IBM *@* server

iSeries Disk Arm Requirements Based on Processor Model Performance

Larry Whitley, Farnaz Toussi and Clark Anderson
iSeries System Architecture and Performance
IBM Rochester Lab
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As higher capacity disk devices (disk units, or Direct Access Storage Devices, or DASDs, or arms, or drives) for the iSeries™ and AS/400™ systems become available, *fewer arms* are needed to satisfy the *capacity* requirements. This *can lead to configuring too few disk arms to meet the workload* placed on them. **A lack of disk arms can bottleneck the processor's performance.** To avoid such a bottleneck, a *certain number of disk arms is needed for optimum performance* on each processor level. This number is independent of the quantity of drives needed to meet the desired storage capacity.

WARNING: The worksheets in this guide should never be used alone to make purchase decisions. They can be used to determine the number of disk arms needed to minimize the DASD bottleneck on iSeries and AS/400 computers running multi-user environments, not how many DASDs should be installed on a system.

Not all situations require that DASDs never bottleneck processor speed. Please see Relationship to Other Sizing Tools on page 5 for determining the best number of DASDs that should be installed.

Table of Contents

1 Why is it Important to Have Enough Disk Arms ?

As stated on the first page, a lack of disk arms can bottleneck processor performance. There are several reasons this occurs. This section attempts to clarify a few of them.

- A physical disk drive (non-cached) can only perform a certain number of disk accesses each second before performance starts to be impacted.

    While today's technology allows a disk to perform in excess of 100 operations each second, performance is impacted far before that number of disk accesses is reached. The impact starts to be dramatically felt when the number of disk accesses reaches about 40% of the maximum. This can be explained by queuing theory.

    If more accesses are requested than can be completed in given period of time (often a fraction of a second), some requests must wait in a queue while the previous requests are processed. This occurs because disk requests occur in random time intervals, and take varying amounts of time to complete. The greater the number of disk requests each second and/or the longer they take to be processed, the more queuing occurs. For those requests that must spend time in a queue, the total response time equals not only the time for the drive to service the access request, but also the time spent waiting in the queue.

    To keep things at their optimum (very few disk requests needing to wait), the drive should probably not need to do more than about 30 requests/second (depending on the disk drive, the controller, the protection approach, and other variables). Once the disk gets to 40% utilization, performance is already starting to fall off (too many requests can be waiting in the queue).

- Performance problems can occur if a customer sizes a server based strictly on capacity. They may specify too few disk arms. As an example:

    For simplicity, we will ignore RAID in this discussion. Let's assume a customer needs 175 GB of capacity. They also need to perform 600 disk accesses each second. In this example, these accesses must occur at the disk level, *after* accounting for the iSeries system self-cacheing capabilities (which are discussed on the following page).

    Using 17.5 GB drives, only 10 disks would be required. This means that each disk would need to do about 60 accesses each second. At this rate, performance could be a problem (due to the amount of queuing). However, if 8.5 GB disks were used, the customer would have 21 disks, and with less than 30 disk requests per second, performance should be quite good (very little queuing).

    Therefore, if a customer wants good performance while using 17.5 GB disks, he or she cannot simply use 10 disk drives. Options would include:
    1) Install 20 of the 17.5 GB disks (which gives them more capacity than they need).
    2) Do something to reduce the number of disk requests going to the disks each second.

    With iSeries single level store architecture, the best way to reduce the number of requests going to the disks is to increase the amount of memory installed on the system. With single level store, additional system memory acts as a cache for all disk requests and the reduction in the number of physical disk requests can be dramatic. Usually, adding system memory is more effective until the system is at its maximum memory capacity. At

that point, if disk performance is still an issue, adding a read cache between the system and the disk drives may be worth investigating.

> *Note:* File accesses by an Integrated xSeries Server (IXS) are NOT cached by iSeries single level store algorithms. Therefore a cache between the system and the disks can provide a benefit if disk response times are an issue.

The net is, just because a 17.5 GB drive is double the size of an 8.5 GB drive does not mean you can use half as many. Performance could be impacted. However, sometimes by using 17.5 GB disks and adding a little additional capacity, the performance goals can be met, while minimizing the cost. For example, from a capacity standpoint, a customer may have needed ten 17.5 GB drives or twenty 8.5 GB drives. While 10 drives might not provide sufficient disk speed, 12 disks might. The total cost of 12 of the 17.5 GB drives (including controllers, towers, etc.) is far less than 20 of the 8.5 GB disks and the customer gets more capacity as part of the bargain.

v The faster the processor, the more disk accesses it can request each second. This is obvious, but needs to be stated. The people who feel they should be able to merely size the disk based on capacity do not recognize the processing power of the iSeries system. For example, even the smallest 820 has the potential to issue in excess of 1,000 disk requests per second, when running a database-intensive application that has been very efficiently programmed.

The reality is that usually only a fraction of this number of requests is issued. This is due to several factors, including: compute-intensive applications running at the same time as database-intensive applications; and not having sufficient workload to run the processor at its full capacity.

The worksheets in this document attempt to take several of these factors into account.

v The iSeries system has a very efficient "self-cacheing" capability implemented in the single level store architecture. Basically, when an iSeries system has sufficient memory, up to 80% (and often more) of the (potentially tens of thousands of) disk accesses may not need to physically occur at the disk level. The data is already in memory. Therefore, with sufficient memory, the number of disks required for good performance can decrease. *However,* at the disk level, the drive itself can still only perform a given number of accesses each second!

Some customers feel that using an external read cache will allow more disk accesses to occur each second. While this is true, the effectiveness of the external disk cache decreases as the size of the memory on the system increases. Therefore, an 8 GB external cache may be very effective if the system only has 1/2 GB of memory, but if the system had for example 4 GB of memory, the effectiveness of the external cache would be severely limited. A high percentage of the accesses that were cached within the disk subsystem would never be requested, because the data was already in the iSeries system's memory. In technical terms, the hit-to-miss ratio of the external cache becomes unacceptably high -- and performance suffers.

The net of this discussion is that to provide balanced performance, a system needs a sufficient number of disk drives. This document will help ensure that you do have sufficient disk resources to meet the performance -- not just capacity -- requirements of your application.

2 Relationship to Other Sizing Tools

The information in the accompanying worksheets and tables is based on studies done by the Rochester Lab for specific sets of transactions and assumptions. The benchmarks used to produce the tables may not accurately reflect your specific environment. Unique customer applications may generate more or less disk activity than the applications used to produce the tables. *There are other sizing tools that provide more accurate configuration projections*. They consider not only the processor and disk speeds, but also application requirements, memory capacity, existing drive utilization, etc.

a. **The Workload Estimator assists IBM approved IBM Business Partners, and customers in projecting a model that meets capacity requirements within CPU % utilization objectives. The *IBM eServer Workload Estimator* is available online at** http://www.ibm.com/eserver/iseries/support/estimator**.**

b. **Capacity planning tools *BEST/1*, available for V5R1 and older systems, and *Patrol for iSeries - Predict*, available for V5R2 and newer systems from BMC Software Inc., in conjunction with actual customer measurements on an existing system/ application, usually provide more accurate information than these worksheets and tables, since they can rely on the customer's actual workload. These are recommended for final configurations.**

Also, the information in the worksheets is intended to be used as a **GUIDELINE** and *NOT AS UNALTERABLE RULES*. Without data available for particular application scenarios, it is impossible to give definitive, specific rules on numbers of disk arms required in all customer cases. The information here is a best attempt to provide a general recommendation that should apply in many customer situations. It is important to realize that the specifics of individual application scenarios can cause variation in the appropriate number of disks required for each case. Additional information about each specific customer's system, coupled with experience and judgment, can alter the correct recommendation. Individual cases can differ from the general guidelines listed in the tables.

It is true that more drives could be used than are determined by worksheets from this guide and there may be environments and workloads where more devices may be required to meet speed requirements, thus making the results "minimum" values. But adding more DASDs than the resultant value from the worksheets is not likely to be needed for performance reasons. Thus the results from this guide typically represent a "maximum" value that are needed to greatly reduce the likelihood of any DASD bottleneck to system speed.

3 Recent Worksheet Updates

This edition includes data for new 870, 825, 810 and 800 processor models and newer 890 processor features. Several 840 processor numbers have been updated as well. It also introduces 4326 & 4327 15,000 RPM DASDs and latest generation 2844 Input/Output Processors (IOPs) and 2757 & 2782 Input/Output Adapters (IOAs).

4 Understanding the Worksheets

The worksheets use a simple step-by-step approach to calculating the number of disk arms required. All of the data needed to perform the calculations is contained in tables associated with the specific

iSeries-AS/400 models, and in a separate table which provides adjustment factors for the various combinations of Input/Output Processors/Adapters (IOP/IOAs), DASDs and protection methods. The data in these tables is based upon the following set of assumptions:

- "Typical" Commercial OLTP or Client/Server transactions are executed.
- The processor generates physical disk accesses as rapidly as the applications and the speed of the processor permit.
- A limitation of **70% processor utilization** is imposed to match the published recommendations for good interactive performance.
- It is assumed that enough memory is installed to meet the recommended paging rates.
- The values generated apply to a single OS/400 partition. The number of disks required by the system is the sum of the number of disks required for each partition on the system.

    Note: Additional memory can decrease the number of disk arms needed. See "Appendix C".

Installing at least the number of disk arms calculated using the worksheets ensures that DASD utilization will not exceed the recommended guidelines. Be cautious, however, when configuring models with "low levels" of interactive performance. The "non-interactive" performance can be used for either data-intensive or compute-intensive functions. The table values selected for use in calculations need to accurately reflect the manner in which the non-interactive processing power is used.

To use the worksheets, one must know or make assumptions about information that includes:

- The System (1) model type, (2) processor feature number, and where applicable, the (3) interactive feature (see section "6.6 **Interactive Features**" on page 13).
    The faster the processor, the more likely it will need to "wait" on the disk, therefore the more arms it needs to "keep busy".
- The (4) IOP/IOA type
- (5) DASD protection method.
    RAID-5, Mirroring or No Protection. And if mirroring disk drives, (6) DASD read-to-write access ratios. See section "6.3 **Mirrored Environments**" on page 12 for details.
- The (7) DASD device type
    The tables assume all devices are the same type and capacity. See section "6.2 **Mixing Disk Features**" on page 12 for more information.
- For non-interactive processing, the mix of data-intensive or compute-intensive functions, the (8) "type" of workload.
    "Traditional" Server activities, such as PC file/print serving, e-Mail or Lotus Notes/Domino serving, and static-page Internet serving require fewer disk accesses and are primarily sequential. In contrast, OLTP (On-Line Transaction Processing), where "green screen" types of applications have been rewritten to take advantage of client-server features, perform a lot of random disk accesses for each transaction. See section "5 Workload Discussion -- Processor and Interactive CPW" on page 9 for more details.
- The (9) estimated CPU utilization during peak periods of operation.
    This can be used to prorate the number of arms calculated from the worksheets relative to the 70% utilization assumed. This may be especially appropriate for new systems. For example, on a new processor upgrade, where the CPU is not expected to exceed 35% for the first few months of operation, only half the arms calculated would be required. As CPU usage rises above this amount over time, more arms would be needed. Eventually, at full system capacity, a requirement for the full number shown in the table would be expected. See section "6.4 **CPU Utilization Considerations**" on page 13 for additional discussion.

*The example below illustrates most of these considerations and shows how **selecting the number of disk drives based solely on their capacity** (and the lowest price for the desired capacity) **could result in inadequate performance.***

Desired system disk capacity: 80 GB (usable capacity), plus RAID-5 parity capacity
CPU model: 820-2396, Interactive feature 1522
Expected CPU utilization: 70%
Expected Server workload: Traditional Client/Server, Light disk usage
Proposed DASD device: # 4318 (17 GB, 10,000 RPM)
IOP type: # 2763 PCI RAID Disk Unit Controller, RAID-5 Mode

Selection of disk drive feature # 4318 (17 GB, 10000 RPM) might be the first choice, as it meets system capacity needs and requires few disks and supporting features, which in turn produces a low price. Based only on capacity, 5 disk arms would be sufficient for usable data plus parity in a single RAID-5 array. To determine whether 5 arms are also sufficient for performance, it is necessary to use the worksheet for Model 820, found on page 22. The worksheet is duplicated below, with the values filled in for this example.

Example for 820-2396, interactive feature 1522, with #4318 DASD and #2763 IOA

Worksheet for Model 820 DASD Arms required for performance	
1. In Table 12, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1) 950
2. In Table 12, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2) 70
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3) 880 (950-70)
4. In Table 13, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4) 16
5. In Table 13, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5) 59
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload.	6) 4.4 (70/16)
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload.	7) 14.9 (880/59)
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8) 19.3 (14.9+4.4)
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the controller, DASD device, and protection method to be used. Enter the number on line 9.	9) 1.19
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the number of DASD arms required for the selected system, hardware configuration, and workload.	10) 17 (19.3/1.19)

In the worksheet, two types of values are used from the Model 820 tables. On lines 1 and 2, the CPW values are entered for the selected processor and interactive features. On lines 4 and 5, arm factors are entered for the interactive and server workloads. The arm factors represent, for a #2763 IOA and #4318 disk, the CPW rating for which a single disk arm can handle the disk operations generated by the selected workload. The arm factors are affected by the characteristics of the individual AS/400 models. In the worksheet, an adjustment factor from the IOP/IOA/DASD Adjustment table on page 14 is used to adjust the number of disk arms for the selected hardware and protection method.

From the worksheet, we find that 17 #4318 disk arms are required to satisfy the minimum performance requirement with a #2763. Therefore, 5 Arms would provide sufficient capacity for usable data plus parity in a single RAID 5 Array, **but** do **NOT** satisfy the minimum performance requirement of 17 arms.

By using feature # 4318 (17 GB, 10,000 RPM), 17 arms provide sufficient capacity (usable data plus parity in 2 separate RAID-5 Arrays), *and* provide acceptable performance. Alternatively, we could replace the IOA feature #2763 with IOA feature #4778, and use device feature #4317 (8.58 GB, 10,000 RPM). This would lead to the calculations shown in the worksheet below.

Example for 820-2396, interactive feature 1522 with #4317 DASD and #4778 IOA

Worksheet for Model 820 DASD Arms required for performance	
1. In Table 12, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1) 950
2. In Table 12, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2) 70
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3) 880 *(950-70)*
4. In Table 13, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4) 16
5. In Table 13, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5) 59
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload.	6) 4.4 *(70/16)*
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload.	7) 14.9 *(880/59)*
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8) 19.3 *(14.9+4.4)*
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the controller, DASD device, and protection method to be used. Enter the number on line 9.	9) 1.56
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the number of DASD arms required for the selected system, hardware configuration, and workload.	10) 13 *(19.3/1.56)*

Using IOA feature #4778, and device feature #4317 (8.58 GB, 10, 000RPM), 13 disk arms provide sufficient capacity (usable data plus parity in 2 separate RAID-5 Arrays), *and* provide acceptable performance.

From this we can conclude that using either #2763 IOAs with 17 #4318 disk devices, or #4778 IOAs with 13 #4317 disk devices will satisfy both the capacity and performance requirements of the system. Either of the options can be selected, and the final choice may be made based on other considerations, such as the price of the entire configuration.

5   Workload Discussion -- Processor and Interactive CPW

Most often, the performance of iSeries systems is specified with two numbers, "Processor" and "Interactive" CPW. The Processor CPW is a metric that indicates the relative performance of the system when running commercial processing workloads. These workloads may be database intensive or compute intensive and may or may not use SQL. A portion of the total Processor CPW can be designated for traditional 5250 terminal (green screen) use via an Interactive Feature Card. The Interactive CPW is a metric that indicates the relative performance available to the system when running 5250 ("green screen") workloads.

When an iSeries system is acting as a server to other workstations (PCs, Macs or UNIX workstations communicating over TCP/IP would be examples - these workstations are not doing 5250 emulation) or systems, there will be one or more applications receiving requests across a communications network from those workstations and/or systems. These applications will only use "Processor CPW", but are highly variable in the amount of disk performance each require.

 * Some applications place a relatively small, predominantly sequential workload on the disks. These types of applications include: PC file/print serving; Internet serving of "Static" pages (especially those with high graphical content); Lotus Notes/Domino mail serving; and any activity that performs relatively few random disk accesses. Some of these types of activities heavily exercise the CPU, others do not.

 * Some applications perform heavy random disk activity while using relatively little CPU power. These programs typically perform On-Line Transaction Processing (OLTP).

   * When running OLTP applications some programs will use "Green Screen" approaches and will run against the level of "Interactive CPW" purchased. They will usually have a relatively low amount of CPU performance available to them (lower CPW number), but still perform large numbers of random disk accesses. The amount of disk activity generated in this mode is usually limited by the available CPU resource and the number of users actively using the workstations.

   * There are also OLTP applications that have been written to take advantage of client-server features. They perform many random disk accesses for each transaction. Because they are not running as 5250 applications, the full processing power of the system available to them. Applications like these can generate the same disk workload requirements as those generated by the 5250 applications, but these applications will typically have more (processor) CPW available for their use.

 * Query applications, especially those processing through an alternate access path (secondary index to the data), and data warehousing applications, especially when performing "drill down" activities, can also generate large numbers of random disk accesses. These applications take advantage of the higher levels of "processor" performance and can therefore generate heavy disk activity.

To address the various requirements the tables present arm factors for three different server-oriented workloads: Light, Heavy and Mixed. They should not be used blindly. It will often be necessary to "weight" two of the values to obtain a result that matches the customer's actual environment.

5.1.1 *Light Disk Workload Environments:*

A "Light" disk access rate was determined when running *only* server applications (i.e., no interactive, green screen applications) that are *compute-intensive* and generate relatively few, sequential oriented disk accesses. Applications such as Lotus Notes/Domino; Internet Web serving of "static" pages, images, and graphics; and some SAP R/3 environments fit this category (note that production environments of SAP can sometimes be heavier in disk load than what is created by the Industry Benchmark applications for SAP R/3. The Industry Benchmark scenario is aligned with the "Light" concept for SAP R/3). These applications produce less load on disk arms than "Interactive" types of applications. Even with relatively high CPU power provided in "server/batch" mode processing, the light use of disk by these applications limits the load on the arms. *Note:* File/Print Serving of PC files also generates relatively little disk activity, but since most of this activity uses an Integrated xSeries Server (IXS), there is relatively little iSeries-AS/400 CPU activity.

5.1.2 *Heavy Disk Workload Environments:*

This value evaluates processors running *OLTP types of transactions* that have been *written to run in the faster, client/server or "batch" mode (larger CPW value).* These types of transactions can use the entire CPW performance capability of the processor and therefore can generate a significant disk workload. The types of programs were discussed earlier. They perform extensive random access processing, often via SQL or ODBC for OLTP apps running on the "non-5250" side.

Because the programs can generate heavy disk activity, and there is a significant amount of processing power available (processor level of CPW), the "Heavy Disk Workload" values generate a requirement for a relatively large number of disk arms.

5.1.3 *Mixed Disk Workload Environments:*

The arm factor value for mixed workloads is based on a 50/50 weighted mix of the number of disk arms required for the "Light" and "Heavy" Disk Workload values. It is used primarily as an example, and is a "compromise" number. It was created by determining the number of disk arms required for a light workload and heavy workload, and then finding the arm factor that would yield a 50/50 weighting of those values.

It is suggested that you *do not use* *this value*, but *instead, weight the number of arms required to support the Server CPW for "Light" and "Heavy" workload values in a manner that is appropriate for your specific workload.*

The following example shows how this would be done. It uses the same system used in the earlier example. Using a filled in copy of the worksheet on page 22 we see that 14.9 arms are needed to support a light workload, and 55 arms are needed for a heavy workload. These are the values that are calculated on line 7, assuming the associated workload. For a 50/50 Mixed Workload, we can calculate that (50% x 14.9) + (50% x 55) = 35 ("unadjusted") arms are required. This value is then used on line 7 to complete the computations. The end result is the total number of arms required to support an OLTP workload using the interactive CPW plus the mixed workload on the server CPW.

Example: Mixed Workload on Model 820-2396/1522, with #4317 DASD and #4778 IOA

Worksheet for Model 820 **DASD Arms required for performance**	
1. In Table 12, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1) 950
2. In Table 12, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2) 70
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3) 880 (950-70)
4. In Table 13, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4) 16
5. In Table 13, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5) 59 (Light) 16 (Heavy)
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload.	6) 4.4 (70/16)
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload.	7) 14.9 (Light) 55.0 (Heavy) 35.0 (50%)
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8) 39.4
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the controller, DASD device, and protection method to be used. Enter the number on line 9.	9) 1.56
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the number of DASD arms required for the selected system, hardware configuration, and workload.	10) 26

One should weight the 2 extreme values for *"Heavy"* and *"Light"* whenever possible by the percentage appropriate to your specific combination of "Light" and "Heavy" Disk workload activity on the system. If you have no idea of the workload balance, 50% values shown in the tables may be used as a compromise. Recognize however, that depending on the situation, additional disks may need to be added once the workload balance has been determined.

IMPORTANT: *Do NOT* use the Mixed Disk Workload values if the server does Heavy Disk Workload activity during certain periods of time, and Light Disk activity at other times. In this situation, you *must size for the "worst" case*, and use the Heavy Disk Workload value. The *Mixed Disk Workload* value is appropriate *only* when the CPU is used *concurrently* for both *"Heavy" and "Light" workloads*.

When sizing for SAP R/3, consider that some customers have experienced heavier disk traffic in production vs. that generated by the Industry Benchmark. Thus, actual production SAP environments can span the range of "Light" to "Mixed", depending on each unique customer installation. When sizing for SAP in a 3-tier environment, the server workload for the database server is somewhere between 'server light' and server 'medium'.

6   Additional Considerations When Using the Tables

6.1 Load Source Drive

For proper Disk protection on systems prior to the 6x0 and Sx0 models, the first drive on the system (usually called the "**load source drive**") had to be mirrored, and used a much slower controller than the RAID-capable controllers. All newer models allow use of a faster controller that also allows this drive to be used in a RAID-5 array. The tables account for the potential speed difference of the "load source drive" (and it's mirror, where indicated). They *assume all other arms* on a system *have the same speed and capacity.*

6.2 Mixing Disk Features

The tables do not attempt to address performance for **mixtures of disk feature capacities** or types within the same partition. Data allocation algorithms and frequency of access patterns make that task too complex for this discussion. The crux of the problem is that larger capacity disks are more likely to get accessed more frequently. Thus portions of the disk subsystem (larger capacity disks) can be more of a bottleneck than other portions (smaller capacity disks).

In order to minimize the potential of disk speed bottlenecks, it is recommended for systems with mixed capacity disks to take steps to balance access rates across disks, not across capacity. This can be done in various ways. The rebalancing tool can be used. We recommend using the "Usage Balancing" algorithm, not the "Capacity Balancing" algorithm. And manual placement of data such that larger capacity disks hold more 'cold' data that gets accessed less frequently, while spreading out 'hot' data evenly across all of the accessible disks can help as well.

6.3 Mirrored Environments

In a *mirrored environment*, *writes* must occur *on both disk drives*. This increases the number of writes that are generated. Therefore, in a mirrored environment, the number of arms required must be increased by the percentage of DASD accesses (for an unmirrored system) that are disk writes. For example, assume a system with a read-to-write ratio of 3-to-1. This means the system does 3 reads for every write (which totals 4 disk accesses). In a mirrored environment, an extra disk access is required for every "write" -- 5 accesses occur (3 reads plus *2 writes)*. This is 25% more activity than the tables show for the "unprotected" environment.

The IOP/IOA/DASD Adjustment Table values for mirroring are based on the assumption that the read-to-write ratio is 2-to-1. This value gives a 33% increase in the amount of disk traffic, and therefore yields a 33% increase in the number of disk arms required.

If possible, when calculating the appropriate number of arms for a system that will employ mirroring, you should adjust the IOP/IOA/DASD adjustment value from Table 1 based on the read-to-write ratio for the system. The read and write information for the system is shown in the Performance Reports. The correct IOP/IOA/DASD adjustment value can be determined by multiplying the value for unprotected systems by the anticipated read percentage. For example, in a system that uses #2778 IOP/IOAs and #6717 disk devices, the IOP/IOA/DASD adjustment value from Table 1 for an unprotected system is 2.07. If the system has a read percentage of 55%, then the correct adjustment

value to use when calculating the number of disk arms required, when using mirroring with this system and IOP/IOA/DASD combination, is 2.07 * 0.55 , which is 1.14.

If the read-to-write ratio information is not available, the value from Table 1 for mirroring may be used. Recognize however, that depending on the situation, additional disks may need to be added once the actual read-to-write ratio has been determined.

> *Note:* Some measurements of server applications such as Lotus Notes/Domino and SAP R/3 have shown read-to-write ratios as high as 40%-50% (in part due to very efficient internal caching of the reads).

6.4 CPU Utilization Considerations

The simple assumption for the table is that the CPU is running near its recommended limit for interactive activity -- 70% during peak periods. It is recognized that in many cases, systems are not pushed to this limit particularly in new installations. If it is known that full CPU capacity is not expected to be used when the DASD configuration is installed, then the table value for arms required may be prorated. For example, on a processor model upgrade, where additional work is not expected to be added to the system for some time, it might be projected that the CPU for interactive work is not to exceed 35% during peak periods. In this case, the number of arms required would be half of the table value.

CAUTION: Ensure that the highest planned system usage is considered over time. As additional work is added to the system, **more disk arms** are required. If a prorated number of disks is selected (instead of the values shown in the table), when the total work exceeds the peak usage amount assumed in this planning exercise, DASD hardware upgrades will likely be required. The listed information assumes that the total number of arms needed as the system approaches its full interactive capacity matches the values shown.

6.5 Journaling

The numbers of disk arms listed in the table do **NOT** include drives for journal receiver arms in separate, dedicated ASPs. Arms configured specially for journal activity are in addition to those listed in the tables.

The Redbook titled, "Striving for Optimal Journal Performance on DB2 Universal Database for iSeries" is recommended reading for obtaining best Journaling speed. It can be found online at http://publib-b.boulder.ibm.com/Redbooks.nsf/RedbookAbstracts/sg246286.html?Open .

6.6 Interactive Features

The worksheet calculations assume that the full CPW available with the selected interactive feature will be used for interactive OLTP workloads. In some cases, such as systems with the smallest available interactive feature, this assumption may not apply. If it is known the system will run *only* client-server applications that are *compute-intensive* and generate relatively few, sequential disk accesses, then the computation of the disk arm requirements for the interactive CPW can be omitted. In this case, enter 0 (zero) for the interactive CPW on line 2 of the worksheets for the server models.

7 IOP/IOA/DASD Adjustments to Arm Requirements

The number of disk arms required to support a given workload on any CPU model will be affected by the combination of controller (IOP/IOA) and DASD features selected. The number of disk arms required will also be affected by the use of RAID-5 or mirroring capabilities. The tables on this page give adjustment factors for each combination of IOP/IOA, DASD, and protection method. This adjustment factor is used to adjust the model-specific disk-arm recommendations on the following pages for differences in the selected hardware configuration.

Table 1a - Direct Attached IOP/IOA/DASD Adjustment Factors

Controller (IOA only[1]) :	2726,2740,2741, 2763		2748, 4748, 2778, 4778, 9778			2782		2757	
DASD Model - Capacity:	6605 - 1GB xx06 - 2GB xx07 - 4GB xx13 - 8GB xx14 - 17GB xx24 -17GB	xx17 - 8GB xx18 - 17GB xx19 - 35GB	6605 xx06 xx07 xx13 xx14 xx24	xx17 xx18 xx19	4326 - 35GB 4327 - 70GB	xx17 xx18 xx19	4326 4327	xx17 xx18 xx19	4326 4327
	Hardware Adjustment Factor								
No Protection	1.38	1.59	1.59	2.07	3.28	2.71	4.12	3.64	5.68
RAID-5	1.04	1.19	1.19	1.56	2.46	2.03	3.09	2.73	4.26
Mirroring[2]	1.04	1.19	1.19	1.56	2.46	2.03	3.09	2.73	4.26

.

Table 1 b - SAN Attached IOP/IOA/DASD Adjustment Factors

Controller (IOP/IOA):	2843/2766
DASD Model:	2105 Fx0
	Hardware Adjustment Factor
RAID-5	1.56

Notes:

1. For direct attached DASD, the Adjustment Factors are not dependent upon IOP type
2. The adjustment factors for mirroring assume a read-to-write ratio of 2-to-1, therefore represent a 33% decrease from the adjustments for no protection. If the read-to-write ratio for the system is different, the correct adjustment factor should be selected by *decreasing* the adjustment factor from the "No Protection" row of the table by the appropriate amount. See " **Mirrored Environments**" on page 12 for details
3. For detailed information on the performance characteristics of these DASD arms, refer to Chapter 14 (DASD Performance) in the **iSeries Performance Capabilities Reference V5R2** available online at http://www-1.ibm.com/servers/eserver/iseries/perfmgmt/resource.htm .

8   DASD Arms Required for Performance Worksheets

Mixed disk workload values are an example of 50% Light Load plus 50% Heavy Load. Use the actual percentages for your case when determining the number of arms for the Mixed environment. See "***Mixed Disk Workload Environments:***" on page 10 for details.

Heavy disk workload scenarios apply to the percentage of time the system runs OLTP types of applications that have been written to run in the faster, client/server "batch" mode.

Light disk workload scenarios apply to the percentage of time the system runs newer server applications that are more compute-intense, and run in client/server "batch" mode. See section " Workload Discussion -- Processor and Interactive CPW" starting on page 9 for more details on these concepts.

For Processor CPW values and Arm Factors for Capacity Upgrade on Demand (CUoD) Processor Features, the tables in the following worksheets list only the values for the BASE number of processors ("Min") as well as values that represent the full capacity (BASE + ON DEMAND) of the server for all processors active ("Max"). For values associated with each incremental processor activation see "Appendix A: Capacity Upgrade on Demand (CUoD) Feature Adjustments" on page 34.

DASD Arms Required for Performance iSeries Model **890**

In order to determine the number of disk arms needed for optimum performance for an iSeries Model 890, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 890 DASD Arms required for performance		Example: Model 890-2488(Max)/1587 , Heavy server workload, 4748 IOA, 4317 DASD, RAID-5	Example: Model 890-2488(Max) /1587, Heavy server workload, 2757 IOA, 4327 DASD, RAID-5
1. In Table 2, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 37400	1) 37400
2. In Table 2, find the Interactive/Package Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2) 16500	2) 16500
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 20900	3) 20900
4. In Table 3, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 19	4) 19
5. In Table 3, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5) 19	5) 19
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload.	6)	6) 868.4	6) 868.4
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload.	7)	7) 1100	7) 1100
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 1968.4	8) 1968.4
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the controller, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.56	9) 4.26
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 1262	10) 463

Table 2 - Model 890 CPW

Processor Feature	Processor CPW	Interactive CPW for Interactive Features									
		1591	1588	1587	1585	1583	1581	1579	1578	1577	1576
2488 Max	37400	37400	20200	16500	10000	4550	2000	1050	560	240	120
2488 Min	29300	N/A	20200	16500	10000	4550	2000	1050	560	240	120
2487 Max	29300	N/A	20200	16500	10000	4550	2000	1050	560	240	120
2487 Min	20000	N/A	N/A	16500	10000	4550	2000	1050	560	240	120
		Interactive CPW for Package Features									
		Enterprise					Standard				
2498 Max	37400	37400					0				
2498 Min	29300	29300					0				
2497 Max	29300	29300					0				
2497 Min	20000	20000					0				

Table 3 - Model 890 Arm Factors

Processor Feature	Workload			
	Interactive	Server - Light	Server - Mixed	Server - Heavy
2488, 2498 Max	19	94	31	19
2488, 2498 Min	19	96	31	19
2487, 2497 Max	19	96	32	32
2487, 2497 Min	20	99	33	20

 For values associated with each incremental processor activation see "Appendix A: Capacity Upgrade on Demand (CUoD) Feature Adjustments" on page 34.

DASD Arms Required for Performance iSeries Model **870**

In order to determine the number of disk arms needed for optimum performance for an iSeries Model 870, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 870 **DASD Arms required for performance**	Example: Model 870-2486(Min)/ Standard, Light server workload, 2757 IOA, 4326 DASD, RAID-5	Example: Model 870-2486(Min) /Standard, Heavy server workload, 2757 IOA, 4326 DASD, RAID-5
1. In Table 4 find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 11500	1) 11500
2. In Table 4 find the Package Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2) 0	2) 0
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 11500	3) 11500
4. In Table 5 for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 20	4) 20
5. In Table 5 for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5) 99	5) 20
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload.	6)	6) 0	6) 0
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload.	7)	7) 116.2	7) 575
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 116.2	8) 575
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the controller, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 4.26	9) 4.26
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 28	10) 135

Table 4- Model 870 CPW

Processor Feature	Processor CPW	Interactive CPW for Package Features	
		Enterprise (7421)	Standard (7419)
2486 Max	20000	20000	0
2486 Min	11500	11500	0

Table 5- Model 870 Arm Factors

Processor Feature	Workload			
	Interactive	Server - Light	Server - Mixed	Server - Heavy
2486 Max	20	98	33	20
2486 Min	20	99	33	20

For values associated with each incremental processor activation see "Appendix A: Capacity Upgrade on Demand (CUoD) Feature Adjustments" on page 34.

DASD Arms Required for Performance iSeries Model **840**

In order to determine the number of disk arms needed for optimum performance for an iSeries Model 840, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 840 **DASD Arms required for performance**		Example: Model 840-2420/1540 , Light server workload, 4748 IOA, 4317 DASD, RAID-5	Example: Model 840-2420/1540 , Heavy server workload, 4748 IOA, 4317 DASD, RAID-5
1. In Table 6, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 16500	1) 16500
2. In Table 6, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2) 120	2) 120
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 16380	3) 16380
4. In Table 7, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 22	4) 22
5. In Table 7, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5) 111	5) 22
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload.	6)	6) 5.5	6) 5.5
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload.	7)	7) 147.6	7) 744.7
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 153.1	8) 750
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the controller, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.56	9) 1.56
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 99	10) 481

Table 6 - Model 840 CPW

Processor Feature	Processor CPW	Interactive Features								
		1548	1547	1546	1545	1544	1543	1542	1541	1540
2461	20200	20200	16500	10000	4550	2000	1050	560	240	120
2354 Max	20200	20200	16500	10000	4550	2000	1050	560	240	120
2354 Min	16500	N/A	16500	10000	4550	2000	1050	560	240	120
2353 Max	16500	N/A	16500	10000	4550	2000	1050	560	240	120
2353 Min	12000	N/A	N/A	10000	4550	2000	1050	560	240	120
2352 Max	12000	N/A	N/A	10000	4550	2000	1050	560	240	120
2352 Min	9000	N/A	N/A	N/A	4550	2000	1050	560	240	120
2420	16500	N/A	16500	10000	4550	2000	1050	560	240	120
2418	10000	N/A	N/A	10000	4550	2000	1050	560	240	120
2419 Max	16500	N/A	16500	10000	4550	2000	1050	560	240	120
2419 Min	13200	N/A	N/A	10000	4550	2000	1050	560	240	120
2417 Max	13200	N/A	N/A	10000	4550	2000	1050	560	240	120
2417 Min	10000	N/A	N/A	10000	4550	2000	1050	560	240	120
2416 Max	10000	N/A	N/A	10000	4550	2000	1050	560	240	120
2416 Min	7800	N/A	N/A	N/A	4550	2000	1050	560	240	120

Table 7 - Model 840 Arm Factors

Processor Feature	Workload			
	Interactive	Server - Light	Server - Mixed	Server - Heavy
2461	22	112	37	22
2354 Max	22	112	37	22
2354 Min	22	111	37	22
2353 Max	22	111	37	22
2353 Min	22	111	37	22
2352 Max	22	111	37	22
2352 Min	22	111	37	22
2420	22	111	37	22
2418	22	111	37	22
2419 Max	22	111	37	22
2419 Min	22	112	37	22
2417 Max	22	112	37	22
2417 Min	22	111	37	22
2416 Max	22	111	37	22
2416 Min	22	111	37	22

 For values associated with each incremental processor activation see "Appendix A: Capacity Upgrade on Demand (CUoD) Feature Adjustments" on page 34.

DASD Arms Required for Performance iSeries Model **830**

In order to determine the number of disk arms needed for optimum performance for an iSeries Model 830, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 830 DASD Arms required for performance		Example: Model 830-2402/1533 , Light server workload, 4748 IOA, 4317 DASD, RAID-5	Example: Model 830-2403/1533 , Heavy server workload, 4748 IOA, 4317 DASD, RAID-5
1. In Table 8 , find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 4200	1) 7350
2. In Table 8 , find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2) 240	2) 240
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 3960	3) 7110
4. In Table 9 , for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 19	4) 17
5. In Table 9 , for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5) 93	5) 17
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload.	6)	6) 12.6	6) 14.1
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload.	7)	7) 42.6	7) 418.2
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 55.2	8) 432.3
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the controller, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.56	9) 1.56
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the number of DASD arms required for the selected system, hardware configuration and workload.	10)	10) 36	10) 278

Table 8 - Model 830 CPW

Processor Feature	Processor CPW	Interactive Features						
		1537	1536	1535	1534	1533	1532	1531
2349 Max	7350	4550	2000	1050	560	240	120	70
2349 Min	4200	N/A	2000	1050	560	240	120	70
2403	7350	4550	2000	1050	560	240	120	70
2402	4200	N/A	2000	1050	560	240	120	70
2400	1850	N/A	N/A	1050	560	240	120	70

Table 9 - Model 830 Arm Factors

Processor Feature	Workload			
	Interactive	Server - Light	Server - Mixed	Server - Heavy
2349 Max	15	77	25	15
2349 Min	16	81	27	16
2403	17	88	29	17
2402	19	93	31	19
2400	17	62	26	17

For values associated with each incremental processor activation see "Appendix A: Capacity Upgrade on Demand (CUoD) Feature Adjustments" on page 34.

DASD Arms Required for Performance iSeries Model **825**

In order to determine the number of disk arms needed for optimum performance for an iSeries Model 825, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 825 **DASD Arms required for performance**		Example: Model 825-2473(Max)/ Server, Light server workload, 2757 IOA, 4326 DASD, RAID-5	Example: Model 825-2473(Min) /Server, Light server workload, 2757 IOA, 4326 DASD, RAID-5
1. In Table 10, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 6600	1) 3600
2. In Table 10, find the Package Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2) 6600	2) 3600
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 0	3) 0
4. In Table 11, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 20	4) 21
5. In Table 11, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5) 100	5) 103
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload.	6)	6) 330	6) 171.4
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload.	7)	7) 0	7) 0
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 330	8) 171.4
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the controller, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 4.26	9) 4.26
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 78	10) 41

Table 10 - Model 825 CPW

Processor Feature	Processor CPW	Interactive CPW for Package Features	
		Enterprise (7418)	Standard (7416)
2473 Max	6600	6600	0
2473 Min	3600	3600	0

Table 11 - Model 825 Arm Factors

Processor Feature	Workload			
	Interactive	Server - Light	Server - Mixed	Server - Heavy
2473 Max	20	100	33	20
2473 Min	21	103	34	21

For values associated with each incremental processor activation see "Appendix A: Capacity Upgrade on Demand (CUoD) Feature Adjustments" on page 34.

DASD Arms Required for Performance iSeries Model **820**

In order to determine the number of disk arms needed for optimum performance for an iSeries Model 820, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 820 DASD Arms required for performance		Example: Model 820-2396/1522 , Light server workload, 4748 IOA, 4317 DASD, RAID-5	Example: Model 820-2398/1522 , Heavy server workload, 4748 IOA, 4317 DASD, RAID-5
1. In Table 12, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 950	1) 3200
2. In Table 12, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2) 70	2) 70
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 880	3) 3130
4. In Table 13, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 16	4) 16
5. In Table 13, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5) 59	5) 16
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload.	6)	6) 4.4	6) 4.4
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload.	7)	7) 14.9	7) 195.6
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 19.3	8) 200.0
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the controller, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.56	9) 1.56
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 13	10) 129

Table 12 - Model 820 CPW

Processor Feature	Processor CPW	Interactive Features						
		1527	1526	1525	1524	1523	1522	1521
2438	3700	2000	1050	560	240	120	70	35
2437	2350	N/A	1050	560	240	120	70	35
2436	1100	N/A	N/A	560	240	120	70	35
2435	600	N/A	N/A	N/A	240	120	70	35
2398	3200	2000	1050	560	240	120	70	35
2397	2000	N/A	1050	560	240	120	70	35
2396	950	N/A	N/A	560	240	120	70	35
2395	370	N/A	N/A	N/A	240	120	70	35

Table 13 - Model 820 Arm Factors

Processor Feature	Workload			
	Interactive	Server - Light	Server - Mixed	Server - Heavy
2438	20	97	33	20
2437	16	78	26	16
2436	16	58	25	16
2435	16	55	24	16
2398	16	78	26	16
2397	16	77	26	16
2396	16	59	25	16
2395	16	53	24	16

DASD Arms Required for Performance iSeries Model **810**

In order to determine the number of disk arms needed for optimum performance for an iSeries Model 810, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 810 DASD Arms required for performance	Example: Model 810-2466 / Standard, Light server workload, 2757 IOA, 4326 DASD, RAID-5	Example: Model 810-2466 / Standard, Heavy server workload, 2757 IOA, 4326 DASD, RAID-5
1. In Table 14, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 1020	1) 1020
2. In Table 14, find the Package Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2) 0	2) 0
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 1020	3) 1020
4. In Table 15, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 17	4) 17
5. In Table 15, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5) 64	5) 17
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload.	6)	6) 0	6) 0
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload.	7)	7) 15.9	7) 60
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 15.9	8) 60
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the controller, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 4.26	9) 4.26
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 4	10) 15

Table 14 - Model 810 CPW

Processor Feature	Processor CPW	Interactive CPW for Package Features	
		Enterprise	Standard
2469	2700	2700	0
2467	1470	1470	0
2466	1020	1020	0

Table 15 - Model 810 Arm Factors

Processor Feature	Workload			
	Interactive	Server - Light	Server - Mixed	Server - Heavy
2469	16	79	27	16
2467	17	64	27	17
2466	17	64	27	17

DASD Arms Required for Performance iSeries Model **800**

In order to determine the number of disk arms needed for optimum performance for an iSeries Model 800, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 800 DASD Arms required for performance	Example: Model 800-2464 / Standard, Light server workload, 2782 IOA, 4327 DASD, RAID-5	Example: Model 800-2464 / Standard, Heavy server workload, 2782 IOA, 4327 DASD, RAID-5
1. In Table 16, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 950	1) 950
2. In Table 16, find the Package Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2) 0	2) 0
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 950	3) 950
4. In Table 17, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 16	4) 16
5. In Table 17, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5) 59	5) 16
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload.	6)	6) 0	6) 0
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload.	7)	7) 16.1	7) 59.4
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 16.1	8) 59.4
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the controller, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 3.09	9) 3.09
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 6	10) 20

Table 16 - Model 800 CPW

Processor Feature	Processor CPW	Interactive CPW for Package Features	
		Enterprise	Standard
2464	950	950	0
2463	300	300	0

Table 17 - Model 800 Arm Factors

Processor Feature	Workload			
	Interactive	Server - Light	Server - Mixed	Server - Heavy
2464	16	59	25	16
2463	12	60	19	12

DASD Arms Required for Performance iSeries
CPU Intensive Models

In order to determine the number of disk arms needed for optimum performance for an iSeries CPU Intensive Dedicated Server Models, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for CPU Intensive Models DASD Arms required for performance		Example: Model 890-0197, Light server workload, 4748 IOA, 4317 DASD, RAID-5
1. In Table 18 , find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) `29300`
2. In Table 19 , for the selected processor feature, find the arm factor for workload. Enter the value on line 2.	2)	2) `96`
3. Divide line 1 by line 2. Enter the result on line 3. This is the unadjusted number of arms required to support the interactive workload.	3)	3) `305.1`
4. In Table 1 on page 14, find the hardware adjustment factor corresponding to the controller, DASD device, and protection method to be used. Enter the number on line 4.	4)	4) `1.56`
5. Divide line 3 by line 4 and round the result up to the nearest whole number. Enter the result on line 5. This is the number of DASD arms required for the selected system, hardware configuration, and workload..	5)	5) 196

Table 18 - CPU Intensive Model CPW*s*

Model	Processor Feature	Processor CPW
890	0198	37400
	0197	29300
840	0159	20200
	0158	12000
830	0153	7350
820	0152	3700
	0151	2350
	0150	1100

Table 19 - CPU Intensive Model Arm Factors

Model	Processor Feature	Workload
		Server - Light
890	0198	94
	0197	96
840	0159	87
	0158	98
830	0153	77
820	0152	93
	0151	73
	0150	55

DASD Arms Required for Performance
All iSeries <u>Dedicated Server for Domino</u> Models

In order to determine the number of disk arms needed for optimum performance for an iSeries Dedicated Server for Domino Model, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Domino Models DASD Arms required for performance		Example: Model 820-2427, MCU workload, 4748 IOA, 4317 DASD, RAID-5
1. In Table 20, find the processor feature for the desired model. Enter the corresponding processor "Mail and Calendaring Users" (MCU) on line 1.	1)	1) 9890
2. In Table 21, for the selected model & processor feature, find the arm factor for Domino workload. Enter the value on line 2.	2)	2) 225
3. Divide line 1 by line 2. Enter the result on line 3. This is the unadjusted number of arms required to support the interactive workload.	3)	3) 43.96
4. In Table 1 on page 14, find the hardware adjustment factor corresponding to controller, DASD device, and protection method to be used. Enter number on line 4.	4)	4) 1.56
5. Divide line 3 by line 4 and round the result up to the nearest whole number. Enter the result on line 5. This is the number of DASD arms required for the selected system, hardware configuration, and workload.	5)	5) 29

Table 20 - Domino Model MCU*s*

Model	Processor Feature	Processor MCU
825	2473 (6 way) / (4-way)	17,400 / 11600
820	2458	11810
	2457	6660
	2456	3110
	2427	9890
	2426	5610
	2425	2570
810	2469	7900
	2467	4200
	2466	3100
270	2454	6660
	2452	3070
	2424	5050
	2423	2570
	2422	1600

Table 21 - Domino Model Arm Factors

Model	Processor Feature	Workload = DOMINO
825	2473 (6 way) / (4 way)	264 / 331
820	2458	295
	2457	208
	2456	156
	2427	225
	2426	234
	2425	151
810	2469	232
	2467	183
	2466	194
270	2454	230
	2452	171
	2424	210
	2423	151
	2422	200

DASD Arms Required for Performance iSeries Model **270**

In order to determine the number of disk arms needed for optimum performance for an iSeries Model 270, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load. A separate worksheet is provided for the Domino version of the 270.

Worksheet for Model 270 **DASD Arms required for performance**		Example: Model 270-2252/1519 , Light server workload, 4748 IOA, 4317 DASD, RAID-5
1. In Table 22, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 950
2. In Table 22, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2) 50
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 900
4. In Table 23, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 16
5. In Table 23, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5) 56
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload.	6)	6) 3.1
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload.	7)	7) 16.1
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 19.2
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the controller, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.56
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 13

Table 22 - Model 270 CPW

Processor Feature	Processor CPW	Interactive Features				
		1520	1519	1518	1517	1516
2434	2,350	70	N/A	N/A	N/A	0
2432	1,070	N/A	50	N/A	N/A	0
2431	465	N/A	N/A	30	N/A	N/A
2253	2,000	70	N/A	N/A	N/A	0
2252	950	N/A	50	N/A	N/A	0
2250	370	N/A	N/A	30	N/A	0
2248	150	N/A	N/A	N/A	25	N/A

Table 23 - Model 270 Arm Factors

Processor Feature	Workload			
	Interactive	Server - Light	Server - Mixed	Server - Heavy
2434	16	78	26	16
2432	16	59	25	16
2431	15	58	24	15
2253	16	83	26	16
2252	16	56	25	16
2250	16	46	24	16
2248	11	50	18	11

DASD Arms Required for Performance AS/400 Model __250__

In order to determine the number of disk arms needed for optimum performance for an AS/400 Model 250, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 250 DASD Arms required for performance		Example: Model 250-2295, light server workload, 2763 IOA, 6817 DASD, Mirroring
1. In Table 24, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 50
2. In Table 24, find the Interactive CPW for the desired model. Enter it on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2) 15
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 35
4. In Table 24, for the desired model, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 8
5. In Table 24, for the desired model, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5) 25
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload.	6)	6) 1.88
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload.	7)	7) 1.4
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 3.28
9. In Table 1 on page 14, find hardware adjustment factor corresponding to controller, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.04
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 4

Table 24 - Model 250 CPW and Arm Factors

Processor Feature	Processor CPW	Interactive CPW	Arm Factors by Workload			
			Interactive	Server - Light	Server - Mixed	Server - Heavy
2296	75	20	10	38	16	10
2295	50	15	8	25	12	8

DASD Arms Required for Performance AS/400 Model **740**

In order to determine the number of disk arms needed for optimum performance for an AS/400 Model 740, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 740 DASD Arms required for performance		Example: Model 740-2069/1510, Light server workload, 2748 IOA, 6613 DASD, RAID-5	
1. In Table 25, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1)	3660
2. In Table 25, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2)	1050
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3)	2610
4. In Table 26, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4)	16
5. In Table 26, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5)	81
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload.	6)	6)	65.6
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload.	7)	7)	32.2
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8)	97.8
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to controller, DASD device, and protection method to be used. Enter the number on line 9.	9)	9)	1.19
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10)	83

Table 25 - Model 740 CPW

Processor Feature	Processor CPW	Interactive Features				
		1513	1512	1511	1510	1514
2070	4550	4550	3660	2000	1050	120
2069	3660	N/A	3660	2000	1050	120

Table 26 - Model 740 Arm Factors

Processor Feature	Workload			
	Interactive	Server - Light	Server - Mixed	Server - Heavy
2070	14	71	24	14
2069	16	81	27	16

DASD Arms Required for Performance AS/400 Model **730**

In order to determine the number of disk arms needed for optimum performance for an AS/400 Model 730, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 730 DASD Arms required for performance		Example: Model 730-2067/1509, Heavy server workload, 2748 IOA, 6717 DASD, RAID-5	
1. In Table 27, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1)	`2000`
2. In Table 27, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2)	`560`
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3)	`1440`
4. In Table 28, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4)	`13`
5. In Table 28, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5)	`13`
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload.	6)	6)	`43.1`
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload.	7)	7)	`110.8`
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8)	`153.9`
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the controller, DASD device, and protection method to be used. Enter the number on line 9.	9)	9)	`1.56`
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10)	`99`

Table 27 - Model 730 CPW

Processor Feature	Processor CPW	Interactive Features					
		1511	1510	1509	1508	1507	1506
2068	2,890	2,000	1,050	560	240	N/A	70
2067	2,000	2,000	1,050	560	240	N/A	70
2066	1,050	N/A	1,050	560	240	120	70
2065	560	N/A	N/A	560	240	120	70

Table 28 - Model 730 Arm Factors

Processor Feature	Workload			
	Interactive	Server - Light	Server - Mixed	Server - Heavy
2068	15	72	24	15
2067	13	65	21	13
2066	13	48	21	13
2065	13	47	21	13

DASD Arms Required for Performance AS/400 Model **720**

In order to determine the number of disk arms needed for optimum performance for an AS/400 Model 720, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 720 DASD Arms required for performance		Example: Model 720-2062/1502, Light server workload, 2741 IOA, 6717 DASD, Mirroring
1. In Table 29, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 420
2. In Table 29, find the Interactive Feature for the desired model. Enter the corresponding interactive CPW on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2) 120
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 300
4. In Table 30, for the selected processor feature, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 14
5. In Table 30, for the selected processor feature, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5) 53
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload.	6)	6) 8.6
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload.	7)	7) 5.7
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 14.3
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the controller, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.19
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 13

Table 29 - Model 720 CPW

Processor Feature	Processor CPW	Interactive Features					
		1505	1504	1503	1502	1501	1500
2064	1600	1050	560	240	120	N/A	35
2063	810	N/A	560	240	120	N/A	35
2062	420	N/A	N/A	240	120	70	35
2061	240	N/A	N/A	N/A	120	70	35

Table 30 - Model 720 Arm Factors

Processor Feature	Workload			
	Interactive	Server - Light	Server - Mixed	Server - Heavy
2064	14	53	23	14
2063	14	51	22	14
2062	14	53	21	14
2061	12	48	19	12

DASD Arms Required for Performance AS/400 Model **170**

In order to determine the number of disk arms needed for optimum performance for an AS/400 Model 170, follow the instructions in the worksheet below. The results are for a specific benchmark @ 70% CPU Utilization. Your application may produce a different system load.

Worksheet for Model 170 DASD Arms required for performance		Example: Model 170-2386, light server workload, 2740 IOA, 6707 DASD, RAID-5
1. In Table 31, find the processor feature for the desired model. Enter the corresponding processor CPW on line 1.	1)	1) 460
2. In Table 31, find the Interactive CPW for the desired model. Enter it on line 2. If system does not run interactive workloads, see the discussion of Interactive Features on page 13.	2)	2) 70
3. Subtract line 2 from line 1. Enter the result on line 3. This is the CPW available for server workloads.	3)	3) 390
4. In Table 31, for the desired model, find the arm factor for interactive workloads. Enter the value on line 4.	4)	4) 13
5. In Table 31, for the desired model, find the arm factor for the appropriate server workload. Enter the value on line 5. See " Workload Discussion -- Processor and Interactive CPW" on page 9 for more information on workload concepts.	5)	5) 46
6. Divide line 2 by line 4. Enter the result on line 6. This is the unadjusted number of arms required to support the interactive workload.	6)	6) 5.4
7. Divide line 3 by line 5. Enter the result on line 7. This is the unadjusted number of arms required to support the server workload.	7)	7) 8.5
8. Add lines 6 and 7, and enter the result on line 8. This is the total unadjusted number of arms.	8)	8) 13.9
9. In Table 1 on page 14, find the hardware adjustment factor corresponding to the controller, DASD device, and protection method to be used. Enter the number on line 9.	9)	9) 1.04
10. Divide line 8 by line 9 and round the result up to the nearest whole number. Enter the result on line 10. This is the number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 14

Table 31 - Model 170 CPW and Arm Factors

Processor Feature	Processor CPW	Interactive CPW	Arm Factors by Workload			
			Interactive	Server - Light	Server - Mixed	Server - Heavy
2388	1090	70	15 (See note 1)	57 (See note 1)	See note 1	See note 1
2386	460	70	13 (See note 1)	46 (See note 1)	See note 1	See note 1
2385	460	50	13 (See note 1)	46 (See note 1)	See note 1	See note 1
2292	220	30	10 (See note 1)	44 (See note 1)	See note 1	See note 1
2291	115	25	10	38	16	10
2290	73	20	10	37	16	10
2289	50	15	8	25	12	8
2183	319	67	11 (See note 1)	64 (See note 1)	See note 1	See note 1
2176	319	40	11 (See note 1)	64 (See note 1)	See note 1	See note 1
2164	210	29	10 (See note 1)	42 (See note 1)	See note 1	See note 1
2160	114	23	11	38	17	11
2159	73	16	10	36	16	10

Notes:
1. This system is limited to a maximum of 10 DASD arms. This number is insufficient to support either a heavy server workload or an interactive workload using the full capabilities of the CPU. If using the MFIOP/9728, only 4 disk arms are supported. With only 4 arms, only VERY light DASD load applications are supported with full CPU power.
2. Four arms are required for the minimum RAID-5 protected configuration.

9 Author Contacts and Additional Information

Additional performance information and tuning suggestions are available in the IBM "iSeries Performance Capabilities Reference V5R2, January 2003 Edition" on the internet at: http://www-1.ibm.com/servers/eserver/iseries/perfmgmt/resource.htm .

Questions relating to the information in this document should be directed to
      Clark Anderson (clarkand@us.ibm.com),
      Farnaz Toussi (farnaz@us.ibm.com),
      Larry Whitley (ldw@us.ibm.com),
      or Richard Odell (rjodell@us.ibm.com).

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Appendix A: Capacity Upgrade on Demand (CUoD) Feature Adjustments

If you require values associated with each incremental processor activation, you can calculate the approximate values associated with each processor by using the following worksheet. This may be complicated by the fact that CUoD machines are often used in Logical Partitioning (LPAR) environments. When using LPAR you must address only those processors used in each partition. Note: Each LPAR partition has its own disks dedicated for use in that partition. The total number of disks required by the system is the sum of those required for each partition.

Worksheet to adjust CUoD Feature **DASD Arms required for performance**		Example: Model 840-2419/1540 w/22 processors , Light server workload, 4748 IOA, 4317 DASD, RAID-5
1. Following the normal instructions, complete the corresponding worksheet for the desired model 890, 870, 840, 830 or 825, while using the "**Max**" values from the appropriate tables for the desired CUoD Feature. Then place the value from line 10 of that worksheet into line 1 of this worksheet.	1)	1) 99
2. Following the normal instructions, complete the corresponding worksheet for the desired model 890, 870, 840, 830 or 825, while using the "**Min**" values from the appropriate tables for the desired CUoD Feature. Then place the value from line 10 of that worksheet into line 1 of this worksheet.	2)	2) 79
3. Subtract the value in line 2 from the value in line 1, and place in line 3.	3)	3) 20
4. In Table A1 on this page, for the selected CUoD Processor Feature, find the Processor Delta value. Then place that value in line 4	4)	4) 6
5. Divide the value from line 3 by the value from line 4. Place that result into line 5.	5)	5) 3.33
6. In Table A1 on this page, for the selected CUoD Processor Feature, find the Minimum Number of Processors value. Then place that value in line 6	6)	6) 18
7. Set line 7 equal to the desired number of processors. Note: This value must be equal or greater than the Minimum and equal or less than the Maximum Number of Processors for the desired Processor Feature.	7)	7) 22
8. Subtract line 6 from line 7. Enter the result on line 8.	8)	8) 4
9. Multiply value in line 8 by line 5 value. Place result in line 9.	9)	9) 13.32
10. Add the value in line 2 to the value in line 9. Round the result up to the nearest whole number and enter on line 10. This is the number of DASD arms required for the selected system, hardware configuration, and workload.	10)	10) 93

Table A1 - CUoD Feature Processors

Processor Model	Processor Feature	Processor Delta	Minimum Number of Processors	Maximum Number of Processors
890	**2488, 2498**	8	24	32
	2487, 2497	8	16	24
870	**2486**	8	8	16
840	**2354**	6	18	24
	2353	6	12	18
	2352	4	8	12
	2419	6	18	24
	2417	6	12	18
	2416	4	8	12
830	**2349**	4	4	8
825	**2473**	3	3	6

Appendix B: SAN attached Enterprise Storage Server

IBM Enterprise Storage Servers (ESS or code name 'Shark') can be attached to iSeries systems via #2766 PCI Fibre Channel (FC) Disk Controllers. The following worksheet method estimates:

- the number of physical ESS disks (DDMs) needed (line 1),
- how they should be configured :
  - how many RAID Ranks (line 2) - A RAID Rank is a set of 7 active disk drives plus 1 spare.
  - how many LUNs (line 4) - A LUN or Logical UNit represents the capacity of a physical disk drive as defined by a system. Each ESS iSeries LUN is spread across multiple DDMs.
- and how many iSeries FC controllers are needed to attach them (line 6).

Worksheet for ESS DASD Arms required for performance		Example: Model 840-2420/1540 , Light server workload, 2766 IOA, 2105 DASD w/18GB DDMs
1. Following the normal instructions for your processor model and using the 2843/2766 IOP/IOA and 2105-Fx0 Drive Model Adjustment Factor, complete the appropriate worksheet from " DASD Arms Required for Performance Worksheets" section starting on page 15. Then for all models that support ESS, except Dedicated Server for Domino (DSD) and CPU Intensive models , place the value from line 10 of that worksheet into line 1 of this worksheet. For the DSD and CPU Intensive models, place the value from line 5 of their respective worksheet into line 1 of this worksheet. **This value is the number of physical arms required in ESS to support the CPU**.	1)	1) 99
2. Place line 1 value, divided by 7, rounded UP to next whole number, in line 2. **This value is the number of ESS RAID Ranks to configure.**	2)	2) 15
3. In Table B1, for the desired DDM capacity, find the Recommended LUNs per RAID Rank value. Then place that value in line 3.	3)	3) 12
4. Calculate line 4 to be the value in line 2 multiplied by the value in line 3. **This value is the number of LUNs used to address the ESS RAID Ranks**.	4)	4) 180
5. In Table B1, for the desired DDM capacity, find the Recommended LUNs per IOA value. Then place that value in line 5.	5)	5) 32
6. Divide the number of LUNs from line 4 by the value from line 5. Place that number, rounded UP to the next whole number, into line 4. **This value is the number of iSeries Fibre Channel IOAs required to address the ESS LUNs.**	6)	6) 6

Note: This method assumes that the ESS disks are being configured to use RAID-5 protection.

Table B1 - ESS Configuration Parameters

ESS DDM Capacity	Recommended LUNs per RAID Rank	Recommended LUNs per IOA
9GB	6	16
18GB	12	32
36GB	16	32

Note: Besides iSeries rules, these calculations do not take into account all ESS configuration rules.

Refer to the discussion in Chapter 14 (DASD Performance) of the "iSeries Performance Capabilities Reference V5R2" (available at http://www-1.ibm.com/servers/eserver/iseries/perfmgmt/resource.htm in the AS/400 online library) for more information on ESS performance characteristics.

Appendix C: System Memory vs. Disk Arms

There are cases where the disk arms estimated using the worksheets in this document can be too high. The tables of Arm Factors in the document are derived from experience with systems with very large databases and random accesses of the records in those databases. If the database on a large system is relatively small, or the access to the records in that database are not random, or the database is large but only a small fraction of the database is actively used, it is possible, even likely, that a significant fraction of the database will be cached in memory. When a significant fraction of the database is cached in memory, the number of reads to the disks are reduced. This in turn reduces the number of disk arms needed to support the application.

While we recognize the existence of this phenomena, we do not have data that you can use to modify the calculations in this document to account for this. However, if you have a system with the databases in question installed and operational, there is a way of telling, after the fact, whether this is happening on a given system or not.

Using the performance monitor, you can determine the mix of reads and writes to the disks produced by the system. A normal mix of reads and writes to the disks on a transaction processing system is between 55% and 70% reads and between 45% and 30% writes. For small databases, more of the database becomes cached in system memory and the number of reads to the disks goes down while the number of writes remains nearly constant. This shifts the balance of reads and writes to favor the writes. That is you might see a 30% to 40% read and a 70% to 60% write. System's with this pattern across all shifts can safely reduce the number of disk arms required.
The net of all of this is that the reduction in disk reads will reduce the disk utilization, creating the opportunity for the use of fewer, higher capacity disks.

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