string, the data is retrieved for all the superclasses in the database that match the values of the other parameters.

service_subclass_name
: Target service subclass for the workload occurrence. Any work submitted by this workload occurrence will run in this service subclass under the target service superclass with the exception of activities that are mapped, or remapped, to a different subclass.

member
: An input argument of type INTEGER that specifies the number of a member in the same instance as the currently connected database. Specify -1 for the current database member, or -2 for all database members. If the null value is specified, -1 is set implicitly.

Authorization

One of the following authorities is required to execute the routine:
- EXECUTE privilege on the routine
- DATAACCESS authority
- DBADM authority
- SQLADM authority
- WLMADM authority

Default PUBLIC privilege

None

Example

If an administrator wants to see what workload occurrences are running on the system as a whole, the administrator can call the WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES function by specifying a null value or an empty string for *service_superclass_name* and *service_subclass_name* and `-2` for *member*:

```
SELECT SUBSTR(SERVICE_SUPERCLASS_NAME,1,19) AS SUPERCLASS_NAME,
       SUBSTR(SERVICE_SUBCLASS_NAME,1,18) AS SUBCLASS_NAME,
       SUBSTR(CHAR(MEMBER),1,4) AS MEMB,
       SUBSTR(CHAR(COORD_MEMBER),1,4) AS COORDMEMB,
       SUBSTR(CHAR(APPLICATION_HANDLE),1,7) AS APPHNDL,
       SUBSTR(WORKLOAD_NAME,1,22) AS WORKLOAD_NAME,
       SUBSTR(CHAR(WORKLOAD_OCCURRENCE_ID),1,6) AS WLO_ID
FROM TABLE(WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES
      (CAST(NULL AS VARCHAR(128)), CAST(NULL AS VARCHAR(128)), -2))
       AS SCINFO
ORDER BY SUPERCLASS_NAME, SUBCLASS_NAME, MEMB, APPHNDL,
       WORKLOAD_NAME, WLO_ID
```

If the system has four database members and is currently running two workloads, the previous query produces results such as the following ones:

```
SUPERCLASS_NAME    SUBCLASS_NAME      MEMB COORDMEMB ...
------------------ ------------------ ---- --------- ...
SYSDEFAULTMAINTENAN SYSDEFAULTSUBCLASS 0    0         ...
SYSDEFAULTSYSTEMCLA SYSDEFAULTSUBCLASS 0    0         ...
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 0    0         ...
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 0    0         ...
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 1    0         ...
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 1    0         ...
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 2    0         ...
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 2    0         ...
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 3    0         ...
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 3    0         ...
```

```
... APPHNDL WORKLOAD_NAME         WLO_ID
... ------- --------------------- ------
... -       -                     -
... -       -                     -
... 1       SYSDEFAULTUSERWORKLOAD 1
... 2       SYSDEFAULTUSERWORKLOAD 2
... 1       SYSDEFAULTUSERWORKLOAD 1
... 2       SYSDEFAULTUSERWORKLOAD 2
... 1       SYSDEFAULTUSERWORKLOAD 1
... 2       SYSDEFAULTUSERWORKLOAD 2
... 1       SYSDEFAULTUSERWORKLOAD 1
... 2       SYSDEFAULTUSERWORKLOAD 2
```

Usage note

The parameters are, in effect, ANDed together. That is, if you specify conflicting input parameters, such as a service superclass SUP_A and a subclass SUB_B such that SUB_B is not a subclass of SUP_A, no rows are returned.

Note: Statistics reported for the workload occurrence (for example, coord_act_completed_total) are reset at the beginning of each unit of work when they are combined with the corresponding workload statistics.

Information returned

Table 73. Information returned for WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES

Column name	Data type	Description
SERVICE_SUPERCLASS_NAME	VARCHAR(128)	service_superclass_name - Service superclass name monitor element
SERVICE_SUBCLASS_NAME	VARCHAR(128)	service_subclass_name - Service subclass name monitor element
DBPARTITIONNUM	SMALLINT	dbpartitionnum - Database partition number monitor element
COORD_PARTITION_NUM	SMALLINT	coord_partition_num - Coordinator partition number monitor element
APPLICATION_HANDLE	BIGINT	application_handle - Application handle monitor element
WORKLOAD_NAME	VARCHAR(128)	workload_name - Workload name monitor element
WORKLOAD_OCCURRENCE_ID	INTEGER	workload_occurrence_id - Workload occurrence identifier monitor element
UOW_ID	INTEGER	uow_id - Unit of work ID monitor element

Table 73. Information returned for WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES (continued)

Column name	Data type	Description
WORKLOAD_OCCURRENCE_STATE	VARCHAR(32)	workload_occurrence_state - Workload occurrence state monitor element
SYSTEM_AUTH_ID	VARCHAR(128)	system_auth_id - System authorization identifier monitor element
SESSION_AUTH_ID	VARCHAR(128)	session_auth_id - Session authorization ID monitor element
APPLICATION_NAME	VARCHAR(128)	appl_name - Application name monitor element
CLIENT_WRKSTNNAME	VARCHAR(255)	client_wrkstnname - Client workstation name monitor element
CLIENT_ACCTNG	VARCHAR(255)	client_acctng - Client accounting string monitor element
CLIENT_USER	VARCHAR(255)	Current value of the CLIENT_USERID special register for this workload occurrence.
CLIENT_APPLNAME	VARCHAR(255)	client_applname - Client application name monitor element
COORD_ACT_COMPLETED_TOTAL	INTEGER	coord_act_completed_total - Coordinator activities completed total monitor element
COORD_ACT_ABORTED_TOTAL	INTEGER	coord_act_aborted_total - Coordinator activities aborted total monitor element
COORD_ACT_REJECTED_TOTAL	INTEGER	coord_act_rejected_total - Coordinator activities rejected total monitor element
CONCURRENT_ACT_TOP	INTEGER	concurrent_act_top - Concurrent activity top monitor element
ADDRESS	VARCHAR(255)	address - IP address from which the connection was initiated
APPL_ID	VARCHAR(128)	appl_id - Application ID
MEMBER	SMALLINT	member - Database member monitor element
COORD_MEMBER	SMALLINT	coord_member - Coordinator member monitor element

WLM_GET_SERVICE_SUBCLASS_STATS table function - Return statistics of service subclasses

The WLM_GET_SERVICE_SUBCLASS_STATS function returns basic statistics for one or more service subclasses.

Refer to Table 74 on page 387 for a complete list of information that can be returned.

Syntax

```
►►—WLM_GET_SERVICE_SUBCLASS_STATS—(—service_superclass_name—,——————————————————►

►—service_subclass_name—,—member—)—————————————————————————————————————————————►◄
```

The schema is SYSPROC.

Table function parameters

`service_superclass_name`
: An input argument of type VARCHAR(128) that specifies the name of a service superclass in the currently connected database. If the argument is null or an empty string, the data is retrieved for all of the superclasses in the database.

`service_subclass_name`
: An input argument of type VARCHAR(128) that specifies the name of a service subclass in the currently connected database. If the argument is null or an empty string, the data is retrieved for all of the subclasses in the database.

`member`
: An input argument of type INTEGER that specifies a valid member number in the same instance as the currently connected database. Specify -1 for the current member, or -2 for all database members. If the null value is specified, -1 is set implicitly.

Authorization

One of the following authorities is required to execute the routine:

- EXECUTE privilege on the routine
- DATAACCESS authority
- DBADM authority
- SQLADM authority
- WLMADM authority

Default PUBLIC privilege

None

Examples

Example 1: Because every activity must be mapped to a DB2 service class before being run, you can monitor the global state of the system by using the service class statistics table functions and querying all of the service classes on all members. In the following example, a null value is passed for *service_superclass_name* and *service_subclass_name* to return statistics for all service classes, and the value -2 is specified for *member* to return statistics for all members:

```
 SELECT SUBSTR(SERVICE_SUPERCLASS_NAME,1,19) AS SUPERCLASS_NAME,
       SUBSTR(SERVICE_SUBCLASS_NAME,1,18) AS SUBCLASS_NAME,
       SUBSTR(CHAR(MEMBER),1,4) AS MEMB,
       CAST(COORD_ACT_LIFETIME_AVG / 1000 AS DECIMAL(9,3))
         AS AVGLIFETIME,
       CAST(COORD_ACT_LIFETIME_STDDEV / 1000 AS DECIMAL(9,3))
         AS STDDEVLIFETIME,
       SUBSTR(CAST(LAST_RESET AS VARCHAR(30)),1,16) AS LAST_RESET
  FROM TABLE(WLM_GET_SERVICE_SUBCLASS_STATS(CAST(NULL AS VARCHAR(128)),
       CAST(NULL AS VARCHAR(128)), -2)) AS SCSTATS
  ORDER BY SUPERCLASS_NAME, SUBCLASS_NAME, MEMB
```

The statement returns service class statistics such as average activity lifetime and standard deviation in seconds, as shown in the following sample output:

```
SUPERCLASS_NAME     SUBCLASS_NAME      MEMB ...
------------------- ------------------ ---- ...
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 0    ...
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 1    ...
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 2    ...
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 3    ...

... AVGLIFETIME STDDEVLIFETIME LAST_RESET
... ----------- -------------- ----------------
...     691.242         34.322 2006-07-24-11.44
...     644.740         22.124 2006-07-24-11.44
...     612.431         43.347 2006-07-24-11.44
...     593.451         28.329 2006-07-24-11.44
```

Example 2: The same table function can also give the highest value for average concurrency of coordinator activities running in the service class on each member:

```
  SELECT SUBSTR(SERVICE_SUPERCLASS_NAME,1,19) AS SUPERCLASS_NAME,
         SUBSTR(SERVICE_SUBCLASS_NAME,1,18) AS SUBCLASS_NAME,
         SUBSTR(CHAR(MEMBER),1,4) AS MEMB,
         CONCURRENT_ACT_TOP AS ACTTOP,
         CONCURRENT_WLO_TOP AS CONNTOP
  FROM TABLE(WLM_GET_SERVICE_SUBCLASS_STATS(CAST(NULL AS VARCHAR(128)),
         CAST(NULL AS VARCHAR(128)), -2)) AS SCSTATS
  ORDER BY SUPERCLASS_NAME, SUBCLASS_NAME, MEMB
```

Sample output is as follows:

```
SUPERCLASS_NAME     SUBCLASS_NAME      MEMB ACTTOP    CONNTOP
------------------- ------------------ ---- --------- ---------
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 0           10         7
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 1            0         0
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 2            0         0
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS 3            0         0
```

By checking the average execution times and numbers of activities in the output of this table function, you can get a good high-level view of the load on each member for a specific database. Any significant variations in the high-level gauges returned by this table function might indicate a change in the load on the system.

Example 3: If an activity uses thresholds with REMAP ACTIVITY TO actions, the activity might spend time in more than one service class during its lifetime. You can determine how many activities have passed through a set of service classes by looking at the ACTIVITIES_MAPPED_IN and ACTIVITIES_MAPPED_OUT columns, as shown in the following example:

```
SELECT SUBSTR(SERVICE_SUPERCLASS_NAME,1,19) AS SUPERCLASS_NAME,
       SUBSTR(SERVICE_SUBCLASS_NAME,1,18) AS SUBCLASS_NAME,
       ACTIVITIES_MAPPED_IN AS MAPPED_IN,
       ACTIVITIES_MAPPED_OUT AS MAPPED_OUT
FROM TABLE(WLM_GET_SERVICE_SUBCLASS_STATS(CAST(NULL AS VARCHAR(128)),
       CAST(NULL AS VARCHAR(128)), -2)) AS SCSTATS
ORDER BY SUPERCLASS_NAME, SUBCLASS_NAME
```

Sample output is as follows:

```
SUPERCLASS_NAME     SUBCLASS_NAME      MAPPED_IN MAPPED_OUT
------------------- ------------------ --------- ----------
SYSDEFAULTUSERCLASS SYSDEFAULTSUBCLASS         0          0
SUPERCLASS1         SYSDEFAULTSUBCLASS         0          0
SUPERCLASS1         SUBCLASS1                  0          7
SUPERCLASS1         SUBCLASS2                  7          0
```

Usage notes

Some statistics are returned only if you set the COLLECT AGGREGATE ACTIVITY DATA and COLLECT AGGREGATE REQUEST DATA parameters for the corresponding service subclass to a value other than NONE.

The WLM_GET_SERVICE_SUBCLASS_STATS table function returns one row of data per service subclass and per member. The function does not aggregate data across service classes (on a partition) or across partitions (for one or more service classes). However, you can use SQL queries to aggregate data.

The parameters are, in effect, ANDed together. That is, if you specify conflicting input parameters, such as a superclass named SUPA and a subclass named SUBB such that SUBB is not a subclass of SUPA, no rows are returned.

Information returned

Table 74. Information returned for WLM_GET_SERVICE_SUBCLASS_STATS

Column name	Data type	Description
SERVICE_SUPERCLASS_NAME	VARCHAR(128)	service_superclass_name - Service superclass name monitor element
SERVICE_SUBCLASS_NAME	VARCHAR(128)	service_subclass_name - Service subclass name monitor element
DBPARTITIONNUM	SMALLINT	dbpartitionnum - Database partition number monitor element
LAST_RESET	TIMESTAMP	last_reset - Last Reset Timestamp monitor element
COORD_ACT_COMPLETED_TOTAL	BIGINT	coord_act_completed_total - Coordinator activities completed total monitor element
COORD_ACT_ABORTED_TOTAL	BIGINT	coord_act_aborted_total - Coordinator activities aborted total monitor element
COORD_ACT_REJECTED_TOTAL	BIGINT	coord_act_rejected_total - Coordinator activities rejected total monitor element
CONCURRENT_ACT_TOP	INTEGER	concurrent_act_top - Concurrent activity top monitor element
COORD_ACT_LIFETIME_TOP	BIGINT	coord_act_lifetime_top - Coordinator activity lifetime top monitor element
COORD_ACT_LIFETIME_AVG	DOUBLE	coord_act_lifetime_avg - Coordinator activity lifetime average monitor element
COORD_ACT_LIFETIME_STDDEV	DOUBLE	Standard deviation of lifetime for coordinator activities at nesting level 0 that were associated with this service subclass since the last reset. If the COLLECT AGGREGATE ACTIVITY DATA parameter of the service class is set to NONE, the value of the column is null. Units are milliseconds. This standard deviation is computed from the coordinator activity lifetime histogram and may be inaccurate if the histogram is not correctly sized to fit the data. The value of -1 is returned if any values fall into the last histogram bin. The COORD_ACT_LIFETIME_STDDEV value of a service subclass is unaffected by activities that pass through the service subclass but are remapped to a different subclass before they are completed.

Table 74. Information returned for WLM_GET_SERVICE_SUBCLASS_STATS (continued)

Column name	Data type	Description
COORD_ACT_EXEC_TIME_AVG	DOUBLE	coord_act_exec_time_avg - Coordinator activities execution time average monitor element
COORD_ACT_EXEC_TIME_STDDEV	DOUBLE	Standard deviation of the execution times for coordinator activities at nesting level 0 that were associated with this service subclass since the last reset. Units are milliseconds. This standard deviation is computed from the coordinator activity executetime histogram and may be inaccurate if the histogram is not correctly sized to fit the data. The value of -1 is returned if any values fall into the last histogram bin. The execution time standard deviation of a service subclass is unaffected by activities that pass through the subclass but are remapped to a different subclass before they are completed.
COORD_ACT_QUEUE_TIME_AVG	DOUBLE	coord_act_queue_time_avg - Coordinator activity queue time average monitor element
COORD_ACT_QUEUE_TIME_STDDEV	DOUBLE	Standard deviation of the queue time for coordinator activities at nesting level 0 that were associated with this service subclass since the last reset. If the COLLECT AGGREGATE ACTIVITY DATA parameter of the service class is set to NONE, the value of the column is null. Units are milliseconds. This standard deviation is computed from the coordinator activity queuetime histogram and may be inaccurate if the histogram is not correctly sized to fit the data. The value of -1 is returned if any values fall into the last histogram bin. The queue time standard deviation is counted only toward the service subclass in which the activity was queued.
NUM_REQUESTS_ACTIVE	BIGINT	Number of requests that are running in the service subclass at the time that this table function is running.

Table 74. Information returned for WLM_GET_SERVICE_SUBCLASS_STATS (continued)

Column name	Data type	Description
NUM_REQUESTS_TOTAL	BIGINT	Number of requests that finished running in this service subclass since the last reset. This finished state applies to any request regardless of its membership in an activity. If the COLLECT AGGREGATE ACTIVITY DATA parameter of the service class is set to NONE, the value of the column is null. The NUM_REQUESTS_TOTAL value of a service subclass is unaffected by requests that pass through the service subclass but are not completed in it.
REQUEST_EXEC_TIME_AVG	DOUBLE	request_exec_time_avg - Request execution time average monitor element
REQUEST_EXEC_TIME_STDDEV	DOUBLE	Standard deviation of the execution times for requests that were associated with this service subclass since the last reset. Units are milliseconds. If the COLLECT AGGREGATE REQUEST DATA parameter of the service class is set to NONE, the value of this column is NULL. This standard deviation is computed from the request executetime histogram and may be inaccurate if the histogram is not correctly sized to fit the data. The value of -1 is returned if any values fall into the last histogram bin. The execution time standard deviation of a service subclass is unaffected by requests that pass through the subclass but were not completed in it.
REQUEST_EXEC_TIME_TOTAL	BIGINT	Sum of the execution times for requests that were associated with this service subclass since the last reset. Units are milliseconds. If the COLLECT AGGREGATE REQUEST DATA parameter of the service class is set to NONE, the value of this column is NULL. This total is computed from the request execution time histogram and may be inaccurate if the histogram is not correctly sized to fit the data. The value of -1 is returned if any values fall into the last histogram bin. The execution time total of a service subclass is unaffected by requests that pass through the subclass but are not completed in it.
ACT_REMAPPED_IN	BIGINT	Number of activities remapped into this service subclass by a threshold REMAP ACTIVITY action since the last reset.

Table 74. Information returned for WLM_GET_SERVICE_SUBCLASS_STATS (continued)

Column name	Data type	Description
ACT_REMAPPED_OUT	BIGINT	Number of activities remapped out of this service subclass by a threshold REMAP ACTIVITY action since the last reset.
CONCURRENT_WLO_TOP	INTEGER	concurrent_wlo_top - Concurrent workload occurrences top monitor element
UOW_TOTAL_TIME_TOP	BIGINT	uow_total_time_top - UOW total time top monitor element
UOW_THROUGHPUT	DOUBLE	uow_throughput - Unit of work throughput monitor element The unit of work throughput since the last reset of the statistics.
UOW_LIFETIME_AVG	DOUBLE	uow_lifetime_avg - Unit of work lifetime average monitor element
UOW_COMPLETED_TOTAL	BIGINT	uow_completed_total - Total completed units of work monitor element
TOTAL_CPU_TIME	BIGINT	total_cpu_time - Total CPU time monitor element
TOTAL_DISP_RUN_QUEUE_TIME	BIGINT	total_disp_run_queue_time - Total dispatcher run queue time monitor element
ACT_THROUGHPUT	DOUBLE	act_throughput - Activity throughput monitor element
CPU_UTILIZATION	DOUBLE	cpu_utilization - CPU utilization monitor element
APP_ACT_COMPLETED_TOTAL	BIGINT	app_act_completed_total - Total successful external coordinator activities monitor element
APP_ACT_ABORTED_TOTAL	BIGINT	app_act_aborted_total - Total failed external coordinator activities monitor element
APP_ACT_REJECTED_TOTAL	BIGINT	app_act_rejected_total - Total rejected external coordinator activities monitor element
MEMBER	SMALLINT	member - Database member monitor element

WLM_GET_SERVICE_SUPERCLASS_STATS - Return statistics of service superclasses

The WLM_GET_SERVICE_SUPERCLASS_STATS function returns basic statistics for one or more service superclasses.

Syntax

```
►►—WLM_GET_SERVICE_SUPERCLASS_STATS—(—service_superclass_name—,—member—)———►◄
```

The schema is SYSPROC.

Table function parameters

service_superclass_name
An input argument of type VARCHAR(128) that specifies the name of a service superclass in the currently connected database. If the argument is null or an empty string, data is retrieved for all the superclasses in the database.

member
An input argument of type INTEGER that specifies a valid member number in the same instance as the currently connected database. Specify -1 for the current database member, or -2 for all database members. If the null value is specified, -1 is set implicitly.

Authorization

One of the following authorities is required to execute the routine:
- EXECUTE privilege on the routine
- DATAACCESS authority
- DBADM authority
- SQLADM authority
- WLMADM authority

Default PUBLIC privilege

None

Example

The following query displays the basic statistics for all the service superclasses on the system, across all database members:

```
SELECT SUBSTR(SERVICE_SUPERCLASS_NAME, 1, 26) SERVICE_SUPERCLASS_NAME,
       MEMBER,
       LAST_RESET,
       CONCURRENT_CONNECTION_TOP CONCURRENT_CONN_TOP
FROM TABLE(WLM_GET_SERVICE_SUPERCLASS_STATS('', -2)) as SCSTATS
```

Sample output is as follows:

```
SERVICE_SUPERCLASS_NAME    MEMBER ...
-------------------------- ------------- ...
SYSDEFAULTSYSTEMCLASS                  0 ...
SYSDEFAULTMAINTENANCECLASS             0 ...
SYSDEFAULTUSERCLASS                    0 ...
```

```
... LAST_RESET                 CONCURRENT_CONN_TOP
... -------------------------- -------------------
... 2006-09-05-09.38.44.396788                   0
... 2006-09-05-09.38.44.396795                   0
... 2006-09-05-09.38.44.396796                   1
```

Usage note

The WLM_GET_SERVICE_SUPERCLASS_STATS table function returns one row of data per service superclass and per member. The function does not aggregate data across service superclasses (on a member) or across members (for one or more service superclasses). However, you can use SQL queries to aggregate data, as shown in the previous example.

Information returned

Table 75. Information returned for WLM_GET_SERVICE_SUPERCLASS_STATS

Column name	Data type	Description
SERVICE_SUPERCLASS_NAME	VARCHAR(128)	service_superclass_name - Service superclass name monitor element
DBPARTITIONNUM	SMALLINT	dbpartitionnum - Database partition number monitor element
LAST_RESET	TIMESTAMP	last_reset - Last Reset Timestamp monitor element
CONCURRENT_CONNECTION_TOP	INTEGER	concurrent_connection_top - Concurrent connection top monitor element
MEMBER	SMALLINT	member - Database member monitor element

WLM_GET_WORK_ACTION_SET_STATS - Return work action set statistics

The WLM_GET_WORK_ACTION_SET_STATS function returns the statistics for a work action set.

Syntax

```
►►—WLM_GET_WORK_ACTION_SET_STATS—(—work_action_set_name—,—member—)——————————►◄
```

The schema is SYSPROC.

Table function parameters

work_action_set_name
: An input argument of type VARCHAR(128) that specifies the work action set to return statistics for. If the argument is null or an empty string, statistics are returned for all work action sets.

member
: An input argument of type INTEGER that specifies a valid member number in the same instance as the currently connected database. Specify -1 for the current database member, or -2 for all database members. If the null value is specified, -1 is set implicitly.

Authorization

One of the following authorities is required to execute the routine:

- EXECUTE privilege on the routine
- DATAACCESS authority
- DBADM authority
- SQLADM authority
- WLMADM authority

Default PUBLIC privilege

None

Example

Assume that there are three work classes: ReadClass, WriteClass, and LoadClass. There is a work action associated with ReadClass and a work action associated with LoadClass, but there is no work action associated with WriteClass. On member 0, the number of activities currently running or queued are as follows:

- ReadClass class: eight
- WriteClass class: four
- LoadClass class: two
- Unassigned: three

```
SELECT SUBSTR(WORK_ACTION_SET_NAME,1,18) AS WORK_ACTION_SET_NAME,
       SUBSTR(CHAR(MEMBER),1,4) AS MEMB,
       SUBSTR(WORK_CLASS_NAME,1,15) AS WORK_CLASS_NAME,
       LAST_RESET,
       SUBSTR(CHAR(ACT_TOTAL),1,14) AS ACT_TOTAL
  FROM TABLE(WLM_GET_WORK_ACTION_SET_STATS
       (CAST(NULL AS VARCHAR(128)), -2)) AS WASSTATS
  ORDER BY WORK_ACTION_SET_NAME, WORK_CLASS_NAME, MEMB
```

Sample output is as follows. Because there is no work action associated with the WriteClass work class, the four activities to which it applies are counted in the artificial class denoted by an asterisk (*) in the output. The three activities that were not assigned to any work class are also included in the artificial class.

```
WORK_ACTION_SET_NAME MEMB WORK_CLASS_NAME LAST_RESET                 ACT_TOTAL
-------------------- ---- --------------- -------------------------- --------------
AdminActionSet       0    ReadClass       2005-11-25-18.52.49.343000 8
AdminActionSet       1    ReadClass       2005-11-25-18.52.50.478000 0
AdminActionSet       0    LoadClass       2005-11-25-18.52.49.343000 2
AdminActionSet       1    LoadClass       2005-11-25-18.52.50.478000 0
AdminActionSet       0    *               2005-11-25-18.52.49.343000 7
AdminActionSet       1    *               2005-11-25-18.52.50.478000 0
```

Information returned

Table 76. Information returned for WLM_GET_WORK_ACTION_SET_STATS

Column name	Data type	Description
WORK_ACTION_SET_NAME	VARCHAR(128)	work_action_set_name - Work action set name monitor element
DBPARTITIONNUM	SMALLINT	dbpartitionnum - Database partition number monitor element
LAST_RESET	TIMESTAMP	last_reset - Last Reset Timestamp monitor element
WORK_CLASS_NAME	VARCHAR(128)	work_class_name - Work class name monitor element
ACT_TOTAL	BIGINT	act_total - Activities total monitor element
MEMBER	SMALLINT	member - Database member monitor element

WLM_GET_WORKLOAD _OCCURRENCE _ACTIVITIES - Return a list of activities

The WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES function returns the list of all activities that were submitted by the specified application on the specified member and have not yet been completed.

Refer to Table 77 on page 395 for a complete list of information that can be returned.

Syntax

```
►►──WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES──(──application_handle──,──────────►

►──member──)──────────────────────────────────────────────────────────────────►◄
```

The schema is SYSPROC.

Table function parameters

application_handle
: An input argument of type BIGINT that specifies an application handle for which a list of activities is to be returned. If the argument is null, the data is retrieved for all the applications in the database.

member
: An input argument of type INTEGER that specifies a valid member number in the same instance as the currently connected database. Specify -1 for the current member, or -2 for all members. If the null value is specified, -1 is set implicitly.

Authorization

One of the following authorities is required to execute the routine:

- EXECUTE privilege on the routine
- DATAACCESS authority
- DBADM authority
- SQLADM authority
- WLMADM authority

Default PUBLIC privilege

None

Examples

Activities currently running with a known application handle

After you identify the application handle, you can look up all the activities currently running in this application. For example, suppose that an administrator wants to list the activities of an application whose application handle, determined by using the **LIST APPLICATIONS** command, is 1. The administrator runs the following query:

```
SELECT SUBSTR(CHAR(COORD_MEMBER),1,5) AS COORD,
     SUBSTR(CHAR(MEMBER),1,4) AS MEMB,
     SUBSTR(CHAR(UOW_ID),1,5) AS UOWID,
     SUBSTR(CHAR(ACTIVITY_ID),1,5) AS ACTID,
     SUBSTR(CHAR(PARENT_UOW_ID),1,8) AS PARUOWID,
     SUBSTR(CHAR(PARENT_ACTIVITY_ID),1,8) AS PARACTID,
            ACTIVITY_TYPE AS ACTTYPE,
     SUBSTR(CHAR(NESTING_LEVEL),1,7) AS NESTING
FROM TABLE(WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES(1, -2)) AS WLOACTS
ORDER BY MEMB, UOWID, ACTID
```

Sample output from the query is as follows:

```
COORD MEMB UOWID ACTID PARUOWID PARACTID ACTTYPE  NESTING
----- ---- ----- ----- -------- -------- -------- -------
0     0    2     3     -        -        CALL     0
0     0    2     5     2        3        READ_DML 1
```

Activities currently running on the system

The following query joins the WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES output with the MON_GET_PKG_CACHE_STMT output on EXECUTABLE_ID to provide statement text for all the SQL activities currently running on the system:

```
SELECT t.application_handle,
       t.uow_id,
       t.activity_id,
       varchar(p.stmt_text, 256) as stmt_text
FROM table(wlm_get_workload_occurrence_ACTIVITIES(NULL, -1)) as t,
     table(mon_get_pkg_cache_stmt(NULL, NULL, NULL, -1)) as p
WHERE t.executable_id = p.executable_id
```

Sample output is as follows:

```
APPLICATION_HANDLE   UOW_ID      ACTIVITY_ID    STMT_TEXT
------------------ ----------- -------------- ------------------------------
1                  1           1              SELECT * FROM SYSCAT.TABLES
47                 1           36             INSERT INTO T1 VALUES(123)
```

Information returned

Table 77. Information returned by WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES

Column name	Data type	Description
APPLICATION_HANDLE	BIGINT	application_handle - Application handle monitor element
DBPARTITIONNUM	SMALLINT	dbpartitionnum - Database partition number monitor element
COORD_PARTITION_NUM	SMALLINT	coord_partition_num - Coordinator partition number monitor element
LOCAL_START_TIME	TIMESTAMP	local_start_time - Local start time monitor element
UOW_ID	INTEGER	uow_id - Unit of work ID monitor element
ACTIVITY_ID	INTEGER	activity_id - Activity ID monitor element
PARENT_UOW_ID	INTEGER	parent_uow_id - Parent unit of work ID monitor element
PARENT_ACTIVITY_ID	INTEGER	parent_activity_id - Parent activity ID monitor element
ACTIVITY_STATE	VARCHAR(32)	activity_state - Activity state monitor element

Table 77. Information returned by WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES (continued)

Column name	Data type	Description
ACTIVITY_STATE (continued)	VARCHAR(32)	Activity state. Possible values are as follows: *QUEUED* The activity is queued by a workload management queuing threshold. In a partitioned database environment, this state might mean that the coordinator agent has made an RPC to the catalog member to obtain threshold tickets and has not yet received a response. This state might indicate that the activity has been queued by a workload management queuing threshold or, if not much time has elapsed, can indicate that the activity is in the process of obtaining its tickets. To obtain a more accurate picture of whether the activity is being queued, determine what agent is working on the activity, and find out whether the EVENT_OBJECT value of the object at the catalog member has a value of WLM_QUEUE. *TERMINATING* The activity has finished running and is being removed from the system.
ACTIVITY_TYPE	VARCHAR(32)	Activity type. Possible values are as follows: • CALL • DDL • LOAD • OTHER • READ_DML • WRITE_DML
NESTING_LEVEL	INTEGER	nesting_level - Nesting level monitor element
INVOCATION_ID	INTEGER	invocation_id - Invocation ID monitor element
ROUTINE_ID	INTEGER	routine_id - Routine ID monitor element
UTILITY_ID	INTEGER	utility_id - Utility ID monitor element
SERVICE_CLASS_ID	INTEGER	service_class_id - Service class ID monitor element
DATABASE_WORK_ACTION_SET_ID	INTEGER	One of the following values: • If this activity has been categorized into a work class of database scope, the value is the ID of the work class set of which this work class is a member. • If this activity has not been categorized into a work class of database scope, the value is null.

Table 77. Information returned by WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES (continued)

Column name	Data type	Description
DATABASE_WORK_CLASS_ID	INTEGER	One of the following values: • If this activity has been categorized into a work class of database scope, the value is the ID of the work class. • If this activity has not been categorized into a work class of database scope, the value is null.
SERVICE_CLASS_WORK_ACTION_SET_ID	INTEGER	One of the following values: • If this activity has been categorized into a work class of service class scope, the value is the ID of the work action set associated with the work class set to which the work class belongs. • If this activity has not been categorized into a work class of service class scope, the value is null.
SERVICE_CLASS_WORK_CLASS_ID	INTEGER	One of the following values: • If this activity has been categorized into a work class of service class scope, the value is the ID of the work class assigned to this activity. • If this activity has not been categorized into a work class of service class scope, the value is null.
EXECUTABLE_ID	VARCHAR(32) FOR BIT DATA	executable_id - Executable ID monitor element
TOTAL_CPU_TIME	BIGINT	total_cpu_time - Total CPU time
ROWS_READ	BIGINT	rows_read - Rows read
ROWS_RETURNED	BIGINT	rows_returned - Rows returned
QUERY_COST_ESTIMATE	BIGINT	query_cost_estimate - Query cost estimate
DIRECT_READS	BIGINT	direct_reads - Direct reads from database
DIRECT_WRITES	BIGINT	direct_writes - Direct writes to database
ENTRY_TIME	TIMESTAMP	entry_time - Entry time
MEMBER	SMALLINT	member - Database member monitor element
COORD_MEMBER	SMALLINT	coord_member - Coordinator member monitor element

WLM_GET_WORKLOAD_STATS table function - Return workload statistics

The WLM_GET_WORKLOAD_STATS function returns one row of workload statistics for every combination of workload name and database member number.

Refer to Table 78 on page 399 for a complete list of information that can be returned.

Syntax

```
►►—WLM_GET_WORKLOAD_STATS—(—workload_name—,—member—)————————————————————►◄
```

The schema is SYSPROC.

Table function parameters

workload_name
: An input argument of type VARCHAR(128) that specifies a workload for which the statistics are to be returned. If the argument is NULL or an empty string, statistics are returned for all workloads.

member
: An input argument of type INTEGER that specifies the number of a member in the same instance as the currently connected database. Specify -1 for the current member, or -2 for all members. If a null value is specified, -1 is set implicitly.

Authorization

One of the following authorities is required to execute the routine:

- EXECUTE privilege on the routine
- DATAACCESS authority
- DBADM authority
- SQLADM authority
- WLMADM authority

Default PUBLIC privilege

None

Example

The following query displays statistics for workloads:

```
SELECT SUBSTR(WORKLOAD_NAME,1,18) AS WL_DEF_NAME,
       SUBSTR(CHAR(MEMBER),1,4) AS MEMB,
       COORD_ACT_LIFETIME_TOP,
       COORD_ACT_LIFETIME_AVG,
       COORD_ACT_LIFETIME_STDDEV
FROM TABLE(WLM_GET_WORKLOAD_STATS(CAST(NULL AS VARCHAR(128)), -2)) AS WLSTATS
ORDER BY WL_DEF_NAME, MEMB
```

Sample output from the query is as follows:

```
WL_DEF_NAME        MEMB COORD_ACT_LIFETIME_TOP ...
------------------ ---- ---------------------- ...
SYSDEFAULTADMWORKL 0                        -1 ...
SYSDEFAULTUSERWORK 0                        -1 ...
WL1                0                         2 ...

... COORD_ACT_LIFETIME_AVG   COORD_ACT_LIFETIME_STDDEV
... ------------------------ ------------------------
... -1.00000000000000E+000    -1.00000000000000E+000
... -1.00000000000000E+000    -1.00000000000000E+000
... +2.56000000000000E+000    +6.00000000000001E-002
```

Usage note

The function does not aggregate data across workloads, members, or service classes. However, you can use SQL queries to aggregate data.

Information returned

Table 78. Information returned by WLM_GET_WORKLOAD_STATS

Column name	Data type	Description
WORKLOAD_NAME	VARCHAR(128)	workload_name - Workload name monitor element
DBPARTITIONNUM	SMALLINT	dbpartitionnum - Database partition number monitor element
LAST_RESET	TIMESTAMP	last_reset - Last Reset Timestamp monitor element
CONCURRENT_WLO_TOP	INTEGER	concurrent_wlo_top - Concurrent workload occurrences top monitor element
CONCURRENT_WLO_ACT_TOP	INTEGER	concurrent_wlo_act_top - Concurrent WLO activity top monitor element
COORD_ACT_COMPLETED_TOTAL	BIGINT	coord_act_completed_total - Coordinator activities completed total monitor element
COORD_ACT_ABORTED_TOTAL	BIGINT	coord_act_aborted_total - Coordinator activities aborted total monitor element
COORD_ACT_REJECTED_TOTAL	BIGINT	coord_act_rejected_total - Coordinator activities rejected total monitor element
WLO_COMPLETED_TOTAL	BIGINT	wlo_completed_total - Workload occurrences completed total monitor element
COORD_ACT_LIFETIME_TOP	BIGINT	coord_act_lifetime_top - Coordinator activity lifetime top monitor element
COORD_ACT_LIFETIME_AVG	DOUBLE	coord_act_lifetime_avg - Coordinator activity lifetime average monitor element
COORD_ACT_LIFETIME_STDDEV	DOUBLE	Standard deviation of lifetime for completed or aborted coordinator activities at nesting level 0 that are associated with this workload. Units are milliseconds. If the COLLECT AGGREGATE ACTIVITY DATA parameter of the workload is set to NONE, the value of the column is null. This standard deviation is computed from the coordinator activity lifetime histogram and may be inaccurate if the histogram is not correctly sized to fit the data. If any values fall into the last histogram bin, the value -1 is returned.
COORD_ACT_EXEC_TIME_AVG	DOUBLE	coord_act_exec_time_avg - Coordinator activities execution time average monitor element
COORD_ACT_EXEC_TIME_STDDEV	DOUBLE	Standard deviation of the execution times for completed or aborted coordinator activities at nesting level 0 that are associated with this workload. Units are milliseconds. This standard deviation is computed from the coordinator activity executetime histogram and may be inaccurate if the histogram is not correctly sized to fit the data. If any values fall into the last histogram bin, the value -1 is returned. If the COLLECT AGGREGATE ACTIVITY DATA parameter of the workload is set to NONE, the value of the column is null.

Table 78. Information returned by WLM_GET_WORKLOAD_STATS (continued)

Column name	Data type	Description
COORD_ACT_QUEUE_TIME_AVG	DOUBLE	coord_act_queue_time_avg - Coordinator activity queue time average monitor element
COORD_ACT_QUEUE_TIME_STDDEV	DOUBLE	Standard deviation of the queue time for completed or aborted coordinator activities at nesting level 0 that are associated with this workload. Units are milliseconds. If the COLLECT AGGREGATE ACTIVITY DATA parameter of the workload is set to NONE, the value of the column is null. This standard deviation is computed from the coordinator activity queuetime histogram and may be inaccurate if the histogram is not correctly sized to fit the data. If any values fall into the last histogram bin, the value -1 is returned.
UOW_TOTAL_TIME_TOP	BIGINT	uow_total_time_top - UOW total time top monitor element
UOW_THROUGHPUT	DOUBLE	uow_throughput - Unit of work throughput monitor element
UOW_LIFETIME_AVG	DOUBLE	uow_lifetime_avg - Unit of work lifetime average monitor element
UOW_COMPLETED_TOTAL	BIGINT	uow_completed_total - Total completed units of work monitor element
TOTAL_CPU_TIME	BIGINT	total_cpu_time - Total CPU time monitor element
TOTAL_DISP_RUN_QUEUE_TIME	BIGINT	total_disp_run_queue_time - Total dispatcher run queue time monitor element
ACT_THROUGHPUT	DOUBLE	act_throughput - Activity throughput monitor element
CPU_UTILIZATION	DOUBLE	cpu_utilization - CPU utilization monitor element
APP_ACT_COMPLETED_TOTAL	BIGINT	app_act_completed_total - Total successful external coordinator activities monitor element
APP_ACT_ABORTED_TOTAL	BIGINT	app_act_aborted_total - Total failed external coordinator activities monitor element
APP_ACT_REJECTED_TOTAL	BIGINT	app_act_rejected_total - Total rejected external coordinator activities monitor element
MEMBER	SMALLINT	member - Database member monitor element

WLM_SET_CLIENT_INFO procedure - Set client information

The WLM_SET_CLIENT_INFO procedure sets client information associated with the current connection at the DB2 server.

By using this procedure, you can set the client's user ID, application name, workstation name, accounting information, or workload information at the DB2 server. Calling this procedure changes the stored values of the relevant transaction processor (TP) monitor client information fields and special register settings for this connection.

The client information fields are used at the DB2 server for determining the identity of the application or user currently using the connection. The client information fields for a connection are considered during DB2 workload evaluation and also displayed in any DB2 audit records or application snapshots generated for this connection.

Unlike the sqleseti API, this procedure does not set client information at the client but instead sets the corresponding client attributes on the DB2 server. Therefore, you cannot use the sqleqry API to query the client information that is set at the DB2 server using this procedure. If an application uses the sqleseti API to change the client information, the new values will change the setting at the DB2 server. If the sqleseti API is used to change either the user ID or the application name without changing the accounting information, the accounting information at the DB2 server will also be reset to the value of the accounting information at the client.

The data values provided with the procedure are converted to the appropriate database code page before being stored in the related TP monitor fields or special registers. Any data value which exceeds the maximum supported size after conversion to the database code page is truncated before being stored at the server. The truncated values are returned by both the TP monitor fields and the special registers when those stored values are queried.

The WLM_SET_CLIENT_INFO procedure is not under transaction control, and client information changes made by the procedure are independent of committing or rolling back units of work. However, because workload reevaluation occurs at the beginning of the next unit of work for each application, you must issue either a COMMIT or a ROLLBACK statement to make client information changes effective.

Syntax

```
►►──WLM_SET_CLIENT_INFO──(──client_userid──,──client_wrkstnname──,──────────────────►

►──client_applname──,──client_acctstr──,──client_workload──)──────────────────────►◄
```

The schema is SYSPROC.

Procedure parameters

client_userid
: An input argument of type VARCHAR(255) that specifies the user ID for the client. If you specify NULL, the value remains unchanged. If you specify an empty string, which is the default value, the user ID for the client is reset to the default value, which is blank.

client_wrkstnname
: An input argument of type VARCHAR(255) that specifies the workstation name for the client. If you specify NULL, the value remains unchanged. If you specify an empty string, which is the default value, the workstation name for the client is reset to the default value, which is blank.

client_applname
: An input argument of type VARCHAR(255) that specifies the application name for the client. If you specify NULL, the value remains unchanged. If you specify an empty string, which is the default value, the application name for the client is reset to the default value, which is blank.

client_acctstr
: An input argument of type VARCHAR(200) that specifies the accounting string

for the client. If you specify NULL, the value remains unchanged. If you specify an empty string, which is the default value, the accounting string for the client is reset to the default value, which is blank.

`client_workload`
: An input argument of type VARCHAR(255) that specifies the workload assignment mode for the client. If you specify NULL, the value remains unchanged. The values are as follows:

SYSDEFAULTADMWORKLOAD
: Specifies that the database connection will be assigned to SYSDEFAULTADMWORKLOAD, enabling users with ACCESSCTRL, DATAACCESS, DBADM, SECADM, or WLMADM authority to bypass the normal workload evaluation.

AUTOMATIC
: Specifies that the database connection will be assigned to a workload chosen by the workload evaluation that is performed automatically by the server.

Note: The *client_workload* argument is case sensitive.

Authorization

One of the following authorities is required to execute the routine:
- EXECUTE privilege on the routine
- DATAACCESS authority
- DBADM authority
- SQLADM authority
- WLMADM authority

Default PUBLIC privilege

None

Examples

The following procedure call sets the user ID, workstation name, application name, accounting string, and workload assignment mode for the client:

```
CALL SYSPROC.WLM_SET_CLIENT_INFO('db2user', 'machine.torolab.ibm.com',
   'auditor', 'Accounting department', 'AUTOMATIC')
```

The following procedure call sets the user ID to db2user2 for the client without setting the other client attributes:

```
CALL SYSPROC.WLM_SET_CLIENT_INFO('db2user2', NULL, NULL, NULL, NULL)
```

The following procedure call resets the user ID for the client to blank without modifying the values of the other client attributes:

```
CALL SYSPROC.WLM_SET_CLIENT_INFO('', NULL, NULL, NULL, NULL)
```

Usage Notes

If the input that you specify for any procedure parameter exceeds its specified field length, the input field is truncated and the procedure runs using the truncated inputs.

Input fields containing single quotations are not supported and result in an error.

Workload management monitor elements

The following monitor elements provide information about activities, threshold violations, and workload management statistics.

act_cpu_time_top – Activity CPU time top monitor element

The high watermark for processor time used by activities at all nesting levels in a service class, workload, or work class. This value is reported in microseconds.

The monitor element returns -1 when COLLECT AGGREGATE ACTIVITY DATA for the service class or workload in which the activity runs is set to NONE. Activities contribute toward this high watermark only when request metrics are enabled. If the collection of activity metrics is not enabled, a value of 0 is returned.

For service classes, when you remap activities between service subclasses with a REMAP ACTIVITY action, only the act_cpu_time_top high watermark of the service subclass where an activity completes is updated, provided that a new high watermark is reached. The act_cpu_time_top high watermarks of other service subclasses an activity is mapped to but does not complete in are unaffected.

Table 79. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats	Always collected
Statistics	event_wcstats	Always collected
Statistics	event_wlstats	Always collected

Usage

Use this element to determine the highest amount of processor time used by an activity on a member for a service class, workload, or work class during the time interval collected.

act_exec_time - Activity execution time monitor element

Time spent executing at this member, in microseconds. For cursors, the execution time is the combined time for the open, the fetches, and the close. The time when the cursor is idle is not counted toward execution time. For routines, execution time is the start to end of routine invocation. The lifetimes of any cursors left open by routine (to return a result set) after the routine finishes are not counted toward the routine execution time. For all other activities, execution time is the difference between start time and stop time. In all cases, execution time does not include time spent initializing or queued.

Table 80. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity	Always collected

Usage

This element can be used alone to know the elapsed time spent executing the activity by DB2 on each member. This element can also be used together with

time_started and **time_completed** monitor elements on the coordinator member to compute the idle time for cursor activities. You can use the following formula:

```
Cursor idle time = (time_completed - time_started) - act_exec_time
```

act_remapped_in – Activities remapped in monitor element

Count of the number of activities to be remapped into this service subclass since the last reset.

Table 81. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats	-

Usage

Use this count to determine whether the remapping of activities into the service subclass is occurring as desired.

act_remapped_out – Activities remapped out monitor element

Count of the number of activities to be remapped out of this service subclass since the last reset.

Table 82. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats	-

Usage

Use this count to determine whether the remapping of activities out of the service subclass is occurring as desired.

act_rows_read_top – Activity rows read top monitor element

The high watermark for the number of rows read by activities at all nesting levels in a service class, workload, or work class.

The monitor element returns -1 when COLLECT AGGREGATE ACTIVITY DATA for the service class or workload in which the activity runs is set to NONE. Activities contribute toward this high watermark only when request metrics are enabled. If the collection of activity metrics is not enabled, a value of 0 is returned.

For service classes, when you remap activities between service subclasses with a REMAP ACTIVITY action only the act_rows_read_top high watermark of the service subclass where an activity completes is updated, provided that a new high watermark is reached. The act_rows_read_top high watermarks of service subclasses an activity is mapped to but does not complete in are unaffected.

Table 83. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats	Always collected
Statistics	event_wcstats	Always collected
Statistics	event_wlstats	Always collected

Usage

Use this element to determine the highest number of rows read by an activity on a member for a service class, workload, or work class during the time interval collected.

act_throughput - Activity throughput monitor element

The rate at which coordinator activities are completed at any nesting level. Measured in coordinator activities per second.

Table 84. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_SAMPLE_SERVICE_CLASS_METRICS - Get sample service class metrics	REQUEST METRICS BASE
MON_SAMPLE_WORKLOAD_METRICS - Get sample workload metrics	REQUEST METRICS BASE
WLM_GET_SERVICE_SUBCLASS_STATS table function - Return statistics of service subclasses	ACTIVITY METRICS BASE
WLM_GET_WORKLOAD_STATS table function - Return workload statistics	ACTIVITY METRICS BASE

Table 85. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats (reported in the details_xml document)	Always collected
Statistics	event_wlstats (reported in the details_xml document)	Always collected

Usage

When returned by the WLM_GET_SERVICE_SUBCLASS_STATS or the WLM_GET_WORKLOAD_STATS function, this monitor element represents the activity throughput since the last reset of the statistics.

When returned by the MON_SAMPLE_SERVICE_CLASS_METRICS or the MON_SAMPLE_WORKLOAD_METRICS function, this monitor element represents the activity throughput since the function was executed.

act_total - Activities total monitor element

Total number of activities at any nesting level that had work actions corresponding to the specified work class applied to them since the last reset.

Table 86. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_WORK_ACTION_SET_STATS table function - Return work action set statistics	ACTIVITY METRICS BASE

Table 87. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_wcstats	-

Usage

Every time an activity has one or more work actions associated with a work class applied to it, a counter for the work class is updated. This counter is exposed using the **`act_total`** monitor element. The counter can be used to judge the effectiveness of the work action set (for example, how many activities have a actions applied). It can also be used to understand the different types of activities on the system.

activate_timestamp - Activate timestamp monitor element

The time when an event monitor was activated.

Table 88. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activity	event_activity	-
Activity	event_activitystmt	-
Activity	event_activityvals	-
Threshold Violations	event_thresholdviolations	-

Usage

Use this element to correlate information returned by the previously mentioned event types.

activity_collected - Activity collected monitor element

This element indicates whether or not activity event monitor records are to be collected for a violated threshold.

Table 89. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Threshold violations	event_thresholdviolations	-

Usage

Use this element to determine whether to expect an activity event for the activity that violated the threshold to be written to the activity event monitor.

When an activity finishes or aborts and the activity event monitor is active at the time, if the value of this monitor element is ‘Y', the activity that violated this threshold will be collected. If the value of this monitor element is ‘N', it will not be collected.

activity_id - Activity ID monitor element

Counter which uniquely identifies an activity for an application within a given unit of work.

Table 90. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE
WLM_GET_SERVICE_CLASS_AGENTS table function - list agents running in a service class	ACTIVITY METRICS BASE
WLM_GET_WORKLOAD_OCCURRENCE _ACTIVITIES table function - Return a list of activities	ACTIVITY METRICS BASE

Table 91. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Locking	-	Always collected
Activities	event_activity	Always collected
Activities	event_activitystmt	Always collected
Activities	event_activityvals	Always collected
Activities	event_activitymetrics	ACTIVITY METRICS BASE
Threshold violations	event_thresholdviolations	Always collected

Usage

Use this element in conjunction with other activity history elements for analysis of the behavior of an activity.

To uniquely identify an activity outside its unit of work, use the combination of **activity_id** and **uow_id** plus one of the following monitor elements: **appl_id** or **agent_id**.

activity_secondary_id - Activity secondary ID monitor element

The value for this element is incremented each time an activity record is written for the same activity. For example, if an activity record is written once as a result of having called the WLM_CAPTURE_ACTIVITY_IN_PROGRESS procedure and a second time when the activity ends, the element would have a value of 0 for the first record and 1 for the second record.

Table 92. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity	-
Activities	event_activitystmt	-
Activities	event_activityvals	-
Activities	event_activitymetrics	ACTIVITY METRICS BASE

Usage

Use this element with **activity_id**, **uow_id**, and **appl_id** monitor elements to uniquely identify activity records when information about the same activity has been written to the activities event monitor multiple times.

For example, information about an activity would be sent to the activities event monitor twice in the following case:

- the WLM_CAPTURE_ACTIVITY_IN_PROGRESS stored procedure was used to capture information about the activity while it was running
- information about the activity was collected when the activity completed, because the COLLECT ACTIVITY DATA clause was specified on the service class with which the activity is associated

activity_type - Activity type monitor element

The type of the activity.

Table 93. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Table 94. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity	Always collected

Usage

The possible values are:

- LOAD
- READ_DML
- WRITE_DML
- DDL
- CALL
- OTHER

The value OTHER is returned for SET statements that do not perform SQL (for example, SET special register, or SET EVENT MONITOR STATE) and the LOCK TABLE statement.

agg_temp_tablespace_top - Aggregate temporary table space top monitor element

The high watermark in KB for the aggregate temporary table space usage of DML activities at all nesting levels in a service class. The aggregate is computed by summing the temporary table space usage across all activities in the service subclass, and this high watermark represents the highest value reached by this aggregate since the last reset. The monitor element returns -1 when COLLECT AGGREGATE ACTIVITY DATA for the service class is set to NONE. An AGGSQLTEMPSPACE threshold must be defined and enabled for at least one service subclass in the same superclass as the subclass to which this record belongs, otherwise a value of 0 is returned.

Table 95. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats	Always collected

Usage

Use this element to determine the highest aggregate DML activity system temporary table space usage reached on a member for a service subclass in the time interval collected.

arm_correlator - Application response measurement correlator monitor element

Identifier of a transaction in the Application Response Measurement (ARM) standard.

Table 96. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity	-

Usage

This element can be used to link an activity collected by the activities event monitor to the applications associated with the activity, if such applications also support the Application Response Measurement (ARM) standard.

bin_id - Histogram bin identifier monitor element

The identifier of a histogram bin. The **bin_id** is unique within a histogram.

Table 97. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_histogrambin	-

Usage

Use this element to distinguish bins within the same histogram.

bottom - Histogram bin bottom monitor element

The exclusive bottom end of the range of a histogram bin. The value of this monitor element is also the top inclusive end of the range of the previous histogram bin, if there is one.

Table 98. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_histogrambin	-

Usage

Use this element with the corresponding **top** element to determine the range of a bin within a histogram.

concurrent_act_top - Concurrent activity top monitor element

The high watermark for the concurrent activities (at any nesting level) in a service subclass since the last reset.

Note: This element monitors the highest concurrent execution of all activities, including those activities that do not participate in the CONCURRENTDBCOORDACTIVITIES threshold. For example, although CALL statements do not count toward the concurrency that is enforced by the CONCURRENTDBCOORDACTIVITIES threshold, they are included in the concurrent activity high watermark measurement.

Table 99. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_SERVICE_CLASS_WORKLOAD _OCCURRENCES table function - list workload occurrences	ACTIVITY METRICS BASE
WLM_GET_SERVICE_SUBCLASS_STATS table function - Return statistics of service subclasses	ACTIVITY METRICS BASE

Table 100. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats	-

Usage

Use this element to know the highest concurrency of activities (including nested activities) reached on a member for a service subclass in the time interval collected.

concurrent_connection_top - Concurrent connection top monitor element

High watermark for concurrent coordinator connections in this service class since the last reset. This field has the same value in every subclass of the same superclass.

Table 101. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_SERVICE_SUPERCLASS_STATS table function - Return statistics of service superclasses	ACTIVITY METRICS BASE

Table 102. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats	-

Usage

This element may be useful in determining where to place thresholds on connection concurrency by showing where the current high watermark is. It is also useful for verifying that such a threshold is configured correctly and doing its job.

concurrent_wlo_act_top - Concurrent WLO activity top monitor element

High watermark for concurrent activities (at any nesting level) of any occurrence of this workload since the last reset.

Table 103. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_WORKLOAD_STATS table function - Return workload statistics	ACTIVITY METRICS BASE

Table 104. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_wlstats	-

Usage

Use this element to know the highest number of concurrent activities reached on a member for any occurrence of this workload in the time interval collected.

concurrent_wlo_top - Concurrent workload occurrences top monitor element

The high watermark for the concurrent occurrences of a workload since the last reset.

Table 105. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_SERVICE_SUBCLASS_STATS table function - Return statistics of service subclasses	ACTIVITY METRICS BASE
WLM_GET_WORKLOAD_STATS table function - Return workload statistics	ACTIVITY METRICS BASE

Table 106. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_wlstats	-
Statistics	event_scstats	-

Usage

Use this element to know the highest concurrency of workload occurrences reached on a member for a workload in the time interval collected.

concurrentdbcoordactivities_db_ threshold_id - Concurrent database coordinator activities database threshold ID monitor element

The ID of the CONCURRENTDBCOORDACTIVITIES database threshold that was applied to the activity.

Table 107. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Usage

Use this element to understand which CONCURRENTDBCOORDACTIVITIES database threshold, if any, was applied to the activity.

concurrentdbcoordactivities_db_threshold _queued - Concurrent database coordinator activities database threshold queued monitor element

This monitor element returns 'Yes' to indicate that the activity was queued by the CONCURRENTDBCOORDACTIVITIES database threshold. 'No' indicates that the activity was not queued.

Table 108. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Usage

Use this element to understand if the activity was queued by the CONCURRENTDBCOORDACTIVITIES database threshold applied to the activity.

concurrentdbcoordactivities_db_ threshold_value - Concurrent database coordinator activities database threshold value monitor element

This monitor element returns the upper bound of the CONCURRENTDBCOORDACTIVITIES database threshold that was applied to the activity.

Table 109. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Usage

Use this element to understand the value of the CONCURRENTDBCOORDACTIVITIES database threshold applied to the activity, if any.

concurrentdbcoordactivities_db_ threshold_violated - Concurrent database coordinator activities database threshold violated monitor element

This monitor element returns 'Yes' to indicate that the activity violated the CONCURRENTDBCOORDACTIVITIES database threshold. 'No' indicates that the activity has not yet violated the threshold.

Table 110. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Usage

Use this element to determine if the activity violated the CONCURRENTDBCOORDACTIVITIES database threshold that was applied to the activity.

concurrentdbcoordactivities_subclass_ threshold_id - Concurrent database coordinator activities service subclass threshold ID monitor element

This monitor element returns the ID of the CONCURRENTDBCOORDACTIVITIES service subclass threshold threshold that was applied to the activity.

Table 111. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Usage

Use this element to understand which CONCURRENTDBCOORDACTIVITIES service subclass threshold, if any, was applied to the activity.

concurrentdbcoordactivities_subclass_ threshold_queued - Concurrent database coordinator activities service subclass threshold queued monitor element

This monitor element returns 'Yes' to indicate that the activity was queued by the CONCURRENTDBCOORDACTIVITIES service subclass threshold. 'No' indicates that the activity was not queued.

Table 112. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Usage

Use this element to understand if the activity was queued by the CONCURRENTDBCOORDACTIVITIES service subclass threshold applied to the activity.

concurrentdbcoordactivities_subclass_ threshold_value - Concurrent database coordinator activities service subclass threshold value monitor element

This monitor element returns the upper bound of the CONCURRENTDBCOORDACTIVITIES service subclass threshold that was applied to the activity.

Table 113. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE
WLM_GET_ACTIVITY_DETAILS table function - Return detailed information about a specific activity	ACTIVITY METRICS BASE

Usage

Use this element to understand the value of the CONCURRENTDBCOORDACTIVITIES service subclass threshold applied to the activity, if any.

concurrentdbcoordactivities_subclass_ threshold_violated - Concurrent database coordinator activities service subclass threshold violated monitor element

This monitor element returns 'Yes' to indicate that the activity violated the CONCURRENTDBCOORDACTIVITIES service subclass threshold. 'No' indicates that the activity has not yet violated the threshold.

Table 114. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Usage

Use this element to determine if the activity violated the CONCURRENTDBCOORDACTIVITIES service subclass threshold that was applied to the activity.

concurrentdbcoordactivities_superclass_ threshold_id - Concurrent database coordinator activities service superclass threshold ID monitor element

The ID of the CONCURRENTDBCOORDACTIVITIES_SUPERCLASS threshold that was applied to the activity.

Table 115. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Usage

Use this element to understand which CONCURRENTDBCOORDACTIVITIES service superclass threshold, if any, was applied to the activity.

concurrentdbcoordactivities_superclass_ threshold_queued - Concurrent database coordinator activities service superclass threshold queued monitor element

This monitor element returns 'Yes' to indicate that the activity was queued by the CONCURRENTDBCOORDACTIVITIES service superclass threshold. 'No' indicates that the activity was not queued.

Table 116. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Usage

Use this element to understand if the activity was queued by the CONCURRENTDBCOORDACTIVITIES service superclass threshold applied to the activity.

concurrentdbcoordactivities_superclass_ threshold_value - Concurrent database coordinator activities service superclass threshold value monitor element

The upper bound of the CONCURRENTDBCOORDACTIVITIES service superclass threshold that was applied to the activity.

Table 117. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Usage

Use this element to understand the value of the CONCURRENTDBCOORDACTIVITIES service superclass threshold applied to the activity, if any.

concurrentdbcoordactivities_superclass_ threshold_violated - Concurrent database coordinator activities service superclass threshold violated monitor element

This monitor element returns 'Yes' to indicate that the activity violated the CONCURRENTDBCOORDACTIVITIES service superclass threshold. 'No' indicates that the activity has not yet violated the threshold.

Table 118. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Usage

Use this element to determine if the activity violated the CONCURRENTDBCOORDACTIVITIES service superclass threshold that was applied to the activity.

concurrentdbcoordactivities_wl_was_threshold _id - Concurrent database coordinator activities workload work action set threshold ID monitor element

The identifier of the CONCURRENTDBCOORDACTIVITIES workload work action set threshold that was applied to the activity.

Table 119. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Usage

Use this element to understand which CONCURRENTDBCOORDACTIVITIES workload work action set threshold, if any, was applied to the activity.

concurrentdbcoordactivities_wl_was_threshold _queued - Concurrent database coordinator activities workload work action set threshold queued monitor element

This monitor element returns `'Yes'` to indicate that the activity was queued by the CONCURRENTDBCOORDACTIVITIES workload work action set threshold. `'No'` indicates that the activity was not queued.

Table 120. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Usage

Use this element to understand if the activity was queued by the CONCURRENTDBCOORDACTIVITIES workload work action set threshold applied to the activity.

concurrentdbcoordactivities_wl_was_threshold _value - Concurrent database coordinator activities workload work action set threshold value monitor element

The upper bound of the CONCURRENTDBCOORDACTIVITIES workload work action set threshold that was applied to the activity.

Table 121. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Usage

Use this element to understand the value of the CONCURRENTDBCOORDACTIVITIES workload work action set threshold applied to the activity.

concurrentdbcoordactivities_wl_was_threshold _violated - Concurrent database coordinator activities workload work action set threshold violated monitor element

This monitor element returns `'Yes'` to indicate that the activity violated the CONCURRENTDBCOORDACTIVITIES workload work action set threshold. `'No'` indicates that the activity has not yet violated the threshold.

Table 122. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Usage

Use this element to determine if the activity violated the CONCURRENTDBCOORDACTIVITIES workload work action set threshold that was applied to the activity.

coord_act_aborted_total - Coordinator activities aborted total monitor element

The total number of coordinator activities at any nesting level that completed with errors since the last reset. For service classes, the value is updated when the activity completes. For workloads, the value is updated by each workload occurrence at the end of its unit of work.

For service classes, if you remap an activity to a different subclass with a REMAP ACTIVITY action before it aborts, then this activity counts only toward the total of the subclass it aborts in.

Table 123. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_SERVICE_CLASS_WORKLOAD _OCCURRENCES table function - list workload occurrences	ACTIVITY METRICS BASE
WLM_GET_SERVICE_SUBCLASS_STATS table function - Return statistics of service subclasses	ACTIVITY METRICS BASE
WLM_GET_WORKLOAD_STATS table function - Return workload statistics	ACTIVITY METRICS BASE

Table 124. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats	-
Statistics	event_wlstats	-

Usage

Use this element to understand if activities on the system are completing successfully. Activities may be aborted due to cancellation, errors or reactive thresholds.

coord_act_completed_total - Coordinator activities completed total monitor element

The total number of coordinator activities at any nesting level that completed successfully since the last reset. For service classes, the value is updated when the activity completes. For workloads, the value is updated by each workload occurrence at the end of its unit of work.

For service classes, if you remap an activity to a different subclass with a REMAP ACTIVITY action before it completes, then this activity counts only toward the total of the subclass it completes in.

Table 125. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_SERVICE_CLASS_WORKLOAD _OCCURRENCES table function - list workload occurrences	ACTIVITY METRICS BASE

Table 125. Table Function Monitoring Information (continued)

Table Function	Monitor Element Collection Level
WLM_GET_SERVICE_SUBCLASS_STATS table function - Return statistics of service subclasses	ACTIVITY METRICS BASE
WLM_GET_WORKLOAD_STATS table function - Return workload statistics	ACTIVITY METRICS BASE

Table 126. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_wlstats	-
Statistics	event_scstats	-

Usage

This element can be used to determine the throughput of activities in the system or to aid in calculating average activity lifetime across multiple members.

coord_act_est_cost_avg - Coordinator activity estimated cost average monitor element

Arithmetic mean of the estimated costs for coordinator DML activities at nesting level 0 associated with this service subclass or work class since the last reset. If the internally tracked average has overflowed, the value -2 is returned. For service subclasses, this monitor element returns -1 when COLLECT AGGREGATE ACTIVITY DATA for the service subclass is set to NONE or BASE. For work classes, this monitor elements returns -1 if no COLLECT AGGREGATE ACTIVITY DATA EXTENDED work action is specified for the work class. For workloads, this monitor element returns -1 when COLLECT AGGREGATE ACTIVITY DATA for the workload is set to NONE or BASE. Units are timerons.

For service classes, the estimated cost of an activity is counted only toward the service subclass in which the activity enters the system. When you remap activities between service subclasses with a REMAP ACTIVITY action, the coord_act_est_cost_avg mean of the service subclass you remap an activity to is unaffected.

Table 127. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats	Always collected
Statistics	event_wcstats	Always collected
Statistics	event_wlstats	Always collected

Usage

Use this statistic to determine the arithmetic mean of the estimated costs of coordinator DML activities at nesting level 0 that are associated this service subclass, workload, or work class that completed or aborted since the last statistics reset.

This average can also be used to determine whether or not the histogram template used for the activity estimated cost histogram is appropriate. Compute the average activity estimated cost from the activity estimated cost histogram. Compare the computed average with this monitor element. If the computed average deviates from the true average reported by this monitor element, consider altering the histogram template for the activity estimated cost histogram, using a set of bin values that are more appropriate for your data.

coord_act_exec_time_avg - Coordinator activities execution time average monitor element

Arithmetic mean of execution times for coordinator activities at nesting level 0 associated with this service subclass or work class since the last reset. If the internally tracked average has overflowed, the value -2 is returned. For service subclasses, this monitor element returns -1 when COLLECT AGGREGATE ACTIVITY DATA for the service subclass is set to NONE. For work classes, this monitor elements returns -1 if no COLLECT AGGREGATE ACTIVITY DATA work action is specified for the work class. For workloads, this monitor element returns -1 when COLLECT AGGREGATE ACTIVITY DATA for the workload is set to NONE. Units are milliseconds.

For service classes, when you remap activities between service subclasses with a REMAP ACTIVITY action, the coord_act_exec_time_avg mean of service subclasses an activity is mapped to but does not complete in is unaffected.

Table 128. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_SERVICE_SUBCLASS_STATS table function - Return statistics of service subclasses	COLLECT AGGREGATE ACTIVITY DATA
WLM_GET_WORKLOAD_STATS table function - Return workload statistics	COLLECT AGGREGATE ACTIVITY DATA

Table 129. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats	-
Statistics	event_wcstats	-
Statistics	event_wlstats	-

Usage

Use this statistic to determine the arithmetic mean of execution time for coordinator activities associated with a service subclass, workload, or work class that completed or aborted.

This average can also be used to determine whether or not the histogram template used for the activity execution time histogram is appropriate. Compute the average activity execution time from the activity execution time histogram. Compare the computed average with this monitor element. If the computed average deviates from the true average reported by this monitor element, consider altering the histogram template for the activity execution time histogram, using a set of bin values that are more appropriate for your data.

coord_act_interarrival_time_avg - Coordinator activity arrival time average monitor element

Arithmetic mean of the time between arrivals of coordinator activities at nesting level 0 associated with this service subclass or work class since the last reset. If the internally tracked average has overflowed, the value -2 is returned. For service subclasses, this monitor element returns -1 when COLLECT AGGREGATE ACTIVITY DATA for the service subclass is set to NONE or BASE. For work classes, this monitor elements returns -1 if no COLLECT AGGREGATE ACTIVITY DATA EXTENDED work action is specified for the work class. For workloads, this monitor element returns -1 when COLLECT AGGREGATE ACTIVITY DATA for the workload is set to NONE or BASE. Units are milliseconds.

For service classes, the inter-arrival time mean is calculated for service subclasses through which activities enter the system. When you remap activities between service subclasses with a REMAP ACTIVITY action, the coord_act_interarrival_time_avg of the service subclass you remap an activity to is unaffected.

Table 130. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats	-
Statistics	event_wcstats	-
Statistics	event_wlstats	-

Usage

Use this statistic to determine the arithmetic mean between arrivals of coordinator activities at nesting level 0 associated with this service subclass, workload, or work class.

The inter-arrival time can be used to determine arrival rate, which is the inverse of inter-arrival time. This average can also be used to determine whether or not the histogram template used for the activity inter-arrival time histogram is appropriate. Compute the average activity inter-arrival time from the activity inter-arrival time histogram. Compare the computed average with this monitor element. If the computed average deviates from the true average reported by this monitor element, consider altering the histogram template for the activity inter-arrival time histogram, using a set of bin values that are more appropriate for your data.

coord_act_lifetime_avg - Coordinator activity lifetime average monitor element

Arithmetic mean of lifetime for coordinator activities at nesting level 0 associated with this service subclass, workload, or work class since the last reset. If the internally tracked average has overflowed, the value -2 is returned. For service subclasses, this monitor element returns -1 when COLLECT AGGREGATE ACTIVITY DATA for the service subclass is set to NONE. For work classes, this monitor elements returns -1 if no COLLECT AGGREGATE ACTIVITY DATA work action is specified for the work class. For workloads, this monitor element returns -1 when COLLECT AGGREGATE ACTIVITY DATA for the workload is set to NONE. Units are milliseconds.

For service classes, when you remap activities between service subclasses with a REMAP ACTIVITY action, only the the coord_act_lifetime_avg mean of the final service class where the activity completes is affected.

Table 131. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_SERVICE_SUBCLASS_STATS table function - Return statistics of service subclasses	COLLECT AGGREGATE ACTIVITY DATA
WLM_GET_WORKLOAD_STATS table function - Return workload statistics	COLLECT AGGREGATE ACTIVITY DATA

Table 132. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats	-
Statistics	event_wcstats	-
Statistics	event_wlstats	-

Usage

Use this statistic to determine the arithmetic mean of the lifetime for coordinator activities associated with a service subclass, workload, or work class that completed or aborted.

This statistic can also be used to determine whether or not the histogram template used for the activity lifetime histogram is appropriate. Compute the average activity lifetime from the activity lifetime histogram. Compare the computed average with this monitor element. If the computed average deviates from the true average reported by this monitor element, consider altering the histogram template for the activity lifetime histogram, using a set of bin values that are more appropriate for your data.

coord_act_lifetime_top - Coordinator activity lifetime top monitor element

High watermark for coordinator activity lifetime, counted at all nesting levels. Units are milliseconds. For service classes, this monitor element returns -1 when COLLECT AGGREGATE ACTIVITY DATA for the service class is set to NONE. For work classes, this monitor element returns -1 if no COLLECT AGGREGATE ACTIVITY DATA work action is specified for the work class. For workloads, this monitor element returns -1 when COLLECT AGGREGATE ACTIVITY DATA for the workload is set to NONE.

To effectively use this statistic with service classes when you also remap activities between service subclasses with a REMAP ACTIVITY action, you must aggregate the coord_act_lifetime_top high watermark of any given service subclass with that of other subclasses affected by the same remapping threshold or thresholds. This is because an activity will complete after it has been remapped to a different service subclass by a remapping threshold, and the time the activity spends in other service subclasses before being remapped is counted only toward the service class in which it completes.

Table 133. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_SERVICE_SUBCLASS_STATS table function - Return statistics of service subclasses	COLLECT AGGREGATE ACTIVITY DATA
WLM_GET_WORKLOAD_STATS table function - Return workload statistics	COLLECT AGGREGATE ACTIVITY DATA

Table 134. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_wcstats	-
Statistics	event_scstats	-
Statistics	event_wlstats	-

Usage

This element can be used to help determine whether or not thresholds on activity lifetime are being effective and can also help to determine how to configure such thresholds.

coord_act_queue_time_avg - Coordinator activity queue time average monitor element

Arithmetic mean of queue time for coordinator activities at nesting level 0 associated with this service subclass or work class since the last reset. If the internally tracked average has overflowed, the value -2 is returned. For service subclasses, this monitor element returns -1 when COLLECT AGGREGATE ACTIVITY DATA for the service subclass is set to NONE. For work classes, this monitor elements returns -1 if no COLLECT AGGREGATE ACTIVITY DATA work action is specified for the work class. For workloads, this monitor element returns -1 when COLLECT AGGREGATE ACTIVITY DATA for the workload is set to NONE. Units are milliseconds.

For service classes, the queue time counts only toward the service subclass in which the activity completes or is aborted. When you remap activities between service subclasses with a REMAP ACTIVITY action, the coord_act_queue_time_avg mean of service subclasses an activity is mapped to but does not complete in is unaffected.

Table 135. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_SERVICE_SUBCLASS_STATS table function - Return statistics of service subclasses	COLLECT AGGREGATE ACTIVITY DATA
WLM_GET_WORKLOAD_STATS table function - Return workload statistics	COLLECT AGGREGATE ACTIVITY DATA

Table 136. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats	Always collected

Table 136. Event Monitoring Information (continued)

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_wcstats	Always collected
Statistics	event_wlstats	Always collected

Usage

Use this statistic to determine the arithmetic mean of the queue time for coordinator activities associated with a service subclass, workload, or work class that completed or aborted.

This statistic can also be used to determine whether or not the histogram template used for the activity queue time histogram is appropriate. Compute the average activity queue time from the activity queue time histogram. Compare the computed average with this monitor element. If the computed average deviates from the true average reported by this monitor element, consider altering the histogram template for the activity queue time histogram, using a set of bin values that are more appropriate for your data.

coord_act_rejected_total - Coordinator activities rejected total monitor element

The total number of coordinator activities at any nesting level that were rejected instead of being allowed to execute since the last reset. This counter is updated when an activity is prevented from executing by either a predictive threshold or a prevent execution work action. For service classes, the value is updated when the activity completes. For workloads, the value is updated by each workload occurrence at the end of its unit of work.

Table 137. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_SERVICE_CLASS_WORKLOAD _OCCURRENCES table function - list workload occurrences	ACTIVITY METRICS BASE
WLM_GET_SERVICE_SUBCLASS_STATS table function - Return statistics of service subclasses	COLLECT AGGREGATE ACTIVITY DATA
WLM_GET_WORKLOAD_STATS table function - Return workload statistics	ACTIVITY METRICS BASE

Table 138. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats	-
Statistics	event_wlstats	-

Usage

This element can be used to help determine whether or not predictive thresholds and work actions that prevent execution are being effective and whether or not they are too restrictive.

coord_partition_num - Coordinator partition number monitor element

The coordinator partition of the unit of work or activity. In a multi-partition system, the coordinator partition is the partition where the application connected to the database.

Table 139. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_SERVICE_CLASS_WORKLOAD _OCCURRENCES table function - list workload occurrences	ACTIVITY METRICS BASE
WLM_GET_WORKLOAD_OCCURRENCE _ACTIVITIES table function - Return a list of activities	ACTIVITY METRICS BASE

Table 140. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Unit of work	-	Always collected
Activities	event_activity	Always collected
Threshold violations	event_thresholdviolations	Always collected

Usage

This element allows the coordinator partition to be identified for activities or units of work that have records on partitions other than the coordinator.

cost_estimate_top - Cost estimate top monitor element

The high watermark for the estimated cost of DML activities at all nesting levels in a service subclass or work class. For service subclasses, this monitor element returns -1 when COLLECT AGGREGATE ACTIVITY DATA for the service subclass is set to NONE. For work classes, this monitor elements returns -1 if no COLLECT AGGREGATE ACTIVITY DATA work action is specified for the work class.

For service classes, the estimated cost of DML activities is counted only toward the service subclass in which the activity enters the system. When you remap activities between service subclasses with a REMAP ACTIVITY action, the cost_estimate_top of the service subclass you remap an activity to is unaffected.

Table 141. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats	-
Statistics	event_wcstats	-
Statistics	event_wlstats	-

Usage

Use this element to determine the highest DML activity estimated cost reached on a member for a service class, workload, or work class in the time interval collected.

cpu_limit - WLM dispatcher CPU limit monitor element

The WLM dispatcher CPU limit configured for the service class.

Table 142. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_SAMPLE_SERVICE_CLASS_METRICS - Get sample service class metrics	ACTIVITY METRICS BASE

cpu_share_type - WLM dispatcher CPU share type monitor element

The type of WLM dispatcher CPU shares configured for the service class. Possible values are soft and hard.

Table 143. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_SAMPLE_SERVICE_CLASS_METRICS - Get sample service class metrics	ACTIVITY METRICS BASE

cpu_shares - WLM dispatcher CPU shares monitor element

The number of WLM dispatcher CPU shares configured for the service class.

Table 144. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_SAMPLE_SERVICE_CLASS_METRICS - Get sample service class metrics	ACTIVITY METRICS BASE

cpu_utilization - CPU utilization monitor element

The total CPU time consumed by the service class or workload on a particular logical partition divided by the amount of CPU time available on the host or the LPAR in a given period of time.

Table 145. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_SAMPLE_SERVICE_CLASS_METRICS - Get sample service class metrics	REQUEST METRICS BASE
MON_SAMPLE_WORKLOAD_METRICS - Get sample workload metrics	REQUEST METRICS BASE
WLM_GET_SERVICE_SUBCLASS_STATS table function - Return statistics of service subclasses	REQUEST METRICS BASE
WLM_GET_WORKLOAD_STATS table function - Return workload statistics	REQUEST METRICS BASE

Table 146. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats (reported in the details_xml document)	REQUEST METRICS BASE

Table 146. Event Monitoring Information (continued)

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_wlstats (reported in the details_xml document)	REQUEST METRICS BASE
Unit of work	Reported in the system_metrics document	REQUEST METRICS BASE

Usage

When returned by the WLM_GET_WORKLOAD_STATS or the WLM_GET_SERVICE_SUBCLASS_STATS function, this monitor element represents the CPU utilization since the last reset of the statistics.

When returned by the MON_SAMPLE_SERVICE_CLASS_METRICS or the MON_SAMPLE_WORKLOAD_METRICS function, this monitor element represents the CPU utilization since the function was executed.

cpu_velocity - CPU velocity monitor element

A measure of the amount of contention for the CPU resources, measured on a scale from 0 to 1, with lower numbers meaning greater contention.

CPU velocity is computed by measuring the amount of time that work in a service class has access to the CPU divided by the total time spent accessing the CPU or waiting to access the CPU. It gives a measure of how efficiently the work is being executed relative to how efficiently it could be executed if such work never had to wait for the CPU. The formula is as follows:

```
cpu_velocity = total_cpu_time / (total_cpu_time + total_disp_run_queue_time)
```

The **wlm_dispatcher** database manager configuration parameter must be set to ON for **cpu_velocity** to be collected.

Table 147. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_SAMPLE_SERVICE_CLASS_METRICS - Sample service class metrics	REQUEST METRICS BASE
MON_SAMPLE_WORKLOAD_METRICS - Sample workload metrics	REQUEST METRICS BASE

Usage

The dispatcher is effective at prioritizing a service class or workload when that service class or workload demands more CPU resources at a given instant than can be supplied. In such instances, the work executing in the service class or workload spends time queuing to access the CPU resources. It is when this occurs that the dispatcher can give more of the CPU resources to such a service class or workload by reducing how much of the CPU resources it gives to another. A high CPU velocity indicates that the dispatcher can have little effect on improving response times or throughput for this service class at its current level of CPU demand because this demand is already being met. A low CPU velocity indicates that the dispatcher can potentially have a significant effect on improving response times or throughput for this service class or workload at its current level of CPU demand.

Use this element to determine whether the work executing in a service class or workload is spending a relatively large proportion of its time queuing to use the CPU resources. If the CPU velocity for a service class is low and you want to increase it, you can adjust the WLM dispatcher control of the CPU resources by increasing the number of CPU shares or increasing the CPU limit assigned to the service class that is exhibiting a low CPU velocity.

db_work_action_set_id - Database work action set ID monitor element

If this activity has been categorized into a work class of database scope, this monitor element shows the ID of the work action set associated with the work class set to which the work class belongs. Otherwise, this monitor element shows the value of 0.

Table 148. Table Function Monitoring Information

Table Function	Monitor Element Collection Command and Level
WLM_GET_ACTIVITY_DETAILS_COMPLETE (reported in DETAILS XML document)	ACTIVITY METRICS BASE
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details	ACTIVITY METRICS BASE

Table 149. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity	Always collected

Usage

This element can be used with the **db_work_class_id** element to uniquely identify the database work class of the activity, if one exists.

db_work_class_id - Database work class ID monitor element

If this activity has been categorized into a work class of database scope, this monitor element displays the ID of the work class. Otherwise, this monitor element displays the value of 0.

Table 150. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_ACTIVITY_DETAILS_COMPLETE table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Table 151. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity	Always collected

Usage

This element can be used with the **db_work_action_set_id** element to uniquely identify the database work class of the activity, if one exists.

destination_service_class_id – Destination service class ID monitor element

The ID of the service subclass to which an activity was remapped when the threshold violation record to which this element belongs was generated. This element has a value of zero for any threshold action other than REMAP ACTIVITY.

Table 152. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Threshold violations	event_thresholdviolations	-

Usage

Use this element to trace the path of an activity through the service classes to which it was remapped. This element can also be used to compute aggregates of how many activities were mapped into a given service subclass.

estimated_cpu_entitlement - Estimated CPU entitlement monitor element

The percentage of total CPU on a host or an LPAR that a service subclass is configured to consume based on its CPU shares assuming that it consumes no more and no less than what it is configured to consume. The determination of which service classes participate in its calculation is based on the actual CPU utilization measured over the sampling period versus the WLM_DISP_MIN_UTIL database manager configuration setting. The impact of a CPU limit on a service class itself, on the service classes with which it competes, or on a parent service class (if it has one) are not taken into account in the calculation.

Table 153. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_SAMPLE_SERVICE_CLASS_METRICS - Get sample service class metrics	ACTIVITY METRICS BASE

histogram_type - Histogram type monitor element

The type of the histogram, in string format.

There are seven histogram types.

CoordActQueueTime
A histogram of the time non-nested activities spend queued (for example, in a threshold queue), measured on the coordinator member.

CoordActExecTime
A histogram of the time non-nested activities spend executing at the coordinator member. Execution time does not include time spent initializing or queued. For cursors, execution time includes only the time spent on open, fetch and close requests. When an activity is remapped between service subclasses, the execution time histogram is updated only for the service subclass in which the activity completes execution.

CoordActLifetime
A histogram of the elapsed time from when a non-nested activity is identified by the database manager until the activity completes execution, as measured on the coordinator member. When you remap activities

between service subclasses, the lifetime histogram is updated only for the service subclass in which the activity completes execution.

CoordActInterArrivalTime
A histogram of the time interval between the arrival of non-nested coordinator activities. The inter-arrival time mean is calculated for service subclasses through which activities enter the system. When you remap activities between service subclasses, the inter-arrival time histogram of the service subclass you remap an activity to is unaffected.

CoordActEstCost
A histogram of the estimated cost of non-nested DML activities. The estimated cost of an activity is counted only toward the service subclass in which the activity enters the system.

ReqExecTime
A histogram of request execution times, which includes requests on the coordinator member, and any subrequests on both coordinator and non-coordinator members (like RPC requests or SMP subagent requests). Requests included may or may not be associated with an activity: Both PREPARE and OPEN requests are included in this histogram, for example, but while OPEN requests are always associated with a cursor activity, PREPARE requests are not part of any activity.The execution time histogram of a service subclass involved in remapping counts the portion of the execution time spent by the partial request in the service subclass.

UowLifetime
A histogram of the elapsed time, measured in milliseconds, from the time that a unit of work is identified by the database manager until the time that the unit of work completes execution (committed or rolled back).

Table 154. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_histogrambin	Always collected

Usage

Use this element to identify the type of histogram. Several histograms can belong to the same statistics record, but only one of each type.

last_wlm_reset - Time of last reset monitor element

This element, in the form of a local timestamp, shows the time at which the last statistics event record of this type was created.

Table 155. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats	-
Statistics	event_wlstats	-
Statistics	event_wcstats	-
Statistics	event_qstats	-

Usage

Use the **`wlm_last_reset`** and **`statistics_timestamp`** monitor elements to determine a period of time over which the statistics in an event monitor statistics record were collected. The collection interval begins at the **`wlm_last_reset`** time and ends at **`statistics_timestamp`**.

num_remaps - Number of remaps monitor element

Count of the number of times this activity has been remapped. If num_remaps is greater than zero, the service_class_id of this activity record is the ID of the last service class to which the activity was remapped.

Table 156. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity	Always collected

Usage

Use this information to verify whether the activity was remapped the expected number of times.

num_threshold_violations - Number of threshold violations monitor element

The number of threshold violations that have taken place in this database since it was last activated.

This monitor element is an alias of the "thresh_violations - Number of threshold violations monitor element" on page 446 monitor element, which is returned by some monitoring (MON_*) table functions.

Table 157. Snapshot Monitoring Information

Snapshot Level	Logical Data Grouping	Monitor Switch
Database	dbase	Basic

For snapshot monitoring, this counter can be reset.

Table 158. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Database	event_db	Always collected

Usage

This element can be used to help determine whether or not thresholds are effective for this particular application or whether the threshold violations are excessive.

number_in_bin - Number in bin monitor element

This element holds the count of the number of activities or requests that fall within the histogram bin.

Table 159. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_histogrambin	-

Usage

Use this element to represent the height of a bin in the histogram.

parent_activity_id - Parent activity ID monitor element

The unique ID of the activity's parent activity within the parent activity's unit of work. If there is no parent activity, the value of this monitor element is 0.

Table 160. Table Function Monitoring Information

Table Function	Monitor Element Collection Command and Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE
WLM_GET_SERVICE_CLASS_AGENTS table function - list agents running in a service class	ACTIVITY METRICS BASE
WLM_GET_WORKLOAD_OCCURRENCE _ACTIVITIES table function - Return a list of activities	ACTIVITY METRICS BASE

Table 161. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity	Always collected

Usage

Use this element along with the **parent_uow_id** element and **appl_id** element to uniquely identify the parent activity of the activity described in this activity record.

parent_uow_id - Parent unit of work ID monitor element

The unique unit of work identifier within an application handle. The ID of the unit of work in which the activity's parent activity originates. If there is no parent activity, the value is 0.

Table 162. Table Function Monitoring Information

Table Function	Monitor Element Collection Command and Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE
WLM_GET_SERVICE_CLASS_AGENTS table function - list agents running in a service class	ACTIVITY METRICS BASE

Table 162. Table Function Monitoring Information (continued)

Table Function	Monitor Element Collection Command and Level
WLM_GET_WORKLOAD_OCCURRENCE _ACTIVITIES table function - Return a list of activities	ACTIVITY METRICS BASE

Table 163. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity	Always collected

Usage

Use this element along with the **parent_activity_id** element and **appl_id** element to uniquely identify the parent activity of the activity described in this activity record.

prep_time - Preparation time monitor element

Time in milliseconds required to prepare an SQL statement (if the activity is an SQL statement; otherwise, the value is 0).

Table 164. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_PKG_CACHE_STMT table function - Get SQL statement activity metrics in the package cache	ACTIVITY METRICS BASE
MON_GET_PKG_CACHE_STMT_DETAILS table function - get detailed metrics for package cache entries	ACTIVITY METRICS BASE

Table 165. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity	Always collected
Package cache	-	COLLECT BASE DATA

Usage

The prep_time monitor element indicates how much time was spent preparing the SQL statement, if this activity was an SQL statement, when the statement was first introduced to the DB2 package cache. This preparation time is not part of the activity lifetime nor does it represent time spent during a specific invocation of the statement if the statement has already been cached in the package cache before that invocation.

queue_assignments_total - Queue assignments total monitor element

The number of times any connection or activity was assigned to this threshold queue since the last reset.

Table 166. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_QUEUE_STATS table function - Return threshold queue statistics	ACTIVITY METRICS BASE

Table 167. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_qstats	-

Usage

This element can be used to determine the number of times any connection or activity was queued in this particular queue in a given period of time determined by the statistics collection interval. This can help to determine the effectiveness of queuing thresholds.

queue_size_top - Queue size top monitor element

Highest queue size that has been reached since the last reset.

Table 168. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_QUEUE_STATS table function - Return threshold queue statistics	ACTIVITY METRICS BASE

Table 169. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_qstats	-

Usage

Use this element to gauge the effectiveness of queuing thresholds and to detect when queuing is excessive.

queue_time_total - Queue time total monitor element

Sum of the times spent in the queue for all connections or activities placed in this queue since the last reset. Units are milliseconds.

Table 170. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_QUEUE_STATS table function - Return threshold queue statistics	ACTIVITY METRICS BASE

Table 171. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_qstats	Always collected

This element is used to gauge the effectiveness of queuing thresholds and to detect when queuing is excessive.

Usage notes

queue_time_total is not reset at the end of a statistic collection interval. If **queue_time_total** is used over multiple intervals, it can be greater than the product of **wlm_collect_int** and **queue_size_top**.

request_exec_time_avg - Request execution time average monitor element

Arithmetic mean of the execution times for requests associated with this service subclass since the last reset. If the internally tracked average has overflowed, the value -2 is returned. This monitor element returns -1 when COLLECT AGGREGATE REQUEST DATA for the service subclass is set to NONE. Units are milliseconds.

When you remap activities between service subclasses with a REMAP ACTIVITY action, the request_exec_time_avg mean counts the partial request in each subclass involved in remapping.

Table 172. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_SERVICE_SUBCLASS_STATS table function - Return statistics of service subclasses	COLLECT AGGREGATE REQUEST DATA

Table 173. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats	-

Usage

Use this statistic to quickly understand the average amount of time that is spent processing each request on a member in this service subclass.

This average can also be used to determine whether or not the histogram template used for the request execution time histogram is appropriate. Compute the average request execution time from the request execution time histogram. Compare the computed average with this monitor element. If the computed average deviates from the true average reported by this monitor element, consider altering the histogram template for the request execution time histogram, using a set of bin values that are more appropriate for your data.

routine_id - Routine ID monitor element

A unique routine identifier. This monitor element returns 0 if the activity is not part of a routine.

Table 174. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in the DETAILS XML document)	ACTIVITY METRICS BASE
MON_GET_PKG_CACHE_STMT table function	ACTIVITY METRICS BASE

Table 174. Table Function Monitoring Information (continued)

Table Function	Monitor Element Collection Level
MON_GET_PKG_CACHE_STMT_DETAILS - Get detailed metrics for package cache entries	ACTIVITY METRICS BASE
WLM_GET_SERVICE_CLASS_AGENTS table function - list agents running in a service class	ACTIVITY METRICS BASE
WLM_GET_WORKLOAD_OCCURRENCE _ACTIVITIES table function - Return a list of activities	ACTIVITY METRICS BASE

Table 175. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activitystmt	Always collected
Unit of work	uow_package_list	Always collected
Package cache	pkgcache_metrics	ACTIVITY METRICS BASE

Usage

The value of this element matches a value from column ROUTINEID of view SYSCAT.ROUTINES. When the activity is part of an SQL PL routine that you declare in another SQL PL routine, the value of this element is the ROUTINEID of the outer routine.

rows_fetched - Rows fetched monitor element

The number of rows read from the table.

This monitor element is an alias of the **rows_read** monitor element.

Note: This monitor element reports only the values for the member for which this information is recorded. In multimember database environments, these values might not reflect the correct totals for the whole activity.

Table 176. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity	Statement

Usage

See the **rows_read** monitor element for details.

rows_modified - Rows modified monitor element

The number of rows inserted, updated, or deleted.

This monitor element is an alias of the **rows_written** monitor element.

Table 177. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_FORMAT_XML_METRICS_BY_ROW - Get formatted row-based output for all metrics	Not applicable; reports whichever elements are contained in the XML document provided as input to the formatting function.
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE
MON_GET_CONNECTION table function - Get connection metrics	REQUEST METRICS BASE
MON_GET_CONNECTION_DETAILS table function - Get detailed connection metrics (reported in DETAILS XML document)	REQUEST METRICS BASE
MON_GET_PKG_CACHE_STMT table function - Get SQL statement activity metrics in the package cache	ACTIVITY METRICS BASE
MON_GET_PKG_CACHE_STMT_DETAILS table function - get detailed metrics for package cache entries	ACTIVITY METRICS BASE
MON_GET_SERVICE_SUBCLASS table function - Get service subclass metrics	REQUEST METRICS BASE
MON_GET_SERVICE_SUBCLASS_DETAILS table function - Get detailed service subclass metrics (reported in DETAILS XML document)	REQUEST METRICS BASE
MON_GET_UNIT_OF_WORK table function - Get unit of work metrics	REQUEST METRICS BASE
MON_GET_UNIT_OF_WORK_DETAILS table function - Get detailed unit of work metrics (reported in DETAILS XML document)	REQUEST METRICS BASE
MON_GET_WORKLOAD table function - Get workload metrics	REQUEST METRICS BASE
MON_GET_WORKLOAD_DETAILS table function - Get detailed workload metrics (reported in DETAILS XML document)	REQUEST METRICS BASE

Table 178. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity (reported in the details_xml document)	ACTIVITY METRICS BASE
Activities	event_activitymetrics	ACTIVITY METRICS BASE
Statistics	event_scstats (reported in the details_xml document)	REQUEST METRICS BASE
Statistics	event_wlstats (reported in the details_xml document)	REQUEST METRICS BASE
Unit of work	Reported in the system_metrics document.	REQUEST METRICS BASE
Activities	event_activity	Statement

Table 178. Event Monitoring Information (continued)

Event Type	Logical Data Grouping	Monitor Switch
Package cache	Reported in the activity_metrics document.	ACTIVITY METRICS BASE

Usage

See the **`rows_written`** monitor element for details.

rows_returned - Rows returned monitor element

The number of rows that have been selected and returned to the application. This element has a value of 0 for partial activity records (for example, if an activity is collected while it is still executing or when a full activity record could not be written to the event monitor due to memory limitations).

This monitor element is an alias of the **`fetch_count`** monitor element.

Table 179. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_FORMAT_XML_METRICS_BY_ROW - Get formatted row-based output for all metrics	Not applicable; reports whichever elements are contained in the XML document provided as input to the formatting function.
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE
MON_GET_CONNECTION table function - Get connection metrics	REQUEST METRICS BASE
MON_GET_CONNECTION_DETAILS table function - Get detailed connection metrics (reported in DETAILS XML document)	REQUEST METRICS BASE
MON_GET_PKG_CACHE_STMT table function - Get SQL statement activity metrics in the package cache	ACTIVITY METRICS BASE
MON_GET_PKG_CACHE_STMT_DETAILS table function - get detailed metrics for package cache entries	ACTIVITY METRICS BASE
MON_GET_SERVICE_SUBCLASS table function - Get service subclass metrics	REQUEST METRICS BASE
MON_GET_SERVICE_SUBCLASS_DETAILS table function - Get detailed service subclass metrics (reported in DETAILS XML document)	REQUEST METRICS BASE
MON_GET_UNIT_OF_WORK table function - Get unit of work metrics	REQUEST METRICS BASE
MON_GET_UNIT_OF_WORK_DETAILS table function - Get detailed unit of work metrics (reported in DETAILS XML document)	REQUEST METRICS BASE
MON_GET_WORKLOAD table function - Get workload metrics	REQUEST METRICS BASE

Table 179. Table Function Monitoring Information (continued)

Table Function	Monitor Element Collection Level
MON_GET_WORKLOAD_DETAILS table function - Get detailed workload metrics (reported in DETAILS XML document)	REQUEST METRICS BASE
WLM_GET_WORKLOAD_OCCURRENCE _ACTIVITIES table function - Return a list of activities	REQUEST METRICS BASE

Table 180. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity (reported in the details_xml document)	ACTIVITY METRICS BASE
Activities	event_activitymetrics	ACTIVITY METRICS BASE
Statistics	event_scstats (reported in the details_xml document)	REQUEST METRICS BASE
Statistics	event_wlstats (reported in the details_xml document)	REQUEST METRICS BASE
Unit of work	Reported in the system_metrics document.	REQUEST METRICS BASE
Activities	event_activity	Always collected
Package cache	Reported in the activity_metrics document.	ACTIVITY METRICS BASE

Usage

This element can be used to help determine thresholds for rows returned to the application or can be used to verify that such a threshold is configured correctly and doing its job.

rows_returned_top - Actual rows returned top monitor element

The high watermark for the actual rows returned of DML activities at all nesting levels in a service class or work class. For service classes, this monitor element returns -1 when COLLECT AGGREGATE ACTIVITY DATA for the service class is set to NONE. For work classes, this monitor element returns -1 if no COLLECT AGGREGATE ACTIVITY DATA work action is specified for the work class. For workloads, this monitor element returns -1 when COLLECT AGGREGATE ACTIVITY DATA for the workload is set to NONE.

For service classes, when you remap activities between service subclasses with a REMAP ACTIVITY action, only the rows_returned_top high watermark of the service subclass where an activity completes is updated. High watermarks of service subclasses an activity is mapped to but does not complete in are unaffected.

Table 181. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats	-
Statistics	event_wcstats	-
Statistics	event_wlstats	-

Usage

Use this element to know the highest DML activity actual rows returned reached on a member for a service class, workload, or work class in the time interval collected.

sc_work_action_set_id - Service class work action set ID monitor element

If this activity has been categorized into a work class of service class scope, this monitor element displays the ID of the work action set associated with the work class set to which the work class belongs. Otherwise, this monitor element displays the value of 0.

Table 182. Table Function Monitoring Information

Table Function	Monitor Element Collection Command and Level
WLM_GET_ACTIVITY_DETAILS_COMPLETE table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Table 183. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity	Always collected

Usage

This element can be used with the **sc_work_class_id** element to uniquely identify the service class work class of the activity, if one exists.

sc_work_class_id - Service class work class ID monitor element

If this activity has been categorized into a work class of service class scope, this monitor element displays the ID of the work class assigned to this activity. Otherwise, this monitor element displays the value of 0.

Table 184. Table Function Monitoring Information

Table Function	Monitor Element Collection Command and Level
WLM_GET_ACTIVITY_DETAILS_COMPLETE table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Table 185. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity	Always collected

Usage

This element can be used with the **sc_work_action_set_id** element to uniquely identify the service class work class of the activity, if one exists.

section_env - Section environment monitor element

A blob that contains the section for an SQL statement. It is the actual section contents, that is the executable form of the query plan.

Table 186. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activitystmt	Always collected
Package cache	-	COLLECT DETAILED DATA

Usage

Use this element with the section explain procedures to explain the statement and view the access plan for the statement.

service_class_id - Service class ID monitor element

Unique ID of service subclass. For a unit of work, this ID represents the service subclass ID of the workload with which the connection issuing the unit of work is associated.

Table 187. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE
MON_GET_SERVICE_SUBCLASS table function - Get service subclass metrics	ACTIVITY METRICS BASE
MON_GET_SERVICE_SUBCLASS_DETAILS table function - Get detailed service subclass metrics	ACTIVITY METRICS BASE
MON_GET_UNIT_OF_WORK table function - Get unit of work metrics	ACTIVITY METRICS BASE
MON_GET_UNIT_OF_WORK_DETAILS table function - Get detailed unit of work metrics	ACTIVITY METRICS BASE
MON_SAMPLE_SERVICE_CLASS_METRICS - Get sample service class metrics	ACTIVITY METRICS BASE
WLM_GET_WORKLOAD_OCCURRENCE _ACTIVITIES table function - Return a list of activities	ACTIVITY METRICS BASE

Table 188. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity (reported in the details_xml document)	ACTIVITY METRICS BASE
Statistics	event_scstats (reported in the details_xml document)	REQUEST METRICS BASE
Locking	-	Always collected
Unit of work	-	Always collected
Statistics	event_histogrambin	Always collected
Statistics	event_scstats	Always collected

Usage

The value of this element matches a value from column SERVICECLASSID of view SYSCAT.SERVICECLASSES. Use this element to look up the service subclass name, or link information about a service subclass from different sources. For example, join service class statistics with histogram bin records.

The value of this element is 0 when the following conditions are met:

- The element is reported in an event_histogrambin logical data group.
- The histogram data is collected for an object that is not a service class.

service_subclass_name - Service subclass name monitor element

The name of a service subclass.

Table 189. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_SERVICE_SUBCLASS table function - Get service subclass metrics	ACTIVITY METRICS BASE
MON_GET_SERVICE_SUBCLASS_DETAILS table function - Get detailed service subclass metrics (reported in DETAILS XML document)	ACTIVITY METRICS BASE
MON_GET_UNIT_OF_WORK table function - Get unit of work metrics	ACTIVITY METRICS BASE
MON_GET_UNIT_OF_WORK_DETAILS table function - Get detailed unit of work metrics (reported in DETAILS XML document)	ACTIVITY METRICS BASE
MON_SAMPLE_SERVICE_CLASS_METRICS - Get sample service class metrics	ACTIVITY METRICS BASE
WLM_GET_QUEUE_STATS table function - Return threshold queue statistics	ACTIVITY METRICS BASE
WLM_GET_SERVICE_CLASS_AGENTS table function - list agents running in a service class	ACTIVITY METRICS BASE
WLM_GET_SERVICE_CLASS_WORKLOAD _OCCURRENCES table function - list workload occurrences	ACTIVITY METRICS BASE
WLM_GET_SERVICE_SUBCLASS_STATS table function - Return statistics of service subclasses	ACTIVITY METRICS BASE

Table 190. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats (reported in the details_xml document)	REQUEST METRICS BASE
Locking	-	Always collected
Unit of work	-	Always collected
Activities	event_activity	Always collected

Table 190. Event Monitoring Information (continued)

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats	Always collected
Statistics	event_qstats	Always collected

Usage

Use this element in conjunction with other activity elements for analysis of the behavior of an activity or with other statistics elements for analysis of a service class or threshold queue.

service_superclass_name - Service superclass name monitor element

The name of a service superclass.

Table 191. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_SERVICE_SUBCLASS table function - Get service subclass metrics	ACTIVITY METRICS BASE
MON_GET_SERVICE_SUBCLASS_DETAILS table function - Get detailed service subclass metrics (reported in DETAILS XML document)	ACTIVITY METRICS BASE
MON_GET_UNIT_OF_WORK table function - Get unit of work metrics	ACTIVITY METRICS BASE
MON_GET_UNIT_OF_WORK_DETAILS table function - Get detailed unit of work metrics (reported in DETAILS XML document)	ACTIVITY METRICS BASE
MON_SAMPLE_SERVICE_CLASS_METRICS - Get sample service class metrics	ACTIVITY METRICS BASE
WLM_GET_QUEUE_STATS table function - Return threshold queue statistics	ACTIVITY METRICS BASE
WLM_GET_SERVICE_CLASS_AGENTS table function - list agents running in a service class	ACTIVITY METRICS BASE
WLM_GET_SERVICE_CLASS_WORKLOAD _OCCURRENCES table function - list workload occurrences	ACTIVITY METRICS BASE
WLM_GET_SERVICE_SUBCLASS_STATS table function - Return statistics of service subclasses	ACTIVITY METRICS BASE
WLM_GET_SERVICE_SUPERCLASS_STATS table function - Return statistics of service superclasses	ACTIVITY METRICS BASE

Table 192. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats (reported in the details_xml document)	REQUEST METRICS BASE

Table 192. Event Monitoring Information (continued)

Event Type	Logical Data Grouping	Monitor Switch
Unit of work	-	Always collected
Activities	event_activity	Always collected
Statistics	event_scstats	Always collected
Statistics	event_qstats	Always collected

Usage

Use this element in conjunction with other activity elements for analysis of the behavior of an activity or with other statistics elements for analysis of a service class or threshold queue.

source_service_class_id - Source service class ID monitor element

The ID of the service subclass from which an activity was remapped when the threshold violation record to which this element belongs was generated. This element has a value of zero when the threshold action is anything other than a REMAP ACTIVITY action.

Table 193. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Threshold violations	event_thresholdviolations	-

Usage

Use this element to trace the path of an activity through the service classes to which it was remapped. It can also be used to compute aggregates of how many activities were mapped out of a given service subclass.

statistics_timestamp - Statistics timestamp monitor element

The time at which this statistics record was generated.

Table 194. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats	-
Statistics	event_wlstats	-
Statistics	event_wcstats	-
Statistics	event_qstats	-
Statistics	event_histogrambin	-

Usage

Use this element to determine when this statistics record was generated.

Use this element along with the `last_wlm_reset` element to identify the time interval over which the statistics in this statistics record were generated.

This monitor element can also be used to group together all statistics records that were generated for the same collection interval.

stmt_invocation_id - Statement invocation identifier monitor element

An identifier that distinguishes one invocation of a routine from others at the same nesting level within a unit of work. It is unique within a unit of work for a specific nesting level.

Table 195. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Table 196. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activitystmt	-
Locking	-	-
Deadlocks with Details History Values[1]	event_stmt_history	-
Deadlocks with Details History[1]	event_stmt_history	-
Unit of work	Reported in the package list.	-

1 This option has been deprecated. Its use is no longer recommended and might be removed in a future release. Use the CREATE EVENT MONITOR FOR LOCKING statement to monitor lock-related events, such as lock timeouts, lock waits, and deadlocks.

Usage

You can use this element to uniquely identify the invocation in which a particular SQL statement has been executed. You can also use this element in conjunction with other statement history entries to see the sequence of SQL statements that caused the deadlock.

temp_tablespace_top - Temporary table space top monitor element

The high watermark in KB for the temporary table space usage of DML activities at all nesting levels in a service class or work class. For service classes, this monitor element returns -1 when COLLECT AGGREGATE ACTIVITY DATA for the service class is set to NONE. For work classes, this monitor elements returns -1 if no COLLECT AGGREGATE ACTIVITY DATA work action is specified for the work class. For workloads, this monitor element returns -1 when COLLECT AGGREGATE ACTIVITY DATA for the workload is set to NONE.

For service classes, when you remap activities between service subclasses with a REMAP ACTIVITY action, only the temp_tablespace_top high watermark of the service subclass where an activity completes is changed. High watermarks of service subclasses an activity is mapped to but does not complete in are unaffected.

Table 197. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats	-
Statistics	event_wcstats	-
Statistics	event_wlstats	-

Usage

Use this element to determine the highest DML activity system temporary table space usage reached on a member for a service class, workload, or work class in the time interval collected.

This element is only updated by activities that have a temporary table space threshold applied to them. If no temporary table space threshold is applied to an activity, a value of 0 is returned.

thresh_violations - Number of threshold violations monitor element

Number of times a threshold was violated.

This monitor element is an alias of the "num_threshold_violations - Number of threshold violations monitor element" on page 431 monitor element, which is returned by snapshot monitoring routines and the Database event monitor.

Table 198. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_FORMAT_XML_METRICS_BY_ROW - Get formatted row-based output for all metrics	Not applicable; reports whichever elements are contained in the XML document provided as input to the formatting function.
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE
MON_GET_CONNECTION table function - Get connection metrics	REQUEST METRICS BASE
MON_GET_CONNECTION_DETAILS table function - Get detailed connection metrics (reported in DETAILS XML document)	REQUEST METRICS BASE
MON_GET_PKG_CACHE_STMT table function - Get SQL statement activity metrics in the package cache	ACTIVITY METRICS BASE
MON_GET_PKG_CACHE_STMT_DETAILS table function - get detailed metrics for package cache entries	ACTIVITY METRICS BASE
MON_GET_SERVICE_SUBCLASS table function - Get service subclass metrics	REQUEST METRICS BASE
MON_GET_SERVICE_SUBCLASS_DETAILS table function - Get detailed service subclass metrics (reported in DETAILS XML document)	REQUEST METRICS BASE
MON_GET_UNIT_OF_WORK table function - Get unit of work metrics	REQUEST METRICS BASE

Table 198. Table Function Monitoring Information (continued)

Table Function	Monitor Element Collection Level
MON_GET_UNIT_OF_WORK_DETAILS table function - Get detailed unit of work metrics (reported in DETAILS XML document)	REQUEST METRICS BASE
MON_GET_WORKLOAD table function - Get workload metrics	REQUEST METRICS BASE
MON_GET_WORKLOAD_DETAILS table function - Get detailed workload metrics (reported in DETAILS XML document)	REQUEST METRICS BASE

Table 199. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity (reported in the details_xml document)	ACTIVITY METRICS BASE
Activities	event_activitymetrics	ACTIVITY METRICS BASE
Statistics	event_scstats (reported in the details_xml) document)	REQUEST METRICS BASE
Statistics	event_wlstats (reported in the details_xml document)	REQUEST METRICS BASE
Package cache	Reported in the activity_metrics document.	ACTIVITY METRICS BASE
Unit of work	Reported in the system_metrics document.	REQUEST METRICS BASE

Usage

Use this element to quickly determine if there have been any WLM thresholds that have been violated. If thresholds have been violated you can then use the threshold violations event monitor (if created and active) to obtain details about the threshold violations.

For example, to obtain details which threshold was violated.

threshold_action - Threshold action monitor element

The action of the threshold to which this threshold violation record applies. Possible values include Stop, Continue and Remap.

Table 200. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Threshold violations	event_thresholdviolations	-

Usage

Use this element to determine whether the activity that violated the threshold was stopped when the violation occurred, was allowed to continue executing, or was remapped to another service subclass. If the activity was stopped, the application that submitted the activity will have received an SQL4712N error. If the activity was remapped to another service subclass, agents working for the activity on the member will be moving to the target service subclass of the threshold.

threshold_domain - Threshold domain monitor element

The domain of the threshold responsible for this queue.

Possible values are
- Database
- Work Action Set
- Service Superclass
- Service Subclass
- Workload

Table 201. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_QUEUE_STATS table function - Return threshold queue statistics	ACTIVITY METRICS BASE

Table 202. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_qstats	-

Usage

This element can be used for distinguishing the queue statistics of thresholds that have the same predicate but different domains.

threshold_maxvalue - Threshold maximum value monitor element

For non-queuing thresholds, this monitor element represents the value that was exceeded to cause this threshold violation. For queuing thresholds, this monitor element represents the level of concurrency that caused the queuing. The level of concurrency that caused the violation of the queuing threshold is the sum of **threshold_maxvalue** and **threshold_queuesize** monitor elements.

Table 203. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Threshold violations	event_thresholdviolations	Always collected

Usage

For activity thresholds, this element provides a historical record of what the threshold's maximum value was at the time the threshold was violated. This is useful when the threshold's maximum value has changed since the time of the violation and the old value is no longer available from the SYSCAT.THRESHOLDS view. For the DATATAGINSC IN and DATATAGINSC NOT IN thresholds, this element contains the value of the data tag that violated the threshold.

threshold_name - Threshold name monitor element

The unique name of the threshold responsible for this queue.

Table 204. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_QUEUE_STATS table function - Return threshold queue statistics	ACTIVITY METRICS BASE

Table 205. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_qstats	-

Usage

Use this element to uniquely identify the queuing threshold whose statistics this record represents.

threshold_predicate - Threshold predicate monitor element

Identifies the type of threshold that was violated or for which statistics were collected.

Table 206. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_QUEUE_STATS table function - Return threshold queue statistics	ACTIVITY METRICS BASE

Table 207. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Threshold violations	event_thresholdviolations	Always collected
Statistics	event_qstats	Always collected

Usage

Use this monitor element in conjunction with other statistics or threshold violation monitor elements for analysis of a threshold violation.

The valid values for this monitor element when reported in the event_thresholdviolations logical group are:

AggSQLTempSpace

SQLTempSpace

SQLRowsReturned

ActivityTotalTime

EstimatedSQLCost

TotalMemberConnections

ConnectionIdleTime

ConcurrentWorkloadOccurrences

ConcurrentWorkloadActivities

ConcurrentDBCoordActivities

TotalSCMemberConnections

SQLRowsRead

SQLRowsReadInSC

CPUTime

CPUTimeInSC

UowTotalTime

DataTagInSC

DataTagNotInSC

The valid values for this monitor element when reported in the event_qstats logical group are:

TotalMemberConnections

ConcurrentDBCoordActivities

TotalSCMemberConnections

threshold_queuesize - Threshold queue size monitor element

The size of the queue for a queuing threshold. An attempt to exceed this size causes a threshold violation. For a non-queuing threshold, this value is 0.

Table 208. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Threshold violations	event_thresholdviolations	-

Usage

Use this element to determine the number of activities or connections in the queue for this threshold at the time the threshold was violated.

thresholdid - Threshold ID monitor element

Identifies the threshold to which a threshold violation record applies or for which queue statistics were collected.

Table 209. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_QUEUE_STATS table function - Return threshold queue statistics	ACTIVITY METRICS BASE

Table 210. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Threshold violations	event_thresholdviolations	-
Statistics	event_qstats	-

Usage

Use this monitor element in conjunction with other activity history monitor elements for analysis of a threshold queue or for analysis of the activity that violated a threshold.

time_completed - Time completed monitor element

The time at which the activity described by this activity record finished executing. This element is a local timestamp.

Table 211. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity	Always collected

Usage

Use this element in conjunction with other activity history elements for analysis of the behavior of an activity.

This field has a value of "0000-00-00-00.00.00.000000" when a full activity record could not be written to a table event monitor due to memory limitations. If the activity was captured while it was in progress, then this field represents the time that activity was collected.

time_created - Time created monitor element

The time at which a user submitted the activity described by this activity record. This element is a local timestamp.

Table 212. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity	-

Usage

Use this element in conjunction with other activity history elements for analysis of the behavior of an activity.

time_of_violation - Time of violation monitor element

The time at which the threshold violation described in this threshold violation record occurred. This element is a local timestamp.

Table 213. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Threshold violations	event_thresholdviolations	-

Usage

Use this element in conjunction with other threshold violations monitor elements for analysis of a threshold violation.

time_started - Time started monitor element

The time at which the activity described by this activity record began executing. This element is a local timestamp.

Table 214. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity	Always collected

Usage

Use this element in conjunction with other activity history elements for analysis of the behavior of an activity.

If the activity got rejected, then the value of **`act_exec_time`** monitor element is 0. In this case, the value of **`time_started`** monitor element equals the value of **`time_completed`** monitor element.

top - Histogram bin top monitor element

The inclusive top end of the range of a histogram bin. The value of this monitor element is also the bottom exclusive end of the range of the next histogram bin.

Table 215. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_histogrambin	-

Usage

Use this element with the corresponding **`bottom`** element to determine the range of a bin within a histogram.

total_disp_run_queue_time - Total dispatcher run queue time monitor element

The total time that requests, that were run in this service class, spent waiting to access the CPU. This value is given in microseconds.

Table 216. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_FORMAT_XML_METRICS_BY_ROW - Get formatted row-based output for all metrics	Not applicable; reports whichever elements are contained in the XML document provided as input to the formatting function.
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE
MON_GET_CONNECTION table function - Get connection metrics	REQUEST METRICS BASE
MON_GET_CONNECTION_DETAILS table function - Get detailed connection metrics (reported in DETAILS XML document)	REQUEST METRICS BASE
MON_GET_PKG_CACHE_STMT table function - Get SQL statement activity metrics in the package cache	ACTIVITY METRICS BASE

Table 216. Table Function Monitoring Information (continued)

Table Function	Monitor Element Collection Level
MON_GET_PKG_CACHE_STMT_DETAILS - Get detailed metrics for package cache entries	ACTIVITY METRICS BASE
MON_GET_SERVICE_SUBCLASS table function - Get service subclass metrics	REQUEST METRICS BASE
MON_GET_SERVICE_SUBCLASS_DETAILS table function - Get detailed service subclass metrics (reported in DETAILS XML document)	REQUEST METRICS BASE
MON_GET_UNIT_OF_WORK table function - Get unit of work metrics	REQUEST METRICS BASE
MON_GET_UNIT_OF_WORK_DETAILS table function - Get detailed unit of work metrics (reported in DETAILS XML document)	REQUEST METRICS BASE
MON_GET_WORKLOAD table function - Get workload metrics	REQUEST METRICS BASE
MON_GET_WORKLOAD_DETAILS table function - Get detailed workload metrics (reported in DETAILS XML document)	REQUEST METRICS BASE
MON_SAMPLE_SERVICE_CLASS_METRICS - Get sample service class metrics	REQUEST METRICS BASE
MON_SAMPLE_WORKLOAD_METRICS - Get sample workload metrics	REQUEST METRICS BASE
WLM_GET_SERVICE_SUBCLASS_STATS table function - Return statistics of service subclasses	REQUEST METRICS BASE
WLM_GET_WORKLOAD_STATS table function - Return workload statistics	REQUEST METRICS BASE

Table 217. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity (reported in the details_xml document)	ACTIVITY METRICS BASE
Package cache	Reported in the activity_metrics document	ACTIVITY METRICS BASE
Statistics	event_scstats (reported in the details_xml document)	REQUEST METRICS BASE
Statistics	event_wlstats (reported in the details_xml document)	REQUEST METRICS BASE
Unit of work	Reported in the system_metrics document	REQUEST METRICS BASE

Usage

Together with the **`total_cpu_time`**, the **`total_disp_run_queue_time`** monitor element can be used to compute a measure of the amount of contention for the CPU resource, measured on a scale from 0 to 1, with lower numbers meaning greater contention for the CPU resource. This measure, called CPU velocity, is computed by measuring the amount of time that work in a service class has access to the CPU divided by the total time spent accessing the CPU or waiting to access the CPU. It gives a measure of how efficiently the work is being executed relative to how efficiently it could be executed if such work never had to wait for the CPU. The formula is as follows:

```
CPU velocity = total_cpu_time / (total_cpu_time + total_disp_run_queue_time)
```

When returned by the WLM_GET_SERVICE_SUBCLASS_STATS or the WLM_GET_WORKLOAD_STATS function, this monitor element represents the total dispatcher run queue wait time since the last reset of statistics.

When returned by the MON_SAMPLE_SERVICE_CLASS_METRICS or the MON_SAMPLE_WORKLOAD_METRICS function, this monitor element represents the total dispatcher run queue wait time since the function was executed.

uow_completed_total - Total completed units of work monitor element

The total number of units of work that completed, either by being committed or rolled back.

Table 218. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_SAMPLE_SERVICE_CLASS_METRICS - Get sample service class metrics	REQUEST METRICS BASE
MON_SAMPLE_WORKLOAD_METRICS - Get sample workload metrics	REQUEST METRICS BASE
WLM_GET_SERVICE_SUBCLASS_STATS table function - Return statistics of service subclasses	REQUEST METRICS BASE
WLM_GET_WORKLOAD_STATS table function - Return workload statistics	REQUEST METRICS BASE

Table 219. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats (reported in the details_xml document)	Always collected
Statistics	event_wlstats (reported in the details_xml document)	Always collected

Usage

When returned by the WLM_GET_SERVICE_SUBCLASS_STATS or the WLM_GET_WORKLOAD_STATS function, this monitor element represents the total completed units of work since the last reset of the statistics.

When returned by the MON_SAMPLE_SERVICE_CLASS_METRICS or the MON_SAMPLE_WORKLOAD_METRICS function, this monitor element represents the total completed units of work since the function was executed.

uow_comp_status - Unit of Work Completion Status

The status of the unit of work and how it stopped.

Element identifier
uow_comp_status

Element type
information

Table 220. Snapshot Monitoring Information

Snapshot Level	Logical Data Grouping	Monitor Switch
Application	appl	Unit of Work
DCS Application	dcs_appl	Basic

Table 221. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Transactions	event_xact	Always collected

Usage You may use this element to determine if the unit of work ended due to a deadlock or abnormal termination. It may have been:

- Committed due to a commit statement
- Rolled back due to a rollback statement
- Rolled back due to a deadlock
- Rolled back due to an abnormal termination
- Committed at normal application termination.
- Unknown as a result of a FLUSH EVENT MONITOR command for which units of work were in progress.

Note: API users should refer to the header file (*sqlmon.h*) containing definitions of database system monitor constants.

uow_elapsed_time - Most Recent Unit of Work Elapsed Time

The elapsed execution time of the most recently completed unit of work.

Element identifier
uow_elapsed_time

Element type
time

Table 222. Snapshot Monitoring Information

Snapshot Level	Logical Data Grouping	Monitor Switch
Application	appl	Unit of Work, Timestamp
DCS Application	dcs_appl	Unit of Work, Timestamp

Usage

Use this element as an indicator of the time it takes for units of work to complete.

This element is composed of two subelements that report time spent as seconds and microseconds (one millionth of a second). The names of the subelements can be derived by adding "_s" and "_ms" to the name of this monitor element. To retrieve the total time spent for this monitor element, the values of the two subelements must be added together. For example, if the "_s" subelement value is 3 and the "_ms" subelement value is 20, then the total time spent for the monitor element is 3.00002 seconds.

uow_id - Unit of work ID monitor element

The unit of work identifier. The unit of work ID is unique within an application handle.

Table 223. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details	ACTIVITY METRICS BASE
MON_GET_UNIT_OF_WORK table function - Get unit of work metrics	ACTIVITY METRICS BASE
MON_GET_UNIT_OF_WORK_DETAILS table function - Get detailed unit of work metrics	ACTIVITY METRICS BASE
WLM_GET_SERVICE_CLASS_AGENTS table function - list agents running in a service class	ACTIVITY METRICS BASE
WLM_GET_SERVICE_CLASS_WORKLOAD_OCCURRENCES table function - list workload occurrences	ACTIVITY METRICS BASE
WLM_GET_WORKLOAD_OCCURRENCE_ACTIVITIES table function - Return a list of activities	ACTIVITY METRICS BASE

Table 224. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Locking	-	Always collected
Unit of work	-	Always collected
Activities	event_activity	Always collected
Activities	event_activitystmt	Always collected
Activities	event_activityvals	Always collected
Activities	event_activitymetrics	ACTIVITY METRICS BASE
Threshold violations	event_thresholdviolations	Always collected
Change history	ddlstmtexec txncompletion	Always collected

Usage

Use this element in conjunction with other activity history elements for analysis of the behavior of an activity.

You can also use this element with the **`activity_id`** and **`appl_id`** monitor elements to uniquely identify an activity.

uow_lifetime_avg - Unit of work lifetime average monitor element

The average lifetime of a unit of work. Measured in milliseconds.

Table 225. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_SAMPLE_SERVICE_CLASS_METRICS - Get sample service class metrics	REQUEST METRICS BASE
MON_SAMPLE_WORKLOAD_METRICS - Get sample workload metrics	REQUEST METRICS BASE
WLM_GET_SERVICE_SUBCLASS_STATS table function - Return statistics of service subclasses	REQUEST METRICS BASE
WLM_GET_WORKLOAD_STATS table function - Return workload statistics	REQUEST METRICS BASE

Table 226. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats (reported in the details_xml document)	Always collected
Statistics	event_wlstats (reported in the details_xml document)	Always collected

Usage

When returned by the WLM_GET_SERVICE_SUBCLASS_STATS or the WLM_GET_WORKLOAD_STATS function, this monitor element represents the average unit of work lifetime since the last reset of the statistics.

When returned by the MON_SAMPLE_SERVICE_CLASS_METRICS or the MON_SAMPLE_WORKLOAD_METRICS function, this monitor element represents the average unit of work lifetime since the function was executed.

uow_lock_wait_time - Total time unit of work waited on locks monitor element

The total amount of elapsed time this unit of work has spent waiting for locks. The value is given in milliseconds.

Element identifier
uow_lock_wait_time

Element type
counter

Table 227. Snapshot Monitoring Information

Snapshot Level	Logical Data Grouping	Monitor Switch
Application	appl	Unit of Work

Usage This element can help you determine the severity of the resource contention problem.

uow_log_space_used - Unit of work log space used monitor element

The amount of log space (in bytes) used in the current unit of work of the monitored application.

Table 228. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_UNIT_OF_WORK table function - Get unit of work metrics	ACTIVITY METRICS BASE
MON_GET_UNIT_OF_WORK_DETAILS table function - Get detailed unit of work metrics (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Table 229. Snapshot Monitoring Information

Snapshot Level	Logical Data Grouping	Monitor Switch
Application	appl	Unit of Work

Table 230. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Transactions	event_xact	Always collected
Unit of work	-	Always collected

Usage

You may use this element to understand the logging requirements at the unit of work level.

uow_start_time - Unit of work start timestamp monitor element

The date and time that the unit of work first required database resources.

Table 231. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_UNIT_OF_WORK table function - Get unit of work metrics	ACTIVITY METRICS BASE
MON_GET_UNIT_OF_WORK_DETAILS table function - Get detailed unit of work metrics (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Table 232. Snapshot Monitoring Information

Snapshot Level	Logical Data Grouping	Monitor Switch
Application	appl	Unit of Work, Timestamp
DCS Application	dcs_appl	Unit of Work, Timestamp

Table 233. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Unit of work	-	-
Transaction	event_xact	-

Usage

This resource requirement occurs at the first SQL statement execution of that unit of work:

- For the first unit of work, it is the time of the first database request (SQL statement execution) after **`conn_complete_time`**.
- For subsequent units of work, it is the time of the first database request (SQL statement execution) after the previous COMMIT or ROLLBACK.

Note: The *SQL Reference* defines the boundaries of a unit of work as the COMMIT or ROLLBACK points.

The database system monitor excludes the time spent between the COMMIT/ROLLBACK and the next SQL statement from its definition of a unit of work. This measurement method reflects the time spent by the database manager in processing database requests, separate from time spent in application logic before the first SQL statement of that unit of work. The unit of work elapsed time does include the time spent running application logic between SQL statements within the unit of work.

You may use this element with the **`uow_stop_time`** monitor element to calculate the total elapsed time of the unit of work and with the **`prev_uow_stop_time`** monitor element to calculate the time spent in the application between units of work.

You can use the **`uow_stop_time`** and the **`prev_uow_stop_time`** monitor elements to calculate the elapsed time for the *SQL Reference* definition of a unit of work.

uow_status - Unit of Work Status

The status of the unit of work.

Element identifier
uow_status

Element type
information

Table 234. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Transactions	event_xact	Always collected

Usage You may use this element to determine the status of a unit of work. API users should refer to the sqlmon.h header file containing definitions of database system monitor constants.

uow_stop_time - Unit of work stop timestamp monitor element

The date and time that the most recent unit of work completed, which occurs when database changes are committed or rolled back.

Table 235. Snapshot Monitoring Information

Snapshot Level	Logical Data Grouping	Monitor Switch
Application	appl	Unit of Work, Timestamp
DCS Application	dcs_appl	Unit of Work, Timestamp

Table 236. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Unit of work	-	-

Usage

Use this element with the **prev_uow_stop_time** monitor element to calculate the total elapsed time between COMMIT/ROLLBACK points, and with the **uow_start_time** monitor element to calculate the elapsed time of the latest unit of work.

The timestamp contents will be set as follows:

- When the application has completed a unit of work and has not yet started a new one (as defined in the **uow_start_time** monitor element), this element reports a valid, non-zero timestamp.
- When the application is currently executing a unit of work, this element reports zeros.
- When the application first connects to the database, this element is set to the value of the **conn_complete_time** monitor element

As a new unit of work is started, the contents of this element are moved to the **prev_uow_stop_time** monitor element.

uow_throughput - Unit of work throughput monitor element

The completion rate of units of work measured in units of work per second.

Table 237. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_SAMPLE_SERVICE_CLASS_METRICS - Get sample service class metrics	REQUEST METRICS BASE
MON_SAMPLE_WORKLOAD_METRICS - Get sample workload metrics	REQUEST METRICS BASE
WLM_GET_SERVICE_SUBCLASS_STATS table function - Return statistics of service subclasses	REQUEST METRICS BASE
WLM_GET_WORKLOAD_STATS table function - Return workload statistics	REQUEST METRICS BASE

Table 238. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_scstats (reported in the details_xml document)	Always collected
Statistics	event_wlstats (reported in the details_xml document)	Always collected

Usage

When returned by the WLM_GET_SERVICE_SUBCLASS_STATS or the WLM_GET_WORKLOAD_STATS function, this monitor element represents the unit of work throughput since the last reset of the statistics.

When returned by the MON_SAMPLE_SERVICE_CLASS_METRICS or the MON_SAMPLE_WORKLOAD_METRICS function, this monitor element represents the unit of work throughput since the function was executed.

uow_total_time_top - UOW total time top monitor element

High watermark for unit of work lifetime, in milliseconds.

Table 239. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_SERVICE_SUBCLASS_STATS table function - Return statistics of service subclasses	REQUEST METRICS BASE
WLM_GET_WORKLOAD_STATS table function - Return workload statistics	REQUEST METRICS BASE

Table 240. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_wlstats	Always collected
Statistics	event_scstats	Always collected

Usage

This element can be used to help determine whether or not the UOWTOTALTIME threshold is effective and can also help to determine how to configure such a threshold.

For service classes, this monitor element returns -1 when COLLECT AGGREGATE ACTIVITY DATA for the service class is set to NONE.

For workloads, this monitor element returns -1 if COLLECT AGGREGATE ACTIVITY DATA for the workload is set to NONE.

For a service class, measurements taken for this high watermark are computed for the service class assigned by the workload. Any mapping by a work action set to change the service class of an activity does not affect this high watermark.

wl_work_action_set_id - Workload work action set identifier monitor element

If this activity has been categorized into a work class of workload scope, this monitor element shows the ID of the work action set associated with the work class set to which the work class belongs. Otherwise, this monitor element shows the value of `0`.

Table 241. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Table 242. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity	Always collected

Usage

Use this monitor element, together with the **wl_work_class_id** monitor element, to uniquely identify the workload work class of the activity, if one exists.

wl_work_class_id - Workload work class identifier monitor element

If this activity has been categorized into a work class of workload scope, then this monitor element displays the identifier of the work class. Otherwise, this monitor element displays the value of 0.

Table 243. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Table 244. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity	Always collected

Usage

Use this monitor element, together with the **wl_work_action_set_id** monitor element, to uniquely identify the workload work class of the activity, if one exists.

wlm_queue_assignments_total - Workload manager total queue assignments monitor element

The number of times that activities have been queued by a WLM threshold.

Table 245. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_FORMAT_XML_METRICS_BY_ROW - Get formatted row-based output for all metrics	Not applicable; reports whichever elements are contained in the XML document provided as input to the formatting function.
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE

Table 245. Table Function Monitoring Information (continued)

Table Function	Monitor Element Collection Level
MON_GET_CONNECTION table function - Get connection metrics	REQUEST METRICS BASE
MON_GET_CONNECTION_DETAILS table function - Get detailed connection metrics (reported in DETAILS XML document)	REQUEST METRICS BASE
MON_GET_PKG_CACHE_STMT table function - Get SQL statement activity metrics in the package cache	ACTIVITY METRICS BASE
MON_GET_PKG_CACHE_STMT_DETAILS table function - get detailed metrics for package cache entries	ACTIVITY METRICS BASE
MON_GET_SERVICE_SUBCLASS table function - Get service subclass metrics	REQUEST METRICS BASE
MON_GET_SERVICE_SUBCLASS_DETAILS table function - Get detailed service subclass metrics (reported in DETAILS XML document)	REQUEST METRICS BASE
MON_GET_UNIT_OF_WORK table function - Get unit of work metrics	REQUEST METRICS BASE
MON_GET_UNIT_OF_WORK_DETAILS table function - Get detailed unit of work metrics (reported in DETAILS XML document)	REQUEST METRICS BASE
MON_GET_WORKLOAD table function - Get workload metrics	REQUEST METRICS BASE
MON_GET_WORKLOAD_DETAILS table function - Get detailed workload metrics (reported in DETAILS XML document)	REQUEST METRICS BASE

Table 246. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity (reported in the details_xml document)	ACTIVITY METRICS BASE
Activities	event_activitymetrics	ACTIVITY METRICS BASE
Statistics	event_scstats (reported in the details_xml) document)	REQUEST METRICS BASE
Statistics	event_wlstats (reported in the details_xml document)	REQUEST METRICS BASE
Package cache	Reported in the activity_metrics document.	ACTIVITY METRICS BASE
Unit of work	Reported in the system_metrics document.	REQUEST METRICS BASE

wlm_queue_time_total - Workload manager total queue time monitor element

The time spent waiting on a WLM queuing threshold. This value is given in milliseconds.

Table 247. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_FORMAT_XML_METRICS_BY_ROW - Get formatted row-based output for all metrics	Not applicable; reports whichever elements are contained in the XML document provided as input to the formatting function.
MON_FORMAT_XML_TIMES_BY_ROW - Get formatted row-based combined hierarchy wait and processing times	Not applicable; reports whichever elements are contained in the XML document provided as input to the formatting function.
MON_FORMAT_XML_WAIT_TIMES_BY _ROW - Get formatted row-based output for wait times	Not applicable; reports whichever elements are contained in the XML document provided as input to the formatting function.
MON_GET_ACTIVITY_DETAILS table function - Get complete activity details (reported in DETAILS XML document)	ACTIVITY METRICS BASE
MON_GET_CONNECTION table function - Get connection metrics	REQUEST METRICS BASE
MON_GET_CONNECTION_DETAILS table function - Get detailed connection metrics (reported in DETAILS XML document)	REQUEST METRICS BASE
MON_GET_PKG_CACHE_STMT table function - Get SQL statement activity metrics in the package cache	ACTIVITY METRICS BASE
MON_GET_PKG_CACHE_STMT_DETAILS table function - get detailed metrics for package cache entries	ACTIVITY METRICS BASE
MON_GET_SERVICE_SUBCLASS table function - Get service subclass metrics	REQUEST METRICS BASE
MON_GET_SERVICE_SUBCLASS_DETAILS table function - Get detailed service subclass metrics (reported in DETAILS XML document)	REQUEST METRICS BASE
MON_GET_UNIT_OF_WORK table function - Get unit of work metrics	REQUEST METRICS BASE
MON_GET_UNIT_OF_WORK_DETAILS table function - Get detailed unit of work metrics (reported in DETAILS XML document)	REQUEST METRICS BASE
MON_GET_WORKLOAD table function - Get workload metrics	REQUEST METRICS BASE
MON_GET_WORKLOAD_DETAILS table function - Get detailed workload metrics (reported in DETAILS XML document)	REQUEST METRICS BASE

Table 248. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity (reported in the details_xml document)	ACTIVITY METRICS BASE
Activities	event_activitymetrics	ACTIVITY METRICS BASE
Statistics	event_scstats (reported in the details_xml) document)	REQUEST METRICS BASE

Table 248. Event Monitoring Information (continued)

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_wlstats (reported in the details_xml document)	REQUEST METRICS BASE
Package cache	Reported in the activity_metrics document.	ACTIVITY METRICS BASE
Unit of work	Reported in the system_metrics document.	REQUEST METRICS BASE

wlo_completed_total - Workload occurrences completed total monitor element

The number of workload occurrences to complete since last reset.

Table 249. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_WORKLOAD_STATS table function - Return workload statistics	ACTIVITY METRICS BASE

Table 250. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_wlstats	-

Usage

Use this element to determine how many occurrences of a given workload are driving work into the system.

work_action_set_id - Work action set ID monitor element

The ID of the work action set to which this statistics record applies.

Table 251. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_histogrambin	Always collected
Statistics	event_wcstats	Always collected

Usage

Use this element in conjunction with other activity history elements for analysis of the behavior of an activity or with other statistics elements for analysis of a work class.

The value of this element is 0 when the following conditions are met:

- The element is reported in an event_histogrambin logical data group.
- The histogram data is collected for an object that is not a work class.

work_action_set_name - Work action set name monitor element

The name of the work action set to which the statistics shown as part of this event are associated.

Table 252. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_QUEUE_STATS table function - Return threshold queue statistics	ACTIVITY METRICS BASE
WLM_GET_WORK_ACTION_SET_STATS table function - Return work action set statistics	ACTIVITY METRICS BASE

Table 253. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_qstats	-
Statistics	event_wcstats	-

Usage

Use this element along with the **`work_class_name`** element to uniquely identify the work class whose statistics are being shown in this record or to uniquely identify the work class which is the domain of the threshold queue whose statistics are shown in this record.

work_class_id - Work class ID monitor element

The identifier of the work class to which this statistics record applies.

Table 254. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_wcstats	Always collected
Statistics	event_histogrambin	Always collected

Usage

Use this element in conjunction with other statistics elements for analysis of a work class.

The value of this element is 0 when the following conditions are met:
- The element is reported in an event_histogrambin logical data group.
- The histogram data is collected for an object that is not a work class.

work_class_name - Work class name monitor element

The name of the work class to which the statistics shown as part of this event are associated.

Table 255. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
WLM_GET_QUEUE_STATS table function - Return threshold queue statistics	ACTIVITY METRICS BASE
WLM_GET_WORK_ACTION_SET_STATS table function - Return work action set statistics	ACTIVITY METRICS BASE

Table 256. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_qstats	-
Statistics	event_wcstats	-

Usage

Use this element along with the **work_action_set_name** element to uniquely identify the work class whose statistics are being shown in this record or to uniquely identify the work class which is the domain of the threshold queue whose statistics are shown in this record.

workload_id - Workload ID monitor element

An integer that uniquely identifies a workload.

Table 257. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_WORKLOAD table function - Get workload metrics	ACTIVITY METRICS BASE
MON_GET_WORKLOAD_DETAILS table function - Get detailed workload metrics	ACTIVITY METRICS BASE
MON_SAMPLE_WORKLOAD_METRICS - Get sample	ACTIVITY METRICS BASE

Table 258. Snapshot Monitoring Information

Snapshot Level	Logical Data Grouping	Monitor Switch
Application	appl_info	Basic

Table 259. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Locking	-	Always collected
Unit of work	-	Always collected
Activities	event_activity (reported in the details_xml document)	ACTIVITY METRICS BASE
Statistics	event_scstats (reported in the details_xml document)	REQUEST METRICS BASE
Statistics	event_wlstats (reported in the details_xml document)	REQUEST METRICS BASE
Unit of work	Reported in the system_metrics document.	Always collected

Table 259. Event Monitoring Information (continued)

Event Type	Logical Data Grouping	Monitor Switch
Statistics	event_wlstats	Always collected
Statistics	event_histogrambin	Always collected
Activities	event_activity	Always collected

Usage

Use this ID to uniquely identify the workload to which this activity, application, histogram bin, or workload statistics record belongs.

The value of this element is 0 when the following conditions are met:
- The element is reported in an event_histogrambin logical data group.
- The histogram data is collected for an object that is not a workload.

workload_name - Workload name monitor element

Name of the workload.

Table 260. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_FORMAT_LOCK_NAME table function - Format the internal lock name and return details	ACTIVITY METRICS BASE
MON_GET_UNIT_OF_WORK table function - Get unit of work metrics	ACTIVITY METRICS BASE
MON_GET_UNIT_OF_WORK_DETAILS table function - Get detailed unit of work metrics	ACTIVITY METRICS BASE
MON_GET_WORKLOAD table function - Get workload metrics	ACTIVITY METRICS BASE
MON_GET_WORKLOAD_DETAILS table function - Get detailed workload metrics	ACTIVITY METRICS BASE
MON_SAMPLE_WORKLOAD_METRICS - Get sample	ACTIVITY METRICS BASE
WLM_GET_QUEUE_STATS table function - Return threshold queue statistics	ACTIVITY METRICS BASE
WLM_GET_SERVICE_CLASS_AGENTS table function - list agents running in a service class	ACTIVITY METRICS BASE
WLM_GET_SERVICE_CLASS_WORKLOAD _OCCURRENCES table function - list workload occurrences	ACTIVITY METRICS BASE
WLM_GET_WORKLOAD_STATS table function - Return workload statistics	ACTIVITY METRICS BASE

Table 261. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Locking	-	Always collected
Unit of work	-	Always collected

Table 261. Event Monitoring Information (continued)

Event Type	Logical Data Grouping	Monitor Switch
Activities	event_activity (reported in the details_xml document)	ACTIVITY METRICS BASE
Statistics	event_scstats (reported in the details_xml document)	REQUEST METRICS BASE
Statistics	event_wlstats (reported in the details_xml document)	REQUEST METRICS BASE
Unit of work	Reported in the system_metrics document.	Always collected
Statistics	event_wlstats	Always collected

Usage

In the statistics event monitor and workload table functions, the workload name identifies the workload for which statistics or metrics are being collected and reported. In the unit of work event monitor and unit of work table functions, the workload name identifies the workload that the unit of work was associated with.

Use the workload name to identify units of work or sets of information that apply to a particular workload of interest.

workload_occurrence_id - Workload occurrence identifier monitor element

The ID of the workload occurrence to which this activity belongs.

Table 262. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_UNIT_OF_WORK table function - Get unit of work metrics	ACTIVITY METRICS BASE
MON_GET_UNIT_OF_WORK_DETAILS table function - Get detailed unit of work metrics	ACTIVITY METRICS BASE
WLM_GET_SERVICE_CLASS_AGENTS table function - list agents running in a service class	ACTIVITY METRICS BASE
WLM_GET_SERVICE_CLASS_WORKLOAD _OCCURRENCES table function - list workload occurrences	ACTIVITY METRICS BASE

Table 263. Event Monitoring Information

Event Type	Logical Data Grouping	Monitor Switch
Unit of work	-	Always collected
Activities	event_activity	Always collected

Usage

Use this to identify the workload occurrence that submitted the activity.

workload_occurrence_state - Workload occurrence state monitor element

The state of the workload occurrence.

Table 264. Table Function Monitoring Information

Table Function	Monitor Element Collection Level
MON_GET_UNIT_OF_WORK table function - Get unit of work metrics	ACTIVITY METRICS BASE
MON_GET_UNIT_OF_WORK_DETAILS table function - Get detailed unit of work metrics (reported in DETAILS XML document)	ACTIVITY METRICS BASE
WLM_GET_SERVICE_CLASS_WORKLOAD _OCCURRENCES table function - list workload occurrences	ACTIVITY METRICS BASE

Usage

Possible values include:

DECOUPLED
: Workload occurrence does not have a coordinator agent assigned (concentrator case).

DISCONNECTPEND
: Workload occurrence is disconnecting from the database.

FORCED
: Workload occurrence has been forced.

INTERRUPTED
: Workload occurrence has been interrupted.

QUEUED
: Workload occurrence coordinator agent is queued by a workload management queuing threshold. In a partitioned database environment, this state may indicate that the coordinator agent has made an RPC another member to obtain threshold tickets and has not yet received a response.

TRANSIENT
: Workload occurrence has not yet been mapped to a service superclass.

UOWEXEC
: Workload occurrence is processing a request.

UOWWAIT
: Workload occurrence is waiting for a request from the client.

Commands

SET WORKLOAD

Specifies the workload to which the database connection is to be assigned. This command can be issued before connecting to a database or it can be used to reassign the current connection once the connection has been established. If the connection has been established, the workload reassignment will be performed at the beginning of the next unit of work.

Authorization

None, but see usage notes

Required connection

None

Command syntax

```
                    ┌─AUTOMATIC────────────┐
►►──SET WORKLOAD TO──┴─SYSDEFAULTADMWORKLOAD─┴───────────────────────────────►◄
```

Command parameters

AUTOMATIC
: Specifies that the database connection will be assigned to a workload chosen by the workload evaluation that is performed automatically by the server.

SYSDEFAULTADMWORKLOAD
: Specifies that the database connection will be assigned to the SYSDEFAULTADMWORKLOAD, allowing users with *accessctrl*, *dataaccess*, *wlmadm*, *secadm* or *dbadm* authority to bypass the normal workload evaluation.

Examples

To assign the connection to the **SYSDEFAULTADMWORKLOAD**:

```
SET WORKLOAD TO SYSDEFAULTADMWORKLOAD
```

To reset the workload assignment so that it uses the workload that is chosen by the workload evaluation performed by the server:

```
SET WORKLOAD TO AUTOMATIC
```

Usage notes

If the session authorization ID of the database connection does not have *accessctrl*, *dataaccess*, *wlmadm*, *secadm* or *dbadm* authority, the connection cannot be assigned to the **SYSDEFAULTADMWORKLOAD** and an SQL0552N error will be returned. If the **SET WORKLOAD TO SYSDEFAULTADMWORKLOAD** command is issued before connecting to a database, the SQL0552N error will be returned after the database connection has been established, at the beginning of the first unit of work. If the command is issued when the database connection has been established, the SQL0552N error will be returned at the beginning of the next unit of work, when the workload reassignment is supposed to take place.

Configuration parameters

wlm_collect_int - Workload management collection interval configuration parameter

This parameter specifies a collect and reset interval, in minutes, for workload management (WLM) statistics.

Every *x* minutes, (where *x* is the value of the **wlm_collect_int** parameter) all workload management statistics are collected and sent to any active statistics event monitor; then the statistics are reset. If an active statistics event monitor exists, depending on how it was created, the statistics are written to a file, to a pipe, or to a table. If it does not exist, the statistics are only reset and not collected.

Collections occur at the specified interval times as measured relative to Sunday at 00:00:00. When the catalog member becomes active, the next collection will occur at the start of the next scheduled interval relative to this fixed time. The scheduled interval is not relative to the catalog member activation time. If a member is not active at the time of collection, no statistics are gathered for that member. For example, if the interval value was set to 60 and the catalog member was activated on 9:24 AM on Sunday, then the collections would be scheduled to occur each hour on the hour. Therefore, the next collection will occur at 10:00 AM. If the member is not active at 10:00 AM, then no statistics will be gathered for that member.

The collect and reset process is initiated from the catalog member. The **`wlm_collect_int`** parameter must be specified on the catalog member. It is not used on other members.

Configuration type
Database

Parameter type
- Configurable online

Default [range]
`0` [`0` (no collection performed), `5 - 32 767`]

The workload management statistics collected by a statistics event monitor can be used to monitor both short term and long term system behavior. A small interval can be used to obtain both short term and long term system behavior because the results can be merged together to obtain long term behavior. However, having to manually merge the results from different intervals complicates the analysis. If it's not required, a small interval unnecessarily increases the processing time. Therefore, reduce the interval to capture shorter term behavior, and increase the interval to reduce processing time when only analysis of long term behavior is sufficient.

The interval needs to be customized per database, not for each SQL request, or command invocation, or application. There are no other configuration parameters that need to be considered.

Note: All WLM statistics table functions return statistics that have been accumulated since the last time the statistics were reset. The statistics will be reset regularly on the interval specified by this configuration parameter.

wlm_dispatcher - Workload management dispatcher

This parameter enables (YES) or disables (NO) the DB2 workload management (WLM) dispatcher. By default, an enabled WLM dispatcher allows the setting of the CPU limits.

Configuration type
Database manager

Applies to
- Database server with local and remote clients
- Database server with local clients
- Partitioned database server with local and remote clients

Parameter type
Configurable Online

Propagation class
Immediate

Default [range]
NO [NO; YES]

When upgrading the DB2 database manager, the value of the **wlm_dispatcher** database manager configuration parameter is set to NO.

The WLM dispatcher provides CPU scheduling capabilities at the service class level in the DB2 database manager using shares-based allocation of CPU resources, or CPU limits, or both.

With the WLM dispatcher enabled, all work running in user and maintenance service classes is placed under the control of the dispatcher. When enabled, CPU limit settings are enforced by the dispatcher as the default case. In order to use shares-based allocation of CPU resources, the **wlm_disp_cpu_shares** database manager configuration parameter must be enabled.

When the **wlm_dispatcher** configuration parameter is set to YES, the following conditions apply:

- If any service class has an agent priority set to any value other than the default, a warning message is written to the db2diag log and the administration notification log at the time of database activation.
- Any attempt to create or alter a service class to set agent priority to a value other than the default value results in a warning being returned to the application that issued the statement to create or alter the service class.

wlm_disp_concur - Workload manager dispatcher thread concurrency

This parameter specifies how the DB2 workload manager (WLM) dispatcher sets the thread concurrency level. You can also manually set the thread concurrency level to a fixed value.

Configuration type
Database manager

Applies to
- Database server with local and remote clients
- Database server with local clients
- Partitioned database server with local and remote clients

Parameter type
Configurable Online

Propagation class
Immediate

Default [range]
COMPUTED [COMPUTED; *manually_set_value*]

When upgrading DB2 database manager, the value of the **wlm_disp_concur** database manager configuration parameter is COMPUTED.

COMPUTED
DB2 database manager computes a fixed thread concurrency level

based upon the value of 4 times the number of logical CPUs available to the DB2 database manager.

manually_set_value
: You can manually set the thread concurrency level to a fixed value (1 - 32767). The optimal value depends on the specific hardware used and the operating system level; generally, in the range of 2 to 4 times the number of logical CPUs on the host or LPAR.

Unit of measure
: Number of concurrent threads

The setting of this database manager configuration parameter controls the number of threads that the WLM dispatcher allows to be dispatched to the operating system run queues in parallel. The value is set as a low multiple of the number of logical CPUs available to the DB2 database manager. In general, you can set the value to 4 times the number of available logical CPUs to take into account possible scheduling latencies that result when threads switch in and out of the active state. An optimal value is just large enough to ensure that there are an adequate numbers of threads for the DB2 database manager to fully use the CPUs on the host or LPAR and no larger. This optimal value ensures maximum efficiency and gives the DB2 WLM dispatcher maximum control over CPU allocation.

wlm_disp_cpu_shares - Workload manager dispatcher CPU shares

This parameter enables (YES) or disables (NO) the control of CPU shares by the DB2 workload manager (WLM) dispatcher. By default, an enabled WLM dispatcher controls only CPU limits.

Configuration type
: Database manager

Applies to
- Database server with local and remote clients
- Database server with local clients
- Partitioned database server with local and remote clients

Parameter type
: Configurable Online

Propagation class
: Immediate

Default [range]
: NO [NO; YES]

When upgrading DB2 database manager, the value of the **wlm_disp_cpu_shares** database manager configuration parameter is NO.

If the value of the **wlm_dispatcher** database manager configuration parameter is set to YES and the value of the **wlm_disp_cpu_shares** database manager configuration parameter is set to NO, the WLM dispatcher can apply only CPU limits to the management of service classes.

If the value of the **wlm_dispatcher** database manager configuration parameter is set to YES and the value of the **wlm_disp_cpu_shares** database manager configuration parameter is set to YES, the WLM dispatcher can apply both CPU limits and CPU shares to the management of service classes. By default, all service classes are assigned 1000 hard CPU shares to ensure an equal division of CPU resources.

Table 265. Summary of required database manager configuration parameter settings for service class management by the DB2 WLM dispatcher

Service class management	Setting of wlm_dispatcher	Setting of wlm_disp_cpu_shares
None	NO	NO
CPU limits	YES	NO
CPU limits + CPU shares	YES	YES

wlm_disp_min_util - Workload manager dispatcher minimum CPU utilization

This parameter specifies the minimum amount of CPU utilization that is necessary for a service class to be included in the DB2 WLM-managed sharing of CPU resources.

Configuration type
Database manager

Applies to
- Database server with local and remote clients
- Database server with local clients
- Multimember database server with local and remote clients

Parameter type
Configurable Online

Propagation class
Immediate

Default [range]
5 [0 to 100]

When upgrading DB2 database manager, the value of the **wlm_disp_min_util** database manager configuration parameter is 5.

Unit of measure
Percent

To illustrate the usage of this database manager configuration parameter with an example, suppose there are three service classes, A, B, and C, and each has 1000 shares of the CPU resources. In this example, the same result is obtained whether the service class shares are hard or soft CPU shares. Service classes A and B each have a CPU utilization that is greater than or equal to the 8% value set for the **wlm_disp_min_util** configuration parameter. Service class C has a 3% CPU utilization that is less than the 8% value set for the **wlm_disp_min_util** configuration parameter. In CPU share calculations, service class C is considered to not have any executing work. Therefore, only service classes A and B equally share the CPU resources and each receives a 50% share. When service class C begins to execute work to an extent that the CPU utilization is greater than or equal to the 8% value set for the **wlm_disp_min_util** configuration parameter, at this point service classes A, B, and C are now considered to equally share the CPU resources and each receives a 33.3% share.

In multimember database environments, it is the aggregate of the CPU utilizations of all the members on a host or LPAR that is compared to the **wlm_disp_min_util** configuration parameter to determine if the host or LPAR is included in the WLM-managed sharing of CPU resources.

Catalog views

SYSCAT.HISTOGRAMTEMPLATEBINS

Each row represents a histogram template bin.

Table 266. SYSCAT.HISTOGRAMTEMPLATEBINS Catalog View

Column Name	Data Type	Nullable	Description
TEMPLATENAME	VARCHAR (128)	Y	Name of the histogram template.
TEMPLATEID	INTEGER		Identifier for the histogram template.
BINID	INTEGER		Identifier for the histogram template bin.
BINUPPERVALUE	BIGINT		The upper value for a single bin in the histogram template.

SYSCAT.HISTOGRAMTEMPLATES

Each row represents a histogram template.

Table 267. SYSCAT.HISTOGRAMTEMPLATES Catalog View

Column Name	Data Type	Nullable	Description
TEMPLATEID	INTEGER		Identifier for the histogram template.
TEMPLATENAME	VARCHAR (128)		Name of the histogram template.
CREATE_TIME	TIMESTAMP		Time at which the histogram template was created.
ALTER_TIME	TIMESTAMP		Time at which the histogram template was last altered.
NUMBINS	INTEGER		Number of bins in the histogram template, including the last bin that has an unbounded top value.
REMARKS	VARCHAR (254)	Y	User-provided comments, or the null value.

SYSCAT.HISTOGRAMTEMPLATEUSE

Each row represents a relationship between a workload management object that can use histogram templates and a histogram template.

Table 268. SYSCAT.HISTOGRAMTEMPLATEUSE Catalog View

Column Name	Data Type	Nullable	Description
TEMPLATENAME	VARCHAR (128)	Y	Name of the histogram template.
TEMPLATEID	INTEGER		Identifier for the histogram template.

Table 268. SYSCAT.HISTOGRAMTEMPLATEUSE Catalog View (continued)

Column Name	Data Type	Nullable	Description
HISTOGRAMTYPE	CHAR (1)		The type of information collected by histograms based on this template. • C = Activity estimated cost histogram • E = Activity execution time histogram • I = Activity interarrival time histogram • L = Activity life time histogram • Q = Activity queue time histogram • R = Request execution time histogram • U = Unit of work life time histogram
OBJECTTYPE	CHAR (1)		The type of WLM object. • b = Service class • k = Work action • w = Workload
OBJECTID	INTEGER		Identifier of the WLM object.
SERVICECLASSNAME	VARCHAR (128)	Y	Name of the service class.
PARENTSERVICECLASSNAME	VARCHAR (128)	Y	The name of the parent service class of the service subclass that uses the histogram template.
WORKACTIONNAME	VARCHAR (128)	Y	The name of the work action that uses the histogram template.
WORKACTIONSETNAME	VARCHAR (128)	Y	The name of the work action set containing the work action that uses the histogram template.
WORKLOADNAME	VARCHAR (128)	Y	The name of the workload that uses the histogram template.

SYSCAT.SERVICECLASSES

Each row represents a service class.

Table 269. SYSCAT.SERVICECLASSES Catalog View

Column Name	Data Type	Nullable	Description
SERVICECLASSNAME	VARCHAR (128)		Name of the service class.
PARENTSERVICECLASSNAME	VARCHAR (128)	Y	Service class name of the parent service superclass.
SERVICECLASSID	SMALLINT		Identifier for the service class.
PARENTID	SMALLINT		Identifier for the parent service class for this service class. 0 if this service class is a super service class.
CREATE_TIME	TIMESTAMP		Time when the service class was created.
ALTER_TIME	TIMESTAMP		Time when the service class was last altered.
ENABLED	CHAR (1)		State of the service class. • N = Disabled • Y = Enabled

Table 269. SYSCAT.SERVICECLASSES Catalog View (continued)

Column Name	Data Type	Nullable	Description
AGENTPRIORITY	SMALLINT		Thread priority of the agents in the service class relative to the normal priority of DB2 threads. • -20 to 20 (Linux and UNIX) • -6 to 6 (Windows) • -32768 = not set
PREFETCHPRIORITY	CHAR (1)		Prefetch priority of the agents in the service class. • H = High • L = Low • M = Medium • Blank = not set
MAXDEGREE	SMALLINT	Y	Reserved for future use.
BUFFERPOOLPRIORITY	CHAR (1)		Bufferpool priority of the agents in the service class • H = High • L = Low • M = Medium • Blank = Not set
INBOUNDCORRELATOR	VARCHAR (128)	Y	For future use.
OUTBOUNDCORRELATOR	VARCHAR (128)	Y	String used to associate the service class with an operating system workload manager service class.
COLLECTAGGACTDATA	CHAR (1)		Specifies what aggregate activity data should be captured for the service class by the applicable event monitor. • B = Collect base aggregate activity data • E = Collect extended aggregate activity data • N = None
COLLECTAGGREQDATA	CHAR (1)		Specifies what aggregate request data should be captured for the service class by the applicable event monitor. • B = Collect base aggregate request data • N = None
COLLECTACTDATA	CHAR (1)		Specifies what activity data should be collected by the applicable event monitor. • D = Activity data with details • N = None • S = Activity data with details and section environment • V = Activity data with details and values • W = Activity data without details • X = Activity data with details, section environment, and values

Table 269. SYSCAT.SERVICECLASSES Catalog View (continued)

Column Name	Data Type	Nullable	Description
COLLECTACTPARTITION	CHAR (1)		Specifies where activity data is collected. • C = Coordinator member of the activity • D = All members
COLLECTREQMETRICS	CHAR (1)		Specifies the monitoring level for requests submitted by a connection that is associated with the service superclass. • B = Collect base request metrics • E = Collect extended request metrics • N = None
CPUSHARES	INTEGER		The number of CPU shares allocated to this service class.
CPUSHARETYPE	CHAR (1)		Specifies the type of CPU shares. • S = Soft shares • H = Hard shares
CPULIMIT	SMALLINT		The maximum percentage of the CPU resource that can be allocated to the service class; -1 if there is no CPU limit.
SORTMEMORYPRIORITY	CHAR (1)		Reserved for future use.
SECTIONACTUALSOPTIONS	VARCHAR (32)		Specifies what section actuals are collected during the execution of a section. The first position in the string represents whether the collection of section actuals is enabled. • B = Enabled and collect basic operator cardinality counts and statistics for each object referenced by the section (DML statements only). • N = Not enabled. The second position is always 'N' and reserved for future use.
COLLECTAGGUOWDATA	CHAR (1)		Specifies what aggregate unit of work data should be captured for the service class by the applicable event monitor. • B = Collect base aggregate unit of work data • N = None
REMARKS	VARCHAR (254)	Y	User-provided comments, or the null value.

SYSCAT.THRESHOLDS

Each row represents a threshold.

Table 270. SYSCAT.THRESHOLDS Catalog View

Column Name	Data Type	Nullable	Description
THRESHOLDNAME	VARCHAR (128)		Name of the threshold.
THRESHOLDID	INTEGER		Identifier for the threshold.

Table 270. SYSCAT.THRESHOLDS Catalog View (continued)

Column Name	Data Type	Nullable	Description
ORIGIN	CHAR (1)		Origin of the threshold. • U = Threshold was created by a user • W = Threshold was created through a work action set
THRESHOLDCLASS	CHAR (1)		Classification of the threshold. • A = Aggregate threshold • C = Activity threshold
THRESHOLDPREDICATE	VARCHAR (15)		Type of the threshold. Possible values are: • AGGTEMPSPACE • CONCDBC • CONCWCN • CONCWOC • CONNIDLETIME • CPUTIME • CPUTIMEINSC • DATATAGINSC • DATATAGNOTINSC • DBCONN • ESTSQLCOST • ROWSREAD • ROWSREADINSC • ROWSRET • SCCONN • TEMPSPACE • TOTALTIME • UOWTOTALTIME
THRESHOLDPREDICATEID	SMALLINT		Identifier for the threshold predicate.
DOMAIN	CHAR (2)		Domain of the threshold. • DB = Database • SB = Service subclass • SP = Service superclass • WA = Work action set • WD = Workload definition • SQ = SQL statement
DOMAINID	INTEGER		Identifier for the object with which the threshold is associated. This can be a service class, work action, workload unique ID, or SQL statement. If this is a database threshold, this value is 0.
ENFORCEMENT	CHAR (1)		Scope of enforcement for the threshold. • D = Database • P = Member • W = Workload occurrence
QUEUING	CHAR (1)		• N = The threshold is not queueing • Y = The threshold is queueing

Table 270. SYSCAT.THRESHOLDS Catalog View (continued)

Column Name	Data Type	Nullable	Description
MAXVALUE	BIGINT		Upper bound specified by the threshold. If THRESHOLDPREDICATE is 'DATATAGINSC' or 'DATATAGNOTINSC', this value encodes one or more data tags.
DATATAGLIST	VARCHAR (256)	Y	If THRESHOLDPREDICATE is 'DATATAGINSC' or 'DATATAGNOTINSC', this value represents one or more data tags as a comma separated list. Otherwise, the null value.
QUEUESIZE	INTEGER		If QUEUEING is 'Y', the size of the queue. -1 otherwise.
OVERFLOWPERCENT	SMALLINT		Reserved for future use.
COLLECTACTDATA	CHAR (1)		Specifies what activity data should be collected by the applicable event monitor. • D = Activity data with details • N = None • S = Activity data with details and section environment • V = Activity data with details and values • W = Activity data without details • X = Activity data with details, section environment, and values
COLLECTACTPARTITION	CHAR (1)		Specifies where activity data is collected. • C = Coordinator member of the activity • D = All members
EXECUTION	CHAR (1)		Indicates the execution action taken after a threshold has been exceeded. • C = Execution continues • F = Application is forced off the system • R = Execution is remapped to a different service subclass • S = Execution stops
REMAPSCID	SMALLINT		Target service subclass ID of the REMAP ACTIVITY action.
VIOLATIONRECORDLOGGED	CHAR (1)		Indicates whether a record is written to the event monitor upon threshold violation. • N = No • Y = Yes
CHECKINTERVAL	INTEGER		The interval, in seconds, in which the threshold condition is checked if THRESHOLDPREDICATE is: • 'CPUTIME' • 'CPUTIMEINSC' • 'ROWSREAD' • 'ROWSREADINSC' Otherwise, -1.

Table 270. SYSCAT.THRESHOLDS Catalog View (continued)

Column Name	Data Type	Nullable	Description
ENABLED	CHAR (1)		• N = This threshold is disabled. • Y = This threshold is enabled.
CREATE_TIME	TIMESTAMP		Time at which the threshold was created.
ALTER_TIME	TIMESTAMP		Time at which the threshold was last altered.
REMARKS	VARCHAR (254)	Y	User-provided comments, or the null value.

SYSCAT.WORKACTIONS

Each row represents a work action that is defined for a work action set.

Table 271. SYSCAT.WORKACTIONS Catalog View

Column Name	Data Type	Nullable	Description
ACTIONNAME	VARCHAR (128)		Name of the work action.
ACTIONID	INTEGER		Identifier for the work action.
ACTIONSETNAME	VARCHAR (128)	Y	Name of the work action set.
ACTIONSETID	INTEGER		Identifier of the work action set to which this work action belongs. This column refers to the ACTIONSETID column in the SYSCAT.WORKACTIONSETS view.
WORKCLASSNAME	VARCHAR (128)	Y	Name of the work class.
WORKCLASSID	INTEGER		Identifier of the work class. This column refers to the WORKCLASSID column in the SYSCAT.WORKCLASSES view.
CREATE_TIME	TIMESTAMP		Time at which the work action was created.
ALTER_TIME	TIMESTAMP		Time at which the work action was last altered.
ENABLED	CHAR (1)		• N = This work action is disabled. • Y = This work action is enabled.

Table 271. SYSCAT.WORKACTIONS Catalog View (continued)

Column Name	Data Type	Nullable	Description
ACTIONTYPE	CHAR (1)		The type of action performed on each DB2 activity that matches the attributes in the work class within scope. • B = Collect basic aggregate activity data, specifiable only for work action sets that apply to service classes or workloads. • C = Allow any DB2 activity under the associated work class to execute and increment the work class counter. • D = Collect activity data with details at the coordinating member of the activity. • E = Collect extended aggregate activity data, specifiable only for work action sets that apply to service classes or workloads. • F = Collect activity data with details, section, and values at the coordinating member of the activity. • G = Collect activity details and section at the coordinating member of the activity and collect activity data at all members. • H = Collect activity details, section, and values at the coordinating member of the activity and collect activity data at all members. • M = Map to a service subclass, specifiable only for work action sets that apply to service classes. • P = Prevent the execution of any DB2 activity under the work class with which this work action is associated. • S = Collect activity data with details and section at the coordinating member of the activity. • T = The action represents a threshold, specifiable only for work action sets that are associated with a database or a workload. • U = Map all activities with a nesting level of zero and all activities nested under these activities to a service subclass, specifiable only for work action sets that apply to service classes. • V = Collect activity data with details and values at the coordinating member. • W = Collect activity data without details at the coordinating member. • X = Collect activity data with details at the coordinating member and collect activity data at all members. • Y = Collect activity data with details and values at the coordinating member and collect activity data at all members. • Z = Collect activity data without details at all members.

Table 271. SYSCAT.WORKACTIONS Catalog View (continued)

Column Name	Data Type	Nullable	Description
REFOBJECTID	INTEGER	Y	If ACTIONTYPE is 'M' (map) or 'N' (map nested), this value is set to the ID of the service subclass to which the DB2 activity is mapped. If ACTIONTYPE is 'T' (threshold), this value is set to the ID of the threshold to be used. For all other actions, this value is NULL.
REFOBJECTTYPE	VARCHAR (30)		If the ACTIONTYPE is 'M' or 'N', this value is set to 'SERVICE CLASS'; if the ACTIONTYPE is 'T', this value is 'THRESHOLD'; the null value otherwise.
SECTIONACTUALSOPTIONS	VARCHAR (32)		Specifies what section actuals are collected during the execution of a section. The first position in the string represents whether the collection of section actuals is enabled. • B = Enabled and collect basic operator cardinality counts and statistics for each object referenced by the section (DML statements only). • N = Not enabled. The second position is always 'N' and reserved for for future use.

SYSCAT.WORKACTIONSETS

Each row represents a work action set.

Table 272. SYSCAT.WORKACTIONSETS Catalog View

Column Name	Data Type	Nullable	Description
ACTIONSETNAME	VARCHAR (128)		Name of the work action set.
ACTIONSETID	INTEGER		Identifier for the work action set.
WORKCLASSSETNAME	VARCHAR (128)	Y	Name of the work class set.
WORKCLASSSETID	INTEGER		The identifier of the work class set that is to be mapped to the object specified by the OBJECTID. This column refers to WORKCLASSSETID in the SYSCAT.WORKCLASSSETS view.
CREATE_TIME	TIMESTAMP		Time at which the work action set was created.
ALTER_TIME	TIMESTAMP		Time at which the work action set was last altered.
ENABLED	CHAR (1)		• N = This work action set is disabled. • Y = This work action set is enabled.
OBJECTTYPE	CHAR (1)		• b = Service superclass • w = Workload • Blank = Database
OBJECTNAME	VARCHAR (128)	Y	Name of the service class or workload.

Table 272. SYSCAT.WORKACTIONSETS Catalog View (continued)

Column Name	Data Type	Nullable	Description
OBJECTID	INTEGER		The identifier of the object to which the work class set (specified by the WORKCLASSSETID) is mapped. If the OBJECTTYPE is 'b', the OBJECTID is the ID of the service superclass. If the OBJECTTYPE is 'w', the OBJECTID is the ID of the workload. If the OBJECTTYPE is blank, the OBJECTID is -1.
REMARKS	VARCHAR (254)	Y	User-provided comments, or the null value.

SYSCAT.WORKCLASSES

Each row represents a work class defined for a work class set.

Table 273. SYSCAT.WORKCLASSES Catalog View

Column Name	Data Type	Nullable	Description
WORKCLASSNAME	VARCHAR (128)		Name of the work class.
WORKCLASSSETNAME	VARCHAR (128)	Y	Name of the work class set.
WORKCLASSID	INTEGER		Identifier for the work class.
WORKCLASSSETID	INTEGER		Identifier for the work class set to which this work class belongs. This column refers to the WORKCLASSSETID column in the SYSCAT.WORKCLASSSETS view.
CREATE_TIME	TIMESTAMP		Time at which the work class was created.
ALTER_TIME	TIMESTAMP		Time at which the work class was last altered.
EVALUATIONORDER	SMALLINT		Uniquely identifies the evaluation order used for choosing a work class within a work class set.

SYSCAT.WORKCLASSSETS

Each row represents a work class set.

Table 274. SYSCAT.WORKCLASSSETS Catalog View

Column Name	Data Type	Nullable	Description
WORKCLASSSETNAME	VARCHAR (128)		Name of the work class set.
WORKCLASSSETID	INTEGER		Identifier for the work class set.
CREATE_TIME	TIMESTAMP		Time at which the work class set was created.
ALTER_TIME	TIMESTAMP		Time at which the work class set was last altered.
REMARKS	VARCHAR (254)	Y	User-provided comments, or the null value.

SYSCAT.WORKLOADAUTH

Each row represents a user, group, or role that has been granted USAGE privilege on a workload.

Table 275. SYSCAT.WORKLOADAUTH Catalog View

Column Name	Data Type	Nullable	Description
WORKLOADID	INTEGER		Identifier for the workload.
WORKLOADNAME	VARCHAR (128)		Name of the workload.
GRANTOR	VARCHAR (128)		Grantor of the privilege.
GRANTORTYPE	CHAR (1)		• U = Grantee is an individual user
GRANTEE	VARCHAR (128)		Holder of the privilege.
GRANTEETYPE	CHAR (1)		• G = Grantee is a group • R = Grantee is a role • U = Grantee is an individual user
USAGEAUTH	CHAR (1)		Indicates whether grantee holds USAGE privilege on the workload. • N = Not held • Y = Held

SYSCAT.WORKLOADCONNATTR

Each row represents a connection attribute in the definition of a workload.

Table 276. SYSCAT.WORKLOADCONNATTR Catalog View

Column Name	Data Type	Nullable	Description
WORKLOADID	INTEGER		Identifier for the workload.
WORKLOADNAME	VARCHAR (128)		Name of the workload.
CONNATTRTYPE	VARCHAR (30)		Type of the connection attribute. • 1 = APPLNAME • 2 = SYSTEM_USER • 3 = SESSION_USER • 4 = SESSION_USER GROUP • 5 = SESSION_USER ROLE • 6 = CURRENT CLIENT_USERID • 7 = CURRENT CLIENT_APPLNAME • 8 = CURRENT CLIENT_WRKSTNNAME • 9 = CURRENT CLIENT_ACCTNG • 10 = ADDRESS
CONNATTRVALUE	VARCHAR (1000)		Value of the connection attribute.

SYSCAT.WORKLOADS

Each row represents a workload.

Table 277. SYSCAT.WORKLOADS Catalog View

Column Name	Data Type	Nullable	Description
WORKLOADID	INTEGER		Identifier for the workload.
WORKLOADNAME	VARCHAR (128)		Name of the workload.
EVALUATIONORDER	SMALLINT		Evaluation order used for choosing a workload.
CREATE_TIME	TIMESTAMP		Time at which the workload was created.
ALTER_TIME	TIMESTAMP		Time at which the workload was last altered.
ENABLED	CHAR (1)		• N = This workload is disabled. • Y = This workload is enabled.
ALLOWACCESS	CHAR (1)		• N = A UOW associated with this workload will be rejected. • Y = A unit of work (UOW) associated with this workload can access the database.
MAXDEGREE	SMALLINT		Maximum degree of parallelism for the workload. The valid values are: 1 to 32767, and -1. If MAXIMUM DEGREE is DEFAULT, the value is -1.
SERVICECLASSNAME	VARCHAR (128)		Name of the service subclass to which a unit of work (associated with this workload) is assigned.
PARENTSERVICECLASSNAME	VARCHAR (128)	Y	Name of the service superclass to which a unit of work (associated with this workload) is assigned.
COLLECTAGGACTDATA	CHAR (1)		Specifies what aggregate activity data should be captured for the workload by the applicable event monitor. • B = Collect base aggregate activity data • E = Collect extended aggregate activity data • N = None
COLLECTACTDATA	CHAR (1)		Specifies what activity data should be collected by the applicable event monitor. • D = Activity data with details • N = None • S = Activity data with details and section environment • V = Activity data with details and values. Applies when the COLLECT column is set to 'C' • W = Activity data without details • X = Activity data with details, section environment, and values
COLLECTACTPARTITION	CHAR (1)		Specifies where activity data is collected. • C = Coordinator member of the activity • D = All members

Table 277. SYSCAT.WORKLOADS Catalog View (continued)

Column Name	Data Type	Nullable	Description
COLLECTDEADLOCK	CHAR (1)		Specifies that deadlock events should be collect by the applicable event monitor. • H = Collect deadlock data with past activities only • N = Do not not collect deadlock data • V = Collect deadlock data with past activities and values • W = Collect deadlock data without past activities and values
COLLECTLOCKTIMEOUT	CHAR (1)		Specifies that lock timeout events should be collect by the applicable event monitor. • H = Collect lock timeout data with past activities only • N = Do not not collect lock timeout data • V = Collect lock timeout data with past activities and values • W = Collect lock timeout data without past activities and values
COLLECTLOCKWAIT	CHAR (1)		Specifies that lock wait events should be collect by the applicable event monitor. • H = Collect lock wait data with past activities only • N = Do not not collect lock wait data • V = Collect lock wait data with past activities and values • W = Collect lock wait data without past activities and values
LOCKWAITVALUE	INTEGER		Specifies the time in milliseconds a lock should wait before a lock event is collected by the applicable event monitor; 0 when COLLECTLOCKWAIT = 'N'
COLLECTACTMETRICS	CHAR (1)		Specifies the monitoring level for activities submitted by an occurrence of the workload. • B = Collect base activity metrics • E = Collect extended activity metrics • N = None

Table 277. SYSCAT.WORKLOADS Catalog View (continued)

Column Name	Data Type	Nullable	Description
COLLECTUOWDATAOPTIONS	VARCHAR (32)		Specifies what unit of work data is collected by the applicable event monitor. The first position in the string represents whether the collection of unit of work data is enabled. • B = Enabled and collect base unit of work data • N = Not enabled Starting from second position, each position in the string represents a specific extended option: • 2 = Package Reference List • 3 = Executable ID list Each position representing an extended option is then set to one of the following values: • Y = Extended option is included • N = Extended option is not included
COLLECTUOWDATA	CHAR (1)		Specifies what unit of work data should be collected by the applicable event monitor. • B = Collect base unit of work data • N = None • P = Collect base unit of work data and the package list This column is deprecated. Information for the column is available from COLLECTUOWDATAOPTIONS.
EXTERNALNAME	VARCHAR (128)	Y	Reserved for future use.
SECTIONACTUALSOPTIONS	VARCHAR (32)		Specifies what section actuals are collected during the execution of a section. The first position in the string represents the whether the collection of section actuals is enabled. • B = Enabled and collect basic operator cardinality counts and statistics for each object referenced by the section (DML statements only). • N = Not enabled. The second position is always 'N' and reserved for for future use.
COLLECTAGGUOWDATA	CHAR (1)		Specifies what aggregate unit of work data should be captured for the workload by the applicable event monitor. • B = Collect base aggregate unit of work data • N = None
REMARKS	VARCHAR (254)	Y	User-provided comments, or the null value.

Appendix A. General naming rules

Rules exist for the naming of all database objects, user names, passwords, groups, files, and paths. Some of these rules are specific to the platform you are working on.

For example, regarding the use of upper and lowercase letters in the names of objects that are visible in the file system (databases, instances, and so on):
- On UNIX platforms, names are case-sensitive. For example, `/data1` is not the same directory as `/DATA1` or `/Data1`
- On Windows platforms, names are not case-sensitive. For example, `\data1` is the same as `\DATA1` and `\Data1`.

Unless otherwise specified, all names can include the following characters:
- The letters A through Z, and a through z, as defined in the basic (7-bit) ASCII character set. When used in identifiers for objects created with SQL statements, lowercase characters "a" through "z" are converted to uppercase unless they are delimited with quotation marks (")
- 0 through 9.
- ! % ( ) { } . - ^ ~ _ (underscore) @, #, $, and space.
- \ (backslash).

Restrictions
- Do not begin names with a number or with the underscore character.
- Do not use SQL reserved words to name tables, views, columns, indexes, or authorization IDs.
- Use only the letters defined in the basic ASCII character set for directory and file names. While your computer's operating system might support different code pages, non-ASCII characters might not work reliably. Using non-ASCII characters can be a particular problem in distributed environment, where different computers might be using different code pages.
- There are other special characters that might work separately depending on your operating system and where you are working with the DB2 database. However, while they might work, there is no guarantee that they will work. It is not recommended that you use these other special characters when naming objects in your database.
- User and group names also must follow the rules imposed by specific operating systems. For example, on Linux and UNIX platforms, characters for user names and group names must be lowercase a through z, 0 through 9, and _ (underscore) for names not starting with 0 through 9.
- Lengths must be less than or equal to the lengths listed in "SQL and XML limits" in the *SQL Reference*.
- **Restrictions on the AUTHID identifier:** In DB2 Version 9.5 and later, you can have a 128-byte authorization ID. However, when the authorization ID is interpreted as an operating system user ID or group name, the operating system naming restrictions apply. For example, the Linux and UNIX operating systems can contain up to 8 characters and the Windows operating systems can contain up to 30 characters for user IDs and group names. Therefore, while you can grant a 128-byte authorization ID, you cannot connect as a user that has that authorization ID. If you write your own security plug-in, you can use the

extended sizes for the authorization ID. For example, you can give your security plug-in a 30-byte user ID and it returns a 128-byte authorization ID during authentication that you can connect to.

You also must consider object naming rules, naming rules in an multicultural support environment, and naming rules in a Unicode environment.

Appendix B. Roles

Roles simplify the administration and management of privileges by offering an equivalent capability as groups but without the same restrictions.

A role is a database object that groups together one or more privileges and can be assigned to users, groups, PUBLIC, or other roles by using a GRANT statement, or can be assigned to a trusted context by using a CREATE TRUSTED CONTEXT or ALTER TRUSTED CONTEXT statement. A role can be specified for the SESSION_USER ROLE connection attribute in a workload definition.

Roles provide several advantages that make it easier to manage privileges in a database system:

- Security administrators can control access to their databases in a way that mirrors the structure of their organizations (they can create roles in the database that map directly to the job functions in their organizations).
- Users are granted membership in the roles that reflect their job responsibilities. As their job responsibilities change, their membership in roles can be easily granted and revoked.
- The assignment of privileges is simplified. Instead of granting the same set of privileges to each individual user in a particular job function, the administrator can grant this set of privileges to a role representing that job function and then grant that role to each user in that job function.
- A role's privileges can be updated and all users who have been granted that role receive the update; the administrator does not need to update the privileges for every user on an individual basis.
- The privileges and authorities granted to roles are always used when you create views, triggers, materialized query tables (MQTs), static SQL and SQL routines, whereas privileges and authorities granted to groups (directly or indirectly) are not used.

  This is because the DB2 database system cannot determine when membership in a group changes, as the group is managed by third-party software (for example, the operating system or an LDAP directory). Because roles are managed inside the database, the DB2 database system can determine when authorization changes and act accordingly. Roles granted to groups are not considered, due to the same reason groups are not considered.
- All the roles assigned to a user are enabled when that user establishes a connection, so all privileges and authorities granted to roles are taken into account when a user connects. Roles cannot be explicitly enabled or disabled.
- The security administrator can delegate management of a role to others.

All DB2 privileges and authorities that can be granted within a database can be granted to a role. For example, a role can be granted any of the following authorities and privileges:

- DBADM, SECADM, DATAACCESS, ACCESSCTRL, SQLADM, WLMADM, LOAD, and IMPLICIT_SCHEMA database authorities
- CONNECT, CREATETAB, CREATE_NOT_FENCED, BINDADD, CREATE_EXTERNAL_ROUTINE, or QUIESCE_CONNECT database authorities
- Any database object privilege (including CONTROL)

A user's roles are automatically enabled and considered for authorization when a user connects to a database; you do not need to activate a role by using the SET ROLE statement. For example, when you create a view, a materialized query table (MQT), a trigger, a package, or an SQL routine, the privileges that you gain through roles apply. However, privileges that you gain through roles granted to groups of which you are a member do not apply.

A role does not have an owner. The security administrator can use the WITH ADMIN OPTION clause of the GRANT statement to delegate management of the role to another user, so that the other user can control the role membership.

Restrictions

There are a few restrictions in the use of roles:

- A role cannot own database objects.
- Permissions and roles granted to groups are not considered when you create the following database objects:
  - Packages containing static SQL
  - Views
  - Materialized query tables (MQT)
  - Triggers
  - SQL Routines

  Only roles granted to the user creating the object or to PUBLIC, directly or indirectly (such as through a role hierarchy), are considered when creating these objects.

Appendix C. Trusted contexts and trusted connections

A trusted context is a database object that defines a trust relationship for a connection between the database and an external entity such as an application server.

The trust relationship is based upon the following set of attributes:
- System authorization ID: Represents the user that establishes a database connection
- IP address (or domain name): Represents the host from which a database connection is established
- Data stream encryption: Represents the encryption setting (if any) for the data communication between the database server and the database client

When a user establishes a database connection, the DB2 database system checks whether the connection matches the definition of a trusted context object in the database. When a match occurs, the database connection is said to be trusted.

A trusted connection allows the initiator of this trusted connection to acquire additional capabilities that may not be available outside the scope of the trusted connection. The additional capabilities vary depending on whether the trusted connection is explicit or implicit.

The initiator of an explicit trusted connection has the ability to:
- Switch the current user ID on the connection to a different user ID with or without authentication
- Acquire additional privileges via the role inheritance feature of trusted contexts

An implicit trusted connection is a trusted connection that is not explicitly requested; the implicit trusted connection results from a normal connection request rather than an explicit trusted connection request. No application code changes are needed to obtain an implicit connection. Also, whether you obtain an implicit trusted connection or not has no effect on the connect return code (when you request an explicit trusted connection, the connect return code indicates whether the request succeeds or not). The initiator of an implicit trusted connection can only acquire additional privileges via the role inheritance feature of trusted contexts; they cannot switch the user ID.

How using trusted contexts enhances security

The three-tiered application model extends the standard two-tiered client and server model by placing a middle tier between the client application and the database server. It has gained great popularity in recent years particularly with the emergence of web-based technologies and the Java 2 Enterprise Edition (J2EE) platform. An example of a software product that supports the three-tier application model is IBM WebSphere Application Server (WAS).

In a three-tiered application model, the middle tier is responsible for authenticating the users running the client applications and for managing the interactions with the database server. Traditionally, all the interactions with the database server occur through a database connection established by the middle tier using a combination of a user ID and a credential that identify that middle tier to the database server. This means that the database server uses the database privileges associated with the middle tier's user ID for all authorization checking and auditing that must occur for any database access, including access performed by the middle tier on behalf of a user.

While the three-tiered application model has many benefits, having all interactions with the database server (for example, a user request) occur under the middle tier's authorization ID raises several security concerns, which can be summarized as follows:

- Loss of user identity

  Some enterprises prefer to know the identity of the actual user accessing the database for access control purposes.
- Diminished user accountability

  Accountability through auditing is a basic principle in database security. Not knowing the user's identity makes it difficult to distinguish the transactions performed by the middle tier for its own purpose from those performed by the middle tier on behalf of a user.
- Over granting of privileges to the middle tier's authorization ID

  The middle tier's authorization ID must have all the privileges necessary to execute all the requests from all the users. This has the security issue of enabling users who do not need access to certain information to obtain access anyway.
- Weakened security

  In addition to the privilege issue raised in the previous point, the current approach requires that the authorization ID used by the middle tier to connect must be granted privileges on all resources that might be accessed by user requests. If that middle-tier authorization ID is ever compromised, then all those resources will be exposed.
- "Spill over" between users of the same connection

  Changes by a previous user can affect the current user.

Clearly, there is a need for a mechanism whereby the actual user's identity and database privileges are used for database requests performed by the middle tier on behalf of that user. The most straightforward approach of achieving this goal would be for the middle-tier to establish a new connection using the user's ID and password, and then direct the user's requests through that connection. Although simple, this approach suffers from several drawbacks which include the following:

- Inapplicability for certain middle tiers. Many middle-tier servers do not have the user authentication credentials needed to establish a connection.
- Performance overhead. There is an obvious performance overhead associated with creating a new physical connection and re-authenticating the user at the database server.
- Maintenance overhead. In situations where you are not using a centralized security set up or are not using single sign-on, there is maintenance overhead in having two user definitions (one on the middle tier and one at the server). This requires changing passwords at different places.

The trusted contexts capability addresses this problem. The security administrator can create a trusted context object in the database that defines a trust relationship between the database and the middle-tier. The middle-tier can then establish an explicit trusted connection to the database, which gives the middle tier the ability to switch the current user ID on the connection to a different user ID, with or without authentication. In addition to solving the end-user identity assertion problem, trusted contexts offer another advantage. This is the ability to control when a privilege is made available to a database user. The lack of control on when privileges are available to a user can weaken overall security. For example, privileges may be used for purposes other than they were originally intended. The security administrator can assign one or more privileges to a role and assign that role to a trusted context object. Only trusted database connections (explicit or implicit) that match the definition of that trusted context can take advantage of the privileges associated with that role.

Enhancing performance

When you use trusted connections, you can maximize performance because of the following advantages:

- No new connection is established when the current user ID of the connection is switched.
- If the trusted context definition does not require authentication of the user ID to switch to, then the overhead associated with authenticating a new user at the database server is not incurred.

Example of creating a trusted context

Suppose that the security administrator creates the following trusted context object:

```
CREATE TRUSTED CONTEXT CTX1
  BASED UPON CONNECTION USING SYSTEM AUTHID USER2
  ATTRIBUTES (ADDRESS   '192.0.2.1')
  DEFAULT ROLE managerRole
   ENABLE
```

If user *user1* requests a trusted connection from IP address 192.0.2.1, the DB2 database system returns a warning (SQLSTATE 01679, SQLCODE +20360) to indicate that a trusted connection could not be established, and that user *user1* simply got a non-trusted connection. However, if user *user2* requests a trusted connection from IP address 192.0.2.1, the request is honored because the connection attributes are satisfied by the trusted context CTX1. Now that use *user2* has established a trusted connection, he or she can now acquire all the privileges and authorities associated with the trusted context role managerRole. These privileges and authorities may not be available to user *user2* outside the scope of this trusted connection

Appendix D. Overview of the DB2 technical information

DB2 technical information is available in multiple formats that can be accessed in multiple ways.

DB2 technical information is available through the following tools and methods:

- DB2 Information Center
  - Topics (Task, concept and reference topics)
  - Sample programs
  - Tutorials
- DB2 books
  - PDF files (downloadable)
  - PDF files (from the DB2 PDF DVD)
  - printed books
- Command-line help
  - Command help
  - Message help

Note: The DB2 Information Center topics are updated more frequently than either the PDF or the hardcopy books. To get the most current information, install the documentation updates as they become available, or refer to the DB2 Information Center at ibm.com.

You can access additional DB2 technical information such as technotes, white papers, and IBM Redbooks® publications online at ibm.com. Access the DB2 Information Management software library site at http://www.ibm.com/software/data/sw-library/.

Documentation feedback

We value your feedback on the DB2 documentation. If you have suggestions for how to improve the DB2 documentation, send an email to db2docs@ca.ibm.com. The DB2 documentation team reads all of your feedback, but cannot respond to you directly. Provide specific examples wherever possible so that we can better understand your concerns. If you are providing feedback on a specific topic or help file, include the topic title and URL.

Do not use this email address to contact DB2 Customer Support. If you have a DB2 technical issue that the documentation does not resolve, contact your local IBM service center for assistance.

DB2 technical library in hardcopy or PDF format

The following tables describe the DB2 library available from the IBM Publications Center at www.ibm.com/e-business/linkweb/publications/servlet/pbi.wss. English and translated DB2 Version 10.1 manuals in PDF format can be downloaded from www.ibm.com/support/docview.wss?rs=71&uid=swg2700947.

Although the tables identify books available in print, the books might not be available in your country or region.

The form number increases each time a manual is updated. Ensure that you are reading the most recent version of the manuals, as listed below.

Note: The *DB2 Information Center* is updated more frequently than either the PDF or the hard-copy books.

Table 278. DB2 technical information

Name	Form Number	Available in print	Last updated
Administrative API Reference	SC27-3864-00	Yes	April, 2012
Administrative Routines and Views	SC27-3865-00	No	April, 2012
Call Level Interface Guide and Reference Volume 1	SC27-3866-00	Yes	April, 2012
Call Level Interface Guide and Reference Volume 2	SC27-3867-00	Yes	April, 2012
Command Reference	SC27-3868-00	Yes	April, 2012
Database Administration Concepts and Configuration Reference	SC27-3871-00	Yes	April, 2012
Data Movement Utilities Guide and Reference	SC27-3869-00	Yes	April, 2012
Database Monitoring Guide and Reference	SC27-3887-00	Yes	April, 2012
Data Recovery and High Availability Guide and Reference	SC27-3870-00	Yes	April, 2012
Database Security Guide	SC27-3872-00	Yes	April, 2012
DB2 Workload Management Guide and Reference	SC27-3891-00	Yes	April, 2012
Developing ADO.NET and OLE DB Applications	SC27-3873-00	Yes	April, 2012
Developing Embedded SQL Applications	SC27-3874-00	Yes	April, 2012
Developing Java Applications	SC27-3875-00	Yes	April, 2012
Developing Perl, PHP, Python, and Ruby on Rails Applications	SC27-3876-00	No	April, 2012
Developing User-defined Routines (SQL and External)	SC27-3877-00	Yes	April, 2012
Getting Started with Database Application Development	GI13-2046-00	Yes	April, 2012

Table 278. DB2 technical information (continued)

Name	Form Number	Available in print	Last updated
Getting Started with DB2 Installation and Administration on Linux and Windows	GI13-2047-00	Yes	April, 2012
Globalization Guide	SC27-3878-00	Yes	April, 2012
Installing DB2 Servers	GC27-3884-00	Yes	April, 2012
Installing IBM Data Server Clients	GC27-3883-00	No	April, 2012
Message Reference Volume 1	SC27-3879-00	No	April, 2012
Message Reference Volume 2	SC27-3880-00	No	April, 2012
Net Search Extender Administration and User's Guide	SC27-3895-00	No	April, 2012
Partitioning and Clustering Guide	SC27-3882-00	Yes	April, 2012
pureXML Guide	SC27-3892-00	Yes	April, 2012
Spatial Extender User's Guide and Reference	SC27-3894-00	No	April, 2012
SQL Procedural Languages: Application Enablement and Support	SC27-3896-00	Yes	April, 2012
SQL Reference Volume 1	SC27-3885-00	Yes	April, 2012
SQL Reference Volume 2	SC27-3886-00	Yes	April, 2012
Text Search Guide	SC27-3888-00	Yes	April, 2012
Troubleshooting and Tuning Database Performance	SC27-3889-00	Yes	April, 2012
Upgrading to DB2 Version 10.1	SC27-3881-00	Yes	April, 2012
What's New for DB2 Version 10.1	SC27-3890-00	Yes	April, 2012
XQuery Reference	SC27-3893-00	No	April, 2012

Table 279. DB2 Connect-specific technical information

Name	Form Number	Available in print	Last updated
DB2 Connect Installing and Configuring DB2 Connect Personal Edition	SC27-3861-00	Yes	April, 2012
DB2 Connect Installing and Configuring DB2 Connect Servers	SC27-3862-00	Yes	April, 2012
DB2 Connect User's Guide	SC27-3863-00	Yes	April, 2012

Displaying SQL state help from the command line processor

DB2 products return an SQLSTATE value for conditions that can be the result of an SQL statement. SQLSTATE help explains the meanings of SQL states and SQL state class codes.

Procedure

To start SQL state help, open the command line processor and enter:

```
? sqlstate or ? class code
```

where *sqlstate* represents a valid five-digit SQL state and *class code* represents the first two digits of the SQL state.
For example, `? 08003` displays help for the 08003 SQL state, and `? 08` displays help for the 08 class code.

Accessing different versions of the DB2 Information Center

Documentation for other versions of DB2 products is found in separate information centers on ibm.com®.

About this task

For DB2 Version 10.1 topics, the *DB2 Information Center* URL is http://publib.boulder.ibm.com/infocenter/db2luw/v10r1.

For DB2 Version 9.8 topics, the *DB2 Information Center* URL is http://publib.boulder.ibm.com/infocenter/db2luw/v9r8/.

For DB2 Version 9.7 topics, the *DB2 Information Center* URL is http://publib.boulder.ibm.com/infocenter/db2luw/v9r7/.

For DB2 Version 9.5 topics, the *DB2 Information Center* URL is http://publib.boulder.ibm.com/infocenter/db2luw/v9r5.

For DB2 Version 9.1 topics, the *DB2 Information Center* URL is http://publib.boulder.ibm.com/infocenter/db2luw/v9/.

For DB2 Version 8 topics, go to the *DB2 Information Center* URL at: http://publib.boulder.ibm.com/infocenter/db2luw/v8/.

Updating the DB2 Information Center installed on your computer or intranet server

A locally installed DB2 Information Center must be updated periodically.

Before you begin

A DB2 Version 10.1 Information Center must already be installed. For details, see the "Installing the DB2 Information Center using the DB2 Setup wizard" topic in *Installing DB2 Servers*. All prerequisites and restrictions that applied to installing the Information Center also apply to updating the Information Center.

About this task

An existing DB2 Information Center can be updated automatically or manually:

- Automatic updates update existing Information Center features and languages. One benefit of automatic updates is that the Information Center is unavailable for a shorter time compared to during a manual update. In addition, automatic updates can be set to run as part of other batch jobs that run periodically.
- Manual updates can be used to update existing Information Center features and languages. Automatic updates reduce the downtime during the update process, however you must use the manual process when you want to add features or languages. For example, a local Information Center was originally installed with both English and French languages, and now you want to also install the German language; a manual update will install German, as well as, update the existing Information Center features and languages. However, a manual update requires you to manually stop, update, and restart the Information Center. The Information Center is unavailable during the entire update process. In the automatic update process the Information Center incurs an outage to restart the Information Center after the update only.

This topic details the process for automatic updates. For manual update instructions, see the "Manually updating the DB2 Information Center installed on your computer or intranet server" topic.

Procedure

To automatically update the DB2 Information Center installed on your computer or intranet server:

1. On Linux operating systems,
   a. Navigate to the path where the Information Center is installed. By default, the DB2 Information Center is installed in the `/opt/ibm/db2ic/V10.1` directory.
   b. Navigate from the installation directory to the `doc/bin` directory.
   c. Run the `update-ic` script:
      ```
      update-ic
      ```
2. On Windows operating systems,
   a. Open a command window.
   b. Navigate to the path where the Information Center is installed. By default, the DB2 Information Center is installed in the `<Program Files>\IBM\DB2 Information Center\Version 10.1` directory, where `<Program Files>` represents the location of the Program Files directory.
   c. Navigate from the installation directory to the `doc\bin` directory.
   d. Run the `update-ic.bat` file:
      ```
      update-ic.bat
      ```

Results

The DB2 Information Center restarts automatically. If updates were available, the Information Center displays the new and updated topics. If Information Center updates were not available, a message is added to the log. The log file is located in `doc\eclipse\configuration` directory. The log file name is a randomly generated number. For example, `1239053440785.log`.

Manually updating the DB2 Information Center installed on your computer or intranet server

If you have installed the DB2 Information Center locally, you can obtain and install documentation updates from IBM.

About this task

Updating your locally installed *DB2 Information Center* manually requires that you:

1. Stop the *DB2 Information Center* on your computer, and restart the Information Center in stand-alone mode. Running the Information Center in stand-alone mode prevents other users on your network from accessing the Information Center, and allows you to apply updates. The Workstation version of the DB2 Information Center always runs in stand-alone mode. .
2. Use the Update feature to see what updates are available. If there are updates that you must install, you can use the Update feature to obtain and install them

   Note: If your environment requires installing the *DB2 Information Center* updates on a machine that is not connected to the internet, mirror the update site to a local file system by using a machine that is connected to the internet and has the *DB2 Information Center* installed. If many users on your network will be installing the documentation updates, you can reduce the time required for individuals to perform the updates by also mirroring the update site locally and creating a proxy for the update site.
   If update packages are available, use the Update feature to get the packages. However, the Update feature is only available in stand-alone mode.
3. Stop the stand-alone Information Center, and restart the *DB2 Information Center* on your computer.

Note: On Windows 2008, Windows Vista (and higher), the commands listed later in this section must be run as an administrator. To open a command prompt or graphical tool with full administrator privileges, right-click the shortcut and then select **Run as administrator**.

Procedure

To update the *DB2 Information Center* installed on your computer or intranet server:

1. Stop the *DB2 Information Center*.
   - On Windows, click **Start** > **Control Panel** > **Administrative Tools** > **Services**. Then right-click **DB2 Information Center** service and select **Stop**.
   - On Linux, enter the following command:
     ```
     /etc/init.d/db2icdv10 stop
     ```
2. Start the Information Center in stand-alone mode.
   - On Windows:
     a. Open a command window.
     b. Navigate to the path where the Information Center is installed. By default, the *DB2 Information Center* is installed in the `*Program_Files*\IBM\DB2 Information Center\Version 10.1` directory, where *Program_Files* represents the location of the `Program Files` directory.
     c. Navigate from the installation directory to the `doc\bin` directory.
     d. Run the `help_start.bat` file:

```
help_start.bat
```

- On Linux:
  a. Navigate to the path where the Information Center is installed. By default, the *DB2 Information Center* is installed in the `/opt/ibm/db2ic/V10.1` directory.
  b. Navigate from the installation directory to the `doc/bin` directory.
  c. Run the `help_start` script:

     ```
     help_start
     ```

The systems default Web browser opens to display the stand-alone Information Center.

3. Click the **Update** button (). (JavaScript must be enabled in your browser.) On the right panel of the Information Center, click **Find Updates**. A list of updates for existing documentation displays.
4. To initiate the installation process, check that the selections you want to install, then click **Install Updates**.
5. After the installation process has completed, click **Finish**.
6. Stop the stand-alone Information Center:
   - On Windows, navigate to the `doc\bin` directory within the installation directory, and run the `help_end.bat` file:

     ```
     help_end.bat
     ```

     Note: The `help_end` batch file contains the commands required to safely stop the processes that were started with the `help_start` batch file. Do not use `Ctrl-C` or any other method to stop `help_start.bat`.
   - On Linux, navigate to the `doc/bin` directory within the installation directory, and run the `help_end` script:

     ```
     help_end
     ```

     Note: The `help_end` script contains the commands required to safely stop the processes that were started with the `help_start` script. Do not use any other method to stop the `help_start` script.
7. Restart the *DB2 Information Center*.
   - On Windows, click **Start** > **Control Panel** > **Administrative Tools** > **Services**. Then right-click **DB2 Information Center** service and select **Start**.
   - On Linux, enter the following command:

     ```
     /etc/init.d/db2icdv10 start
     ```

Results

The updated *DB2 Information Center* displays the new and updated topics.

DB2 tutorials

The DB2 tutorials help you learn about various aspects of DB2 database products. Lessons provide step-by-step instructions.

Before you begin

You can view the XHTML version of the tutorial from the Information Center at http://publib.boulder.ibm.com/infocenter/db2luw/v10r1/.

Some lessons use sample data or code. See the tutorial for a description of any prerequisites for its specific tasks.

DB2 tutorials

To view the tutorial, click the title.

"pureXML®" in *pureXML Guide*
: Set up a DB2 database to store XML data and to perform basic operations with the native XML data store.

DB2 troubleshooting information

A wide variety of troubleshooting and problem determination information is available to assist you in using DB2 database products.

DB2 documentation

Troubleshooting information can be found in the *Troubleshooting and Tuning Database Performance* or the Database fundamentals section of the *DB2 Information Center*, which contains:

- Information about how to isolate and identify problems with DB2 diagnostic tools and utilities.
- Solutions to some of the most common problem.
- Advice to help solve other problems you might encounter with your DB2 database products.

IBM Support Portal

See the IBM Support Portal if you are experiencing problems and want help finding possible causes and solutions. The Technical Support site has links to the latest DB2 publications, TechNotes, Authorized Program Analysis Reports (APARs or bug fixes), fix packs, and other resources. You can search through this knowledge base to find possible solutions to your problems.

Access the IBM Support Portal at http://www.ibm.com/support/entry/portal/Overview/Software/Information_Management/DB2_for_Linux,_UNIX_and_Windows

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Index

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