Component Broker
Advanced Programming Guide
Release 2.0

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Note

Before using this information and the product it supports, be sure to read the general information under Appendix A, “Notices” on page 299.

Fourth Edition (December, 1998)

This edition applies to Release 2.0 of Component Broker and to all subsequent releases and modifications until otherwise indicated in new editions.

Contents

What's New!

The following changes were made to this publication since the previous edition:

- Added a chapter on Non-IBM ORB Usage.
- Updated the Notification Service chapter and added a Managed Object-Based Sample.
- Updated the Query Service chapter.
- Added an index along with other technical and editorial changes.

About This Book

The Component Broker Advanced Programming Guide describes the Component Broker implementation of the CORBA Object Services and the Component Broker Object Request Broker (including Dynamic Invocation Interface (DII) procedures), Interlanguage Object Model (IOM), Interface Definition Language (IDL), and workload management.

Who Should Read This Book

The Advanced Programming Guide is intended for application developers who use the Component Broker environment to build robust, distributed object-oriented applications.

The examples are written in C++; therefore, programming experience in C++ and a background in object-oriented programming is required. A familiarity with Java is also helpful, but not required.

This book is a programming manual for experienced programmers who are going to use this product.

Documentation Conventions

The following conventions distinguish different text elements:

plain — Window titles, folder names, icon names, and method names.

`monospace` — Programming examples, user input at the command line prompt or into an entry field, user output, and directory paths.

bold — Menu choices, push buttons, check boxes, radio buttons, group-box controls, drop-down list boxes, combo-boxes, notebook tabs, and entry fields.

italics — Programming keywords, variables, and attributes, titles of information units, initial use of unique terms, and emphasis.

The following icons are used to indicate platform-specific sections.

WIN — Denotes a section that applies only to the Windows 95 or Windows NT platform. Do not interpret this symbol to denote that an equivalent AIX section exists.

Note: The Windows 95 platform only supports the Component Broker Java client.

AIX — Denotes a section that applies only to the AIX platform. Do not interpret this symbol to denote that an equivalent Windows section exists.

Denotes a section does not apply to OS/390 Component Broker. Do not interpret this symbol to denote that an equivalent exists in OS/390 Component Broker.

The Component Broker Documentation

The following information is part of Component Broker:

- Help information is available from Component Broker product panels.
- The Component Broker online library can be viewed using a frames-compatible Web browser.
- *Component Broker for Windows NT and AIX Quick Beginnings*, G04L-2375 explains how to easily create and verify a starter Component Broker environment. These instructions walk the user through a typical server and client installation. Users can extend this configuration using the information in the *Component Broker for Windows NT and AIX Planning, Performance and Installation Guide* .
- *Component Broker for Windows NT and AIX Planning, Performance and Installation Guide*, SC09-2798 provides a comprehensive overview of the Component Broker environment, then guides the user through planning considerations including capacity planning, performance tuning, prerequisites, and migration. It also leads the user through installation options for all Component Broker environments.
- *Component Broker for Windows NT and AIX CICS and IMS Application Adaptor Quick Beginnings*, GC09-2703 provides a brief technical overview of the CICS and IMS application adaptor and guides the user through its installation and configuration. Step-by-step instructions guide the user through creating an initial CICS and IMS application using application development tools included in the CBToolkit package.
- *Component Broker for Windows NT and AIX Oracle Application Adaptor Quick Beginnings*, GC09-2733 provides a brief technical overview of the Oracle application adaptor and guides the user through its installation and configuration. Step-by-step instructions guide the user through creating an initial Oracle application using application development tools included in the CBToolkit package.
- *Component Broker for Windows NT and AIX System Administration Guide*, SC09-2704 provides information about configuring and operating one or more hosts managed by Component Broker. It also provides general information about using the System Manager User Interface.
- *Component Broker Application Development Tools*, SC09-2705 explains how to create and test Component Broker applications using the tools provided in the CBToolkit with a focus on common development scenarios such as inheritance and team development.
- *Component Broker Programming Guide*, G04L-2376 describes the programming model including business objects, data objects, and information about MOFW, IDL, and C++ CORBA programming.
- *Component Broker Programming Reference*, SC09-2810 contains information about the APIs available to Component Broker application developers.
- *Component Broker for Windows NT and AIX Problem Determination Guide*, SC09-2799 explains how to identify and resolve problems within a Component Broker environment using the tools provided with Component Broker. The book includes information on installation problems, run time errors, debugging of applications, and analysis of log messages.
- *Component Broker Glossary*, SC09-2710 contains terms and definitions relating to Component Broker.
- *OS/390 Component Broker Introduction*, GA22-7324 describes the concepts and facilities of Component Broker and the value it has on the OS/390 platform. The audience is a knowledgeable decision maker or a system programmer.
- *OS/390 Component Broker Planning and Installation*, GA22-7331 describes the planning and installation considerations for Component Broker on OS/390.
- *OS/390 Component Broker System Administration*, GA22-7328 describes system administration tasks and operations tasks, as provided in the system administration user interface for OS/390.

- *OS/390 Component Broker Programming: Assembling Applications*, GA22-7326 provides information for assembling applications using Component Broker on OS/390.
- *OS/390 Component Broker Operations: Messages and Diagnosis*, GA22-7329 provides diagnosis information and describes the messages associated with Component Broker on OS/390.

Chapter 1. Concurrency Service

The following chapter is platform-dependent and does NOT apply to OS/390 Component Broker.

The Concurrency Service is a set of interfaces that allow an application to coordinate access by multiple transactions or threads to a shared resource. Coordinating access to a resource means that, when multiple transactions or threads try to access a single resource at the same time, any conflicting actions are reconciled so that the resource remains in a consistent state. This is known as conflict resolution.

To enable conflict resolution, the Concurrency Service supports locking using lock sets (see “Locks and Lock Sets” on page 3).

Component Broker for OS/390 does not support the Concurrency Service; however, you can achieve the same coordination of access to resources by configuring a Component Broker for OS/390 server with specific policies. See *OS/390 Component Broker Planning and Installation* for further information.

The Purpose of a Concurrency Service

Why would you use a Concurrency Service? To answer this, consider the following typical Object Oriented business scenario. Two bank clerks want to credit the same bank account with two different amounts at the same time. Table 1 shows what could happen if a Concurrency Service is not used.

Table 1. Simultaneous updates. What can happen if a concurrency service is not used.

Program A: Add $100 to a/c	**Program B: Add $20 to a/c**
1. Get value of account=50	
	2. Get value of account =50
3. Add 100 internally to program	
	4. Add 20 internally to program
5. Store the result account=150	
	6. Store the result account=70

The final balance of the account is 70 dollars, rather than 170. Because the order of events is not predetermined, there is no guarantee that you will get the correct result.

To avoid these problems, you can use a Concurrency Service. Table 2 shows what happens if programs A and B use a Concurrency Service.

Table 2 (Page 1 of 2). Simultaneous updates. A concurrency service is used.

Program A: Add $100 to a/c	Program B: Add $20 to a/c
1. Request a write lock on the account	
2. Obtain a write lock	

Table 2 (Page 2 of 2). Simultaneous updates. A concurrency service is used.	
	3. Request a write lock on the account
4. Get value of account =50	
5. Add 100 internally to program	
6. Store the result account=150	
7. Release the lock	
	8. Obtain a write lock
	9. Get value of account =150
	10. Add 20 internally to program
	11. Store the result account=170
	12. Release the lock

This time the result is correct. Table 2 on page 1 introduces the concepts of locks and lock modes (see “Locks and Lock Sets” on page 3 and “Lock Modes” on page 4). A lock is used to regulate access to a resource. A lock mode defines the way in which the resource can be accessed. For example, a “write lock” allows a program to change a file record; a “read lock” only allows the program to inspect it.

In Table 2 on page 1, transaction B is not given a lock straight away, because transaction A already holds a write lock on the account. When transaction A releases its lock, transaction B is able to get a write lock and update the account.

By using a concurrency control service in this way, you get the correct result.

How Concurrency Supports Locking

The Concurrency Service supports both transactional and non-transactional locking (see “Transactional and Non-Transactional Locking”). Locking prevents multiple requesters (transactions or threads that request a lock) from simultaneously accessing the same resource if their activities might conflict. This is illustrated in “The Purpose of a Concurrency Service” on page 1.

The Concurrency Service is primarily intended to be used by server processes that need to manage concurrent access to resources.

The Concurrency Service manages locks on behalf of a single server process (either transactional- or thread-based locks). Shared locks between multiple server processes are not supported.

The Concurrency Service can only be used by server processes, there are no client usage bindings.

Transactional and Non-Transactional Locking

The Concurrency Service is intended primarily for use in a transactional environment, as a complementary service to the Transaction Service (see Chapter 9, “Transaction Service” on page 167). In a transactional environment, locks are acquired and released on behalf of transactions.

It is possible to use the Concurrency Service in a non-transactional environment. In this case, locks are acquired and released on behalf of threads.

The Concurrency Service manages locks on behalf of a single server process (either transactional- or thread-based locks). Shared locks between multiple server processes are not supported.

Managing Updates to Resources

Although the Concurrency Service could be used by a server process to control thread execution as an alternative to semaphores , this would not be very efficient. The Concurrency Service is primarily intended to be used by server processes that need to manage concurrent access to resources. An application requiring access to a particular resource invokes a method on the server process controlling updates. Typically, the concurrency control mechanism is contained entirely within that server process, which defines the association between the locks and resources. V

The Concurrency Service places no restrictions on what a resource can be. It could, for example, be a field within a record, a single file record, or a database - in the example illustrating the “The Purpose of a Concurrency Service” on page 1, it is a bank account. Granularity describes the factors that you should consider when deciding what size each resource should be (see “Granularity” on page 6).

For example, consider an application BankAccount that controls access to resources of type AccountBalance. The AccountBalance class provides a method (AccountBalance::get_balance) for applications wishing to query the balance of AccountBalance objects. The implementation of this method might be as follows:

1. Acquire a read lock on AccountBalance.
2. Read value of AccountBalance.
3. Release the read lock on AccountBalance

The Concurrency Service in a Transactional Environment

The Concurrency Service is intended primarily for use in a transactional environment, as a complementary service to the Transaction Service (see Chapter 9, “Transaction Service” on page 167). In such an environment, a locking mechanism ensures that a transaction is unable to view the partial effects of another transaction (that is, changes that have not been committed).

Related Lock Sets

The Concurrency Service allows a group of lock sets to be related. This enables a server process controlling updates to drop all the locks held by a transaction in a related group by invoking just one operation, the CosConcurrency::LockCoordinator drop_locks() operation.

For example, a server process controlling updates might relate a group of lock sets, each of which it has created to manage access to an individual file. Within the server process's commit and rollback methods, all the locks held on any of the files by the completing transaction can be dropped by a single method call.

Locks and Lock Sets

A lock is associated with a single resource and a single thread or transaction. Locks can be *exclusive* or *shared*. When a transaction or thread holds an exclusive lock on a resource, it means that (in general) no other transaction or thread can obtain a lock to access the resource, until the exclusive lock is released. Write locks are exclusive. If they were not, the timing of write events could result in data corruption or outdated data could be read. Read locks, on the other hand, can be shared; because the resource is not being changed, more than one application can be given a read lock on it, with no danger of any application reading outdated data.

A lock set is a collection of all the locks associated with a single resource. A server process controlling updates creates a lock set for each resource that requires controlled access. When first created, the lock set is empty. Before a transaction or thread can access a controlled resource, it must obtain a lock, in the relevant mode, from the appropriate lock set. If the requested lock cannot be granted immediately, the request is queued. Each request for a lock, whether granted or queued, results in a new lock being created in the lock set. Each lock is associated with its requester, and exists until it is released.

A lock set is therefore the set of locks, both granted and queued, that currently exist for a controlled resource.

Lock Modes

Lock modes are categories of access to resources. They define the level of concurrency that a held lock allows to other (conflicting) requesters of the lock.

Having a variety of lock modes allows more flexible conflict resolution. For example, having different modes for reading and writing means that a resource can support multiple concurrent transactions or threads that are merely reading the data of the resource. The Concurrency Service also defines *intention locks* that support locking at multiple levels of granularity.

These lock modes are available:

Read Lock Mode (R)
Obtains access to the lock for reading. This is known as a shared lock mode, because multiple read locks can be held concurrently on the same resource.

Write Lock Mode (W)
Obtains access to the lock for writing. This is known as an exclusive lock mode, because it prevents other requesters from obtaining a lock on the same resource.

Upgrade Lock Mode (U)
Only one requester can obtain this lock, but while it holds the lock other requesters can obtain read locks. Use of upgrade locks is described in more detail in “Prevent Deadlocks” on page 13.

Intention Read Lock (IR)
Indicates intention to obtain a read lock. Use of the intention read lock is described in more detail in “Granularity” on page 6.

Intention Write Lock (IW)
Indicates intention to obtain a write lock. Use of the intention write lock is described in more detail in “Granularity” on page 6.

Lock Mode Capability

The following table shows the compatibility of the various lock modes. An X shows where lock modes are incompatible.

Table 3 (Page 1 of 2). Lock Mode Compatibility

	IR	R	U	IW	W
Intentional Read (IR)					X

Table 3 (Page 2 of 2). Lock Mode Compatibility					
Read (R)				X	X
Upgrade (U)			X	X	X
Intentional Write (IW)		X	X		X
Write (W)	X	X	X	X	X

Conflicting Locks in a Lock Set

If a transaction or thread requests a lock on a resource and a lock is already held in an incompatible mode (as explained in "Lock Modes" on page 4), the request is said to conflict with the held lock. The only exception to this, is when the held lock is held by the same transaction or thread. See "Multiple Lock Possession."

Servicing Lock Requests in a Lock Set

If a lock request does not conflict with any held locks, and no requests are waiting to be granted in the lock set, the requested lock is granted and added to the set of held locks. If the request does conflict with a currently held lock, but norequests are waiting to be granted, it causes a queue of waiting requests to be created (containing just itself).

If a request is made for a lock, and there is already a queue of one or more waiting requests in the lock set, the request is usually added to the end of the queue (irrespective of whether or not it conflicts with any held locks). However, if both the following apply the lock is granted immediately:

- The requester or, in the case of a transaction, one of its ancestors, already holds a lock in the lock set.
- The request does not conflict with any of the locks held.

Whenever a lock is released, the Concurrency Service automatically tries to grant the lock request that is at the front of the queue. If the request is successfully granted, the Concurrency Service removes it from the front of the queue and tries to grant the next request.

When the Concurrency Service cannot grant the lock request at the front of the queue, it searches down the queue. For each requester waiting, it checks whether that requester (or, in the case of a transaction, one of its ancestors) already holds a lock in the lock set. If this is the case and the request does not conflict with any of the locks held, the request is granted and removed from the queue.

Multiple Lock Possession

The Concurrency Service enables a transaction or thread to hold multiple locks in the same lock set (that is, multiple locks on the same resource) simultaneously. The locks can be of different (and possibly conflicting) modes, or of the same mode. A count is kept of the number of locks of a given mode that the transaction or thread holds. When a lock of that mode is unlocked, the count is decremented. The transaction or thread holds the lock until the count reaches zero. Therefore, to completely release a lock, the number of unlock requests must equal the number of times that the lock has been acquired in that mode.

Programming Considerations

When creating a server process or an application that uses the Concurrency Service, there are a number of points you should consider:

- If a number of transactions or threads are competing for access to shared resources, “Deadlocks” on page 6 can occur. No transaction can proceed because each is waiting for a lock held by another transaction.
- When deciding on the granularity of a lock (that is, the scope of the locked resource), you need to balance the low overhead of coarse granularity with the improved concurrency of fine granularity (see “Granularity”).
- Manage objects explains how an application obtains objects from the Concurrency Service and when, if ever, it can destroy them (see “Manage Objects” on page 14).
- Your server process controlling updates must be able to handle the exceptions that the Concurrency Service raises when it encounters an error (see “Handle Exceptions” on page 15).

Deadlocks

When a number of transactions (or threads) are competing for shared resources, there is the risk of deadlock. This occurs when no transactions in a set can proceed because each is waiting for a lock held by another member of the set.

In the following example, deadlock occurs because programs A and B are each unable to proceed until the other releases its lock. This would be avoided if A and B both attempt to lock resource X first, then Y.

Table 4. Deadlocks

Program A	Program B
1. Request a write lock on resource X	
2. Obtain a write lock on resource X	
	3. Request a write lock on resource Y
	4. Obtain write lock on resource Y
5. Request write lock on resource Y	
6. Thread suspended waiting for program B to release its lock on Y	
	7. Request write lock on resource X
	8. Thread suspended waiting for program A to release its lock on X

Granularity

The *granularity* of a lock relates to the scope of the locked resource. For example, a lock on a resource object that represents a single file record could be described as a “fine granularity lock”; while a lock on an entire database is a "coarse granularity lock".

Coarse granularity locks incur low overhead, because the Concurrency Service has fewer locks to manage, but reduce concurrency because conflicts are more likely to occur. Fine granularity locks improve concurrency, but result in a higher locking overhead because more locks are requested. Selecting a suitable granularity is a balance between the lock overhead and the degree of concurrency required. With the Concurrency Service, a server process controlling updates can use coarse or fine granularity by defining the associated resources appropriately.

A server process controlling updates can support variable levels of granularity on a single resource. For example, consider a collection of files each containing a number of records. A server process could associate a lock set with each of the files and a lock set with each of the records within the files. A transaction could then obtain a coarse granularity lock on a complete file or a finer granularity lock on one of the records contained within a file.

Imagine that a transaction needs to update a record in a file controlled by this server process . It would be insufficient for the transaction simply to acquire a write lock on the record, because another transaction might acquire a write lock on the complete file containing the record, and delete or modify the file.

Alternatively, the server process controlling updates could ensure that a transaction was not able to perform any updates to a record within a file unless it already held a write lock on the complete file. However, this removes the capability of finer granularity locking (on an individual record) that the server process controlling updates aimed to provide.

The Concurrency Service provides two lock modes that a server process can use to solve this problem These modes are **intention read** (IR) and **intention write** (IW).

A transaction intending to obtain a write lock on a fine-granularity resource contained within a coarser granularity resource must first obtain an intention write lock on the coarser granularity resource. In the previous example, the coarse-granularity resource is the file that contains the record to be updated. When the intention write lock is successfully granted, the transaction can then obtain a write lock on the individual record and update it.

Notice that the ownership of an intention write lock does not prevent other transactions from obtaining an intention write lock (or an intention read lock) on the same file. However, it does prevent another transaction (which is not a descendant of the intention lock holder) from obtaining a read, upgrade, or write lock on the file. Essentially, the intention lock has restricted coarse granularity locking on the file so that multiple requesters can simultaneously hold finer granularity locks on its records.

An intention read lock is used in exactly the same way as an intention write lock, to restrict coarse-granularity locking yet allow multiple requesters to hold finer-granularity locks within a resource. An intention read lock is incompatible only with a write lock.

Concurrency Service Tasks

This section describes the tasks performed when using Concurrency Services.

Define a Lock Set

A server process controlling updates creates a lock set for each resource that requires controlled access.

You can define a lock set using either the LockSet interface or the TransactionalLockSet interface. The LockSet interface enables more flexibility, because the lock requests can be made on behalf of the current transaction or, if a transaction does not exist, on behalf of the current thread. There is also no need to pass an extra parameter specifying the transaction when using this interface.

Before carrying out this procedure, make sure you are familiar with: “Locks and Lock Sets” on page 3.

To define a lock set, define the LockSet as a private instance variable in the class header file. For example: Define the lock set as a private instance variable in the class header file as follows:

```
#include <CosConcurrency.hh>

CosConcurrencyControl::LockSet_ptr lockset;
```

only with a write lock.

Create a Lock Set

A server process controlling updates creates a lock set for each resource that requires controlled access.

Before carrying out this procedure, make sure you are familiar with “Locks and Lock Sets” on page 3 and “Define a Lock Set” on page 7.

To create a lock set, follow these steps:

1. Create a lock set for every recoverable object, using a LockSetFactory object. You can do this within the initialization code of your class.
2. Delete the LockSet factory object.

Here is an example:

To create a lock set, include the following in the initialization code for the class:

```
#include <CosConcurrency.hh>
{
   ...
   CosConcurrencyControl::LockSetFactory_ptr const lockset_factory =
   ConcurrencyControl::LockSetFactory::_create();
   this->lockset = lockset_factory->create();
   ...
   release lockset_factory;
   ...
}
```

The LockSetFactory object is needed only to create the LockSet. Once you have finished with a factory, you can destroy it.

Relate Lock Sets

The Concurrency Service allows a group of lock sets to be related (see “Related Lock Sets” on page 3). This enables a server process controlling updates to drop all the locks held by a transaction in a related group by invoking just one operation, the CosConcurrency::LockCoordinator drop_locks() operation.

Before carrying out this procedure, make sure you are familiar with “Create a Lock Set.”

To relate lock sets, follow these steps:

1. Create the primary lock set, to which the others will be related.
2. Relate each additional lock set to the primary lock set as required.

Here is an example:

Create the primary lockset:

```
#include <CosConcurrency.hh>

CosConcurrencyControl::LockSetFactory_ptr const lockset_factory =
ConcurrencyControl::LockSetFactory::_create();
this->lockset = lockset_factory->create();
```

Create a lock set that is related to the initial one:

```
this->lockset2 = lockset_factory->create_related(lockset);
```

Create another lock set that is related to the initial one:

```
this->lockset3 = lockset_factory->create_related(lockset);
```

Note that *lockset3* is also related to *lockset2*.

The LockSetFactory object is needed only to create the LockSets. Once this has been done successfully, you can destroy it:

```
release lockset_factory;
```

Obtain and Release Locks from a Lock Set

Before accessing data, an object must obtain a lock from the appropriate lock set. If the lock cannot be granted immediately, the thread that issued the call is blocked (suspended) until the lock can be granted. If you want the thread to continue doing useful work if the lock cannot be granted immediately, you can use the non-blocking try_lock() operation rather than the blocking lock() operation.

Before carrying out this procedure, make sure you are familiar with “Define a Lock Set” on page 7, “Create a Lock Set” on page 8, and “Locks and Lock Sets” on page 3.

To update data, follow these steps:

1. Use the lock() operation to obtain a write lock from the lock set that controls access to the data.
2. Update the data.
3. Release the write lock.
   - If the lock was acquired on behalf of a transaction, do this only when the transaction has completed.
   - If the lock was acquired on behalf of a thread, do this as soon as all the data has been updated.

To read data, follow these steps:

1. Use the lock() operation to obtain a read lock from the lock set that controls access to the data.
2. Read the data.
3. Release the read lock when it is no longer required.

Here is an example:

The following is an example of a lock request in a BankAccount implementation. A bank clerk updates the balance of an account using a method called BankAccount::updateBalance. Before it can do this, the BankClerk object must obtain a write lock from the BankAccount lockset:

```
this->lockset->lock(CosConcurrencyControl::write);
```

The updateBalance() method can only be used within the scope of a transaction. To avoid making public changes that might later be rolled back, the transaction's locks are not released until commit or rollback.

Release Locks in a Transactional Framework

In a transactional environment, a locking mechanism ensures that a transaction is unable to view the partial effects of another transaction (that is, changes that have not been committed). A transaction should only release its locks when it has completed its updates and is ready to reveal those updates to other transactions.

Although this document refers to transactions obtaining and releasing locks, this is just a convenient shorthand. It is actually the server processes controlling updates that obtain and release locks on behalf of transactions.

Before carrying out this procedure, make sure you are familiar with “The Two-Phase Commit Process” on page 171.

Locks are released as follows:

1. The transaction commits or rolls back its changes.
2. The server process controlling updates using the Concurrency Service ensures that the transaction releases its locks immediately.

   You should release the locks within the server process's commit and rollback methods. To ensure that these methods are called during the two-phase commit logic of the transaction, the resource object must register itself with the transaction Coordinator.

Important: In general, a transaction should always drop its locks during two-phase commit processing as described here. However, if a transaction acquires a lock on a resource and does not make any modifications to that resource (that is, it acquires a read lock), the transaction can drop the lock before committing or rolling back. Be careful not to release locks too early though; if a transaction requires that another transaction does not change a resource, it should hold the read lock until it completes.

When using locks:

- Ensure that a transaction never holds any locks after it has completed.
- Ensure that a transaction never attempts to acquire locks during prepare, commit or rollback processing. Following prepare, a transaction is no longer associated with the current thread, on whose behalf the lock request is made. This could result in deadlock (see “Deadlocks” on page 6).

Complete Top Level Transactions

The Concurrency Service provides the LockCoordinator interface to ease the implementation of dropping locks prior to transaction end. One LockCoordinator object exists for each group of related lock sets for each transaction that holds a lock or has an outstanding request in one or more of the related lock sets (see “Related Lock Sets” on page 3). A server process controlling updates need not concern itself with the creation or management of the LockCoordinator object because the Concurrency Service deals with this internally.

Top-level transactions are completed as follows:

1. Use the get_coordinator() operation to obtain the LockCoordinator object that represents the lock set and the transaction.
2. The transaction drops all the locks that it holds or has an outstanding request on. It should do this when it has committed or rolled back its changes.

Here is an example:

Suppose you are implementing a BankAccount class. You might provide a drop_locks() method that drops all the locks that are held by the transaction passed as an input parameter. First this method gets the LockCoordinator object representing the lock set and the transaction:

```
CosConcurrencyControl::LockCoordinator_ptr const lock_coord;
...
this->lockset->get_coordinator(lock_coord);
```

Next, the transaction drops all the locks that it holds or has an outstanding request on. This is done by the following call:

```
lock_coord->drop_locks();
```

If the lock set were related to other lock sets, invoking drop_locks against the LockCoordinator object would result in all the locks held by the transaction in the other lock sets being dropped as well.

When the transaction has completed, it must drop all its locks. In this example, you might do this in an uninvolve_in_transaction() method of the BankAccount object before voting read-only to prepare or before returning from commit or rollback.

Use Non-transactional Locks

Although the Concurrency Service is designed for use primarily in a transactional environment, it is possible to have lock sets that are only ever called outside the scope of a transaction. In such a case, each lock request in a lock set is always associated with a thread.

Before carrying out this procedure, make sure you are familiar with:

- “Define a Lock Set” on page 7.
- “Create a Lock Set” on page 8.
- “Obtain and Release Locks from a Lock Set” on page 9.
- “Locks and Lock Sets” on page 3.

To use non-transactional locks, follow these steps:

1. Define the lock set.
2. Create the lock set using a LockSetFactory in the class initialization code.
3. Suspend the transaction associated with the current thread.
4. Request a lock in the lock set.
5. Read or update data.
6. Release the lock.
7. Resume the transaction associated with the current thread.

Here is an example:

Suppose in a BankAccount implementation that a class called Traninv is used for keeping track of each transaction's involvement with a recoverable object. It does this using a hash table to implement the Coordinator-to-Resource mapping. To control access to the hash table, a lock set is defined as a private instance variable in the Traninv header file:

```
/* C++ example */

#include <CosConcurrency.hh>
{
  CosConcurrencyControl::LockSetFactory_ptr lsfact;
  CosConcurrencyControl::LockSet_ptr latch;
```

The latch object is then created during the initialization of the Traninv class.

```
// Get the LockSetFactory object (a new one is created if it does not
// exist)

lsfact = CosConcurrencyControl::LockSetFactory::_create();

// Create a lockset using the LockSetFactory object

latch = lsfact->create();
```

Suppose the Traninv class has a get_resource() method that returns the address of the resource associated with a transaction. It acquires this information from the hash table, which must be read locked to ensure that it does not change during access. First the Traninv::get_resource() method suspends the transaction and gets a read lock in the latch lock set on behalf of the current thread:

```
...
CosTransactions::Control_ptr const control = current->suspend();
...
this->latch->lock(CosConcurrencyControl::read);
```

When the relevant data has been accessed, the thread releases the read lock and resumes the transaction:

```
...
this->latch->unlock(CosConcurrencyControl::read);
current->resume(control);
...
release latch;
release lsfact;
```

Change the Mode of a Lock

You can change the mode of a lock that has already been acquired by invoking the change_mode() operation on the lock set object. For example, suppose a server process controlling updates holds an upgrade lock, a special type of read lock used when the server process intends to do a subsequent write (see “Lock Modes” on page 4). It would use the change_mode() operation to upgrade the lock to a write lock.

Before carrying out this procedure, make sure you are familiar with Lock Modes.

To change the mode of a lock, follow these steps:

1. Obtain an upgrade lock. Invoke the lock() operation on the appropriate lock set object.
2. Read the data.
3. If you do not need to update the data, release the lock. If you do need to update the data:
    a. Use the change_mode() operation to change the mode from upgrade to write.
    b. Update the data.
    c. Release the write lock.

Here is an example:

In Use Non-transactional Locks, a class called Traninv is used for keeping track of each transaction's involvement with a recoverable object in a BankAccount implementation (see “Use Non-transactional Locks” on page 11). Traninv has an involve method that creates a coordinator-to-resource mapping for each transaction.

The thread obtains an upgrade lock:

```
this->latch->lock(CosConcurrencyControl::upgrade);
```

Once it has successfully acquired the lock, the method looks in the hash table to see whether a coordinator-to-resource mapping exists that corresponds to the (recently suspended) transaction.

If a mapping already exists in the hash table for this transaction, there is no need to perform any additional actions. The upgrade lock is released:

```
this->latch->unlock(CosConcurrencyControl::upgrade);
```

If no mapping exists for the transaction, involve must create one. It uses the change_mode() operation to change the mode to `write`:

```
this->latch->change_mode(CosConcurrencyControl::upgrade,
        CosConcurrencyControl::write);
```

Now that the thread holds a write lock on the latch, it is safe to proceed with updates to the hash table. The hash table is updated with an entry associating the coordinator to the resource.

When all required changes have been made to the hash table, the transaction releases the write lock:

```
this->latch->unlock(CosConcurrencyControl::write);
```

Prevent Deadlocks

When a number of transactions (or threads) are competing for shared resources, there is the risk of deadlock. This occurs when no transactions in a set can proceed because each is waiting for a lock held by another member of the set.

Before carrying out this procedure, make sure you are familiar with “Deadlocks” on page 6.

To prevent deadlock occurring within a single-process or application, when two transactions try to access a resource already locked by the other transaction, follow these steps:

1. Assign an arbitrary order to the resources that can be locked.
2. Ensure that all transactions or threads request locks in this order.

To prevent deadlock in an application that uses the Concurrency Service across multiple processes, specify a transaction timeout (see “Set a Time Limit for All New Transactions” on page 181).

If the transaction has not completed within the time specified, it automatically rolls back and its locks are released. The timeout value you should choose depends on the application. It should be large enough to ensure that the transaction has time to complete but short enough to be an acceptable time in which to detect deadlock.

To prevent deadlock occurring when two or more requesters attempt to read and then update the same resource, obtain an upgrade lock instead of a read lock.

Here is an example:

In this example, A and B both try to read and then update the same resource:

Table 5 (Page 1 of 2). A and B both try to read and then update the same resource

Program A	Program B
1. Request a read lock on resource	

Table 5 (Page 2 of 2). A and B both try to read and then update the same resource	
2. Obtain a read lock on resource	
	3. Request a read lock on resource
	4. Obtain read lock on resource
5. Request write lock on resource	
6. Thread suspended waiting for program B to release its read lock	
	7. Request write lock on resource
	8. Thread suspended waiting for program A to release its read lock

If each registers for a single upgrade lock, followed by a write lock, the deadlock does not occur:

Table 6. Each registers for a single upgrade lock, followed by a write lock.

Program A	Program B
1. Request an upgrade lock on resource	
2. Obtain an upgrade lock on resource	
	3. Request an upgrade lock on resource
4. Request write lock on resource	
5. Obtain a write lock on resource	
6. Update resource	
7. Release write lock	
8. Release upgrade lock	
	9. Obtain an upgrade lock on resource
	10. Request a write lock on resource
	11. Obtain a write lock on resource

Manage Objects

The first table shows how an application obtains objects from the Concurrency Service, and when, of ever, it can destroy them. If the application is not allowed to destroy an object, the second table shows when the concurrency destroys the object.

Table 7 (Page 1 of 2). How an application obtains and destroys objects from the concurrency service

Object	**How the application obtains the object**	**When the application can destroy the object**
LockSetFactory	LockSetFactory::create	At any time after the application has finished
LockSet	LockSetFactory::create or LockSetFactory::create_related	At any time after the application has finished using it
TransactionalLockSet	LockSetFactory::create_transactional or LockSetFactory::create_transactional_related	At any time after the application has finished using it

Object	How the application obtains the object	When the application can destroy the object
LockCoordinator	LockSet::get_coordinator or TransactionalLockSet::get_coordinator	Never (it is created amd destroyed by the Concurrency Service)

Table 7 (Page 2 of 2). How an application obtains and destroys objects from the concurrency service

Table 8. When the concurrency service destroys the object

Object	How the application obtains the object	When the application can destroy the object
LockCoordinator	LockSet::get_coordinator	LockCoordinator::drop_locks
	TransactionalLockSet::get_coordinator	When the last related LockSet is destroyed

Handle Exceptions

When the Concurrency Service encounters an error and is unable to complete a request successfully, it raises an exception in the application environment. Your application should catch exceptions and take appropriate action.

An exception can be one of those defined in the Concurrency Service interface definition or a standard system exception. The standard system exceptions contain a minor code that identifies the nature of the problem being reported. The system exceptions are listed in the “Errors and Exceptions” section under “Minor Codes Defined,” in the *Component Broker for Windows NT and AIX Problem Determination Guide*. Exceptions are handled as follows:

1. The server process controlling updates should check the environment after every request.
2. If an exception is raised, it must clear it before issuing subsequent requests. If it does not, unpredictable results can occur.

Configure Runtime Support

When you install Component Broker, the installation program sets default values for trace and log files. You can change these using the Object Editor of the System Management interface.

Troubleshoot

Problem Determination is described in the *Component Broker for Windows NT and AIX Problem Determination Guide*.

Chapter 2. Event Service

The following chapter is platform-dependent and does NOT apply to OS/390 Component Broker.

An Event Service allows objects to dynamically register or unregister their interest in specific events. An *event* is an occurrence within an object that is specified to be of interest to one or more objects. The Event Service creates a loosely joined communication channel between objects that are unfamiliar with each other.

The purpose of an Event Service is to enable objects to freely register or unregister their interest in certain events. An Event Service decouples communication between objects by defining two roles for objects: supplier objects and consumer objects. *Suppliers* produce events, while *consumers* process events.

Events are communicated among suppliers and consumers using standard CORBA requests. An Event Service contains event channels that act as supplier and consumer objects. These event channels allow multiple suppliers to communicate with multiple consumers asynchronously and without knowing about each other.

Communicating Asynchronous Events

The Component Broker event service enables you to exchange asynchronous event messages between different objects in the distributed system. This is useful for communicating about events that occur in one part of your application that another part of the application needs to know about. The asynchronous and loosely coupled nature of the event service allows the same event to be communicated to different parts of your application that may be interested in the same thing; neither part of your application needs to know directly of the other parts.

The event service introduces several key concepts:

Events

An event is a specific instance of an event message about a particular event. For instance, an event message may be generated to report that an Insurance Agent has closed a contract for an insurance policy. This event may be monitored by one program that maintains statistics on the number of contracts that are closed on average per hour, and by another program that logs all of the activities of each agent.

Event messages are discrete, relating only to one event. However, events can be replicated to report the same event information to multiple consumers of that event.

Event topics

An event topic defines a specific event type, or a family of related event types. For instance, the events that report when agents have closed their contracts are all of the same type, even though there may be many instances of this, one for each time an agent closes a contract.

Event suppliers

An event supplier is an object that generates event messages: it is a supplier of events, or more literally, the messages that report on that event.

Event consumers
An event consumer is an object that receives event messages, making it a consumer of events.

Event channels
An event channel is a broker of event messages. Event suppliers provide their events to an event channel, and event consumers obtain those events from the same event channel. The event channel is responsible for ensuring that all events that it receives are provided to all of its connected consumers. It is also responsible for mediating between the push and pull communication models.

Each event channel is actually composed of the following seven types of objects: *EventChannel*, which anchors the set of other related event channel objects; *EventSupplierAdmin* and *EventConsumerAdmin* which are administrative objects for mediating event connections; and *PushConsumerProxy, PullConsumerProxy, PushSupplierProxy*, and *PullSupplierProxy* objects which serve to represent a specific connection between individual suppliers and consumers of the event channel.

Communication models
The Component Broker event service supports both a push model of communication as well as a pull model of communication. The push model allows an event supplier to push its events to the event channel. The pull model allows an event channel to pull events from its event suppliers. Likewise, the push model allows an event channel to push events on its event consumers. And the pull model allows an event consumer to pull events from its event channel. An event channel can simultaneously support all communication models between all of its suppliers and consumers.

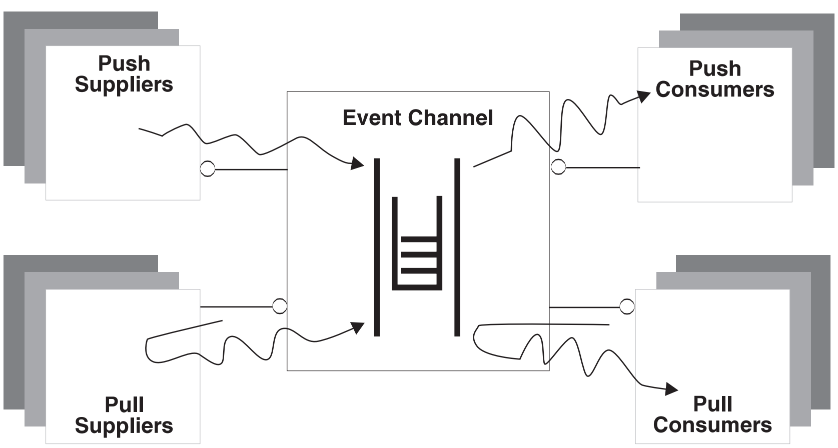


Figure 1. Event Service Relationship Model

Push suppliers use an event channel to push their event messages. Event channels use pull suppliers to pull their event messages. Event channels queue up all the events they receive from all of their suppliers. Event channels use consumers to push all of the events queued up in the channel. Pull consumers use event channels to pull all of the events queued up in the channel.

Communication Models

The event service can be used with either a push model or a pull model of interaction. Event suppliers can either push or pull events with the event channel. Likewise consumers can either push or pull events with the event channel.

A push supplier, having connected with the event channel, can push an event message on the event channel whenever the event occurs, or whenever it is appropriate for the supplier to present the event message to the event channel after the occurrence of the event. The push supplier can push its event(s) using the CosEventComm::PushConsumer::push() method supported by the ProxyPushConsumer that it obtained from the SupplierAdmin during the event channel connection process.

A pull supplier, having connected with the event channel, will have events pulled from it periodically. The event channel does this by invoking a pull() operation on the pull supplier. The pull supplier must support the CosEventComm::PullSupplier interface, and in particular implement the pull() and try_pull() operations. The pull() operation should be implemented to block and return an event message when the event has occurred. The try_pull() operation should never block, but rather should return an event message and a boolean return value of TRUE if an event has occurred, and to return a null message and a boolean return value of FALSE if not.

The event channel will perform its pull() operations on a separate thread for each pull supplier. Nonetheless, the pull supplier should be implemented to return from the pull() operation as quickly as possible (after an event is available) to avoid consuming resources in the event channel that could eventually affect its throughput.

Even though the event channel in Component Broker only uses the pull() operation, both operations should be implemented as other event channel implementations may invoke either. These methods should be implemented to work together so either method can be used interchangeably and yet only produce one event message for an event occurrence.

A push consumer, having connected with the event channel, will have events pushed on it whenever the event message is supplied to the event channel. When an event message is supplied to the event channel, the event channel iterates through its full list of connected push consumers and pushes the same event on each of those consumers.

The push consumer must support the CosEventComm::PushConsumer interface, and in particular implement the push() operation. It is up to the push consumer to decide what to do with the event when it arrives. Often, consumers are implemented to spawn a separate thread of their own to process the event. Each push occurs on a separate thread to isolate the effect that different consumers can have on each other. Nonetheless, push consumers should return from the push() operation as quickly as possible to avoid consuming resources in the event channel that could eventually effect its throughput.

A pull consumer, having connected with the event channel, can pull or try_pull an event from the event channel whenever it is ready to receive the next event message. The pull() operation is a blocking request and only returns when the event channel has another event message to supply to the pull consumer. The try_pull() operation is not blocking and returns an event-message if one is available, or simply return FALSE if not. The pull consumer can pull its event(s) using the CosEventComm::PullSupplier::pull() or CosEventComm::PullSupplier::try_pull() methods supported by the ProxyPullSupplier obtained from the ConsumerAdmin object during the event channel connection process.

Because the CosEventComm::PullSupplier::pull() operation is intended to be a blocking method, and since some events may take a long time to actually occur, it is possible that the communication network will fail or time-out before the supplier has the chance to return from the pull. This can be a significant problem for some applications. If the pull request times out, the consumer is notified through an exception to which it can respond, usually by simply re-invoking the pull request, and perhaps re-connecting to the event channel if necessary. On the other hand, the supplier is not necessarily informed of the error. Typically the supplier is programmed to present an event on return from the pull() method. However, if the connection from the consumer has timed out, then the return occurs without actually supplying anything to the consumer, and the event is lost.

You can reduce the chances of this happening by setting the ORB time-out value for the communication session between the consumer and supplier to zero (no time-out). However, this won't guard against other potential communication errors that could have the same effect. Thus, you should avoid the pull consumer model if it is important to you to avoid lost event messages.

Events

An event is a specific instance of an event message about a particular event. When an instance of an event occurs, an event supplier can produce an event message representing the occurrence of that event. The event message can contain as much or as little information about that occurrence as is relevant to your application.

An event has some form of abstract type, although this type is not formalized by the event service. The event type defines the format of the content of the event message. This is needed so that event suppliers and event consumers can know how to parse the information within the event message.

The event service defines an event message only as a CORBA 'any'. This means that it is entirely up to your application to define the format of the event message in a way that it can use to recognize its contents. The structure of the event message can be as elaborate or as simple as is appropriate for your application's needs. At one extreme, the event message can be a simple integer containing an event identifier, a value that can be used to uniquely identify the occurrence of the event. At this extreme, the event message does not convey anything more about the event instance except that it occurred and a handle that uniquely identifies that occurrence. Event consumers might be able to use this event identifier later to correlate back to a separate repository containing more information about the event.

When designing event messages you should consider the following:

- How much information do your event consumers need to know about the event instance, and what information will they use in the handling of that event?
- Are you likely to introduce other event consumers in the future? What information will they likely need?
- How will you evolve the schema for the event message without affecting backwards compatibility of existing event consumers and suppliers? Are you willing to modify your event suppliers and consumers whenever you change the event schema?
- How often are these events likely to occur? Will they happen so frequently that having too much information in them will likely affect system throughput?
- How often will consumers need all of the information you supply in the event? Would it be better to supply only a little information in the event message, including correlation information that can be used later to obtain the rest of the detailed information from a separate repository if and when it is actually needed?
- How do you want to group event types in an event topic, and what is the relationship of those event topics to event channels? Different event channels can be used for different event topics. Likewise, different event topics can be used to group one or more event types. All of these can be used to separate different event types, thus reducing the amount of information that you have to include in the event message itself.
- How much extra event handling information do you need? Do you need, for instance, to track how long, on average, it takes to process an event message from the time that it is produced to the time that it is consumed? Is there a maximum lifetime for the event handling, a point beyond which if the event is not handled it is no longer relevant and should be discarded? Do you need to prioritize the event? Do you want to correlate related events?

Event Topics

The idea of an event topic is an abstract concept introduced by Component Broker to help you consider the relationship between event instances, event types, and event channels. Within the running system there may be many occurrences of many different types of events. Likewise, you can introduce as many different event channels as you like. Designing an effective event schema requires achieving the right balance between system performance, integrity, and programming and administrative simplicity.

Single Event Channel Schemas

If you use only one event channel for all events supplied and consumed in your application, then administration is fairly straight-forward: you need only define one event channel and share that same event channel with all of your suppliers and consumers. However, using a single event channel raises the following concerns:

- The event channel can become a single point of failure. Since you are only dealing with one event channel, then if that event channel should fail then all of your suppliers and consumers are affected.
- Event suppliers must be able to identify the type and instance of event message they are producing.
- Event consumers need to identify the type(s) and instance(s) of event message they are interested in processing, filtering out all those that they're not interested in, and sorting through the various types and instances they are interested in, if there is more than one type.

Multiple Event Channel Schemas

Another strategy is to have a different event channel for every type of event message, and possibly a different event channel for each set of event messages coming from different groups of either or both suppliers and consumers. This has the obvious consequence of proliferating event channels, and in the latter case significantly increasing administrative complexity for associating groups of either or both event suppliers and consumers to determine which ones should be attached to which event channel instance. By extension, event suppliers and consumers may have to connect to numerous event channels for all of the types of events they handle.

In many cases there are a set of event types that are highly related. For instance, you may have a different event type for each of the steps an insurance agent performs. Each of these event types may be related by virtue that they all pertain to the steps an agent performs. This grouping may be relevant, for instance, if you have an event consumer that tracks all of an agent's actions, as a sort of audit trail to ensure they've followed all of the right procedures or to monitor their productivity.

You can group these related event types into an event topic. This is an artificial grouping, not supported in any formal sense by the event service, that you can use at your discretion and for your convenience. Having identified one or more event topics, you can determine how many event channels you will need. A common practice is to define a distinct event channel for each event topic. Each topic is given a label and each event channel is registered in the system name space with this topic name. Thus a supplier can connect to a particular event channel based on the topic(s) it supplies events for. Similarly, a consumer can connect to a particular event channel based on the topic(s) the consumer handles. Thus, if an event channel fails, only suppliers and consumers of that topic are effected. Likewise, suppliers and consumers can concentrate on the topics that they are programmed to handle, and in doing so avoid the system overhead associated with dealing with events not relevant to them.

Event Suppliers

An event supplier is an object that supplies event messages to an event channel. An event supplier can use either the push or pull model of interaction with the event channel. The same object can be a supplier to more than one event channel concurrently, however if the supplier uses the pull model there is no way for it to distinguish which event channel is pulling an event. Push model event suppliers must support the CosEventComm::PushSupplier interface. Pull model event suppliers must support the CosEventComm::PullSupplier interface. It is up to you to provide an implementation for the appropriate interface if you are introducing an event supplier.

Event suppliers must create a connection to their event channel before they can begin to supply events. To do this, they must first obtain the appropriate event channel. In most cases, event channels are registered in the system name space when they are created, and therefore obtaining an event channel is a matter of resolving its appropriate name in the system name space. As discussed in “Event Topics” on page 21, a common strategy is to register event channels with the name of the event topic they broker. Thus you can use the event topic name to resolve the appropriate event channel. Having located an event channel, the supplier must then connect to it. At this point, the supplier can supply any number of event messages, until the connection is terminated.

Push-model event suppliers can supply events using the CosEventComm::PushConsumer::push() operation on their event channel. Pull-model event suppliers can supply events when they are invoked with either the CosEventComm::PullSupplier::pull() or CosEventComm::PullSupplier::try_pull() operation. The connection with the event channel can be terminated by either the supplier or by the event channel. If the supplier is using the push-model it can disconnect by invoking the CosEventComm::PushConsumer::disconnect_push_consumer() operation on the event channel, and the event channel can disconnect the supplier by invoking the CosEventComm::PushSupplier::disconnect_push_supplier() operation on the supplier. If the supplier is using the pull-model it can disconnect by invoking the CosEventComm::PullConsumer::disconnect_pull_consumer() operation on the event channel, and the event channel can disconnect the supplier by invoking the CosEventComm::PullSupplier::disconnect_pull_supplier() operation on the supplier.

As event channel connections are not retained persistently, if the event channel fails, the connection must be reestablished. In the case of an event channel failure, push model event suppliers are notified in an exception on their next CosEventComm::PushConsumer::push request. Event suppliers should catch the CosEventComm::Disconnected exception. This is an indication that the event channel has failed. At that point, the supplier should re-connect before re-pushing the event.

Pull model event suppliers are never notified if an event channel fails. Instead, pull model event suppliers simply stop being invoked for any further events. If this is an issue for the supplier, it can periodically attempt to reconnect with the event channel. If the event channel has not failed then the reconnect attempt raises the CosEventChannelAdmin::AlreadyConnected exception with no other consequences.

Event suppliers can reside in pure clients. However, since pure clients can not export object references, event suppliers in pure clients are constrained to only use the push model of interaction. Further, pure client event suppliers are not notified if the event channel disconnects. If the event channel disconnects, the event supplier is left to detect the loss of connection with the CosEventComm::Disconnected exception raised on their next push request.

Supplying Events

Supplying events requires you to first locate and connect to an event channel that is intended to handle your event topic. The event service supports two models of interaction between event suppliers and event channels: the push model and the pull model. If your event supplier resides in a pure client, you must use the push model.

Supply events using the following steps:

1. Locate an event channel. You need an event channel with which to connect. The easiest approach is to simply obtain an already existing event channel that has been registered in the system name space. In addition, you can create a new event channel, or use the Component Broker system management facilities to configure a new event.
2. Connect to the event channel. Follow the procedure described in "Connecting to an Event Channel" on page 31 to connect with the event channel.
3. Supply the event. As a push-model event supplier, you can use the CosEventComm::PushConsumer::push() method to push your event on the event channel. As a pull-model event supplier, you must implement the CosEventComm::PullSupplier::pull() and CosEventComm::PullSupplier::try_pull() methods. The pull() method should block until ready to return an event. The try_pull() method should always return immediately; returning a boolean value of TRUE and the event message if one is ready, or returning a boolean value of FALSE and a null event message if not.

The following example demonstrates how to connect as a push supplier to the AgentActions event channel created in "Creating an Event Channel" on page 28 and supply methods using the push() method. This example assumes that you are your own push-supplier object, and that you are operating in a server process.

```
// Declare an intermediate Object, the AgentActions event
// channel, a supplier admin object and a push consumer
// proxy.

CORBA::Object_var intermediateObject;
CosEventChannelAdmin::EventChannel_var agentActionsEC;
CosEventChannelAdmin::SupplierAdmin_var agentActionsSA;
CosEventChannelAdmin::ProxyPushConsumer_var agentActionsPPC;

// Assuming an event structure has been declared in IDL, declare
// an instance of that event structure for reporting on agent
// actions, and a CORBA any for conveying it with.

ActionEventStructure_var agentActionEvent;
::CORBA::Any_var eventAny;

// Locate the AgentActions event channel, obtain the supplier
// admin, and obtain a push consumer proxy.

intermediateObject = CBSeriesGlobal::nameService()
  ->resolve_with_string(
  "/host/resources/event-channels/AgentActions");
agentActionsEC=
  CosEventChannelAdmin::EventChannel::_narrow(intermediateObject);
agentActionsSA = agentActionsEC->for_suppliers();
agentActionsPPC = agentActionsSA->obtain_push_consumer();

// Connect to the event channel proxy.
```

```
agentActionsPPC->connect_push_supplier(this);

// Do some activity for the Insurance agent

  ...

// Supply an event indicating the completion of that action.
           // Fill in the fields of the agentActionEvent

          ...

           // Set the event in an Any
          eventAny <<= agentActionEvent;

           // Push the event
          agentActionsPPC->push(eventAny);
```

Event Consumers

An event consumer is an object that consumes event messages from an event channel. An event consumer can use either the push or pull model of interaction with the event channel. The same object can be a consumer of more than one event channel concurrently, however, and if the consumer uses the push model there is no way for it to distinguish which event channel is pushing an event. Push model event consumers must support the CosEventComm::PushConsumer interface. Pull model event consumers must support the CosEventComm::PullConsumer interface. It is up to you to provide an implementation for the appropriate interface if you are introducing an event consumer.

Event consumers must first create a connection to their event channel before they can begin to consume events. To do this, they must first obtain the appropriate event channel. In most cases, event channels are registered in the system name space when they are created, and obtaining an event channel is simply a matter of resolving its appropriate name in the system name space. As discussed in "Event Topics" on page 21, a common strategy is to register event channels with the name of the event topic they broker. Thus you can use the event topic name to resolve the appropriate event channel.

Having located an event channel, the consumer must then connect to it. At this point, the consumer can consume any number of event messages, until the connection is terminated. Push model event consumers can consume events when they are invoked with the CosEventComm::PushConsumer::push() operation. Pull model event consumers can consume events using either the CosEventComm::PullSupplier::pull() or CosEventComm::PullSupplier::try_pull() operation on their event channel.

The connection with the event channel can be terminated by either the consumer or by the event channel. If the consumer is using the push model, it can disconnect by invoking the CosEventComm::PushSupplier::disconnect_push_supplier() operation on the event channel, and the event channel can disconnect the consumer by invoking the CosEventComm::PushConsumer::disconnect_push_consumer() operation on the consumer. If the consumer is using the pull model it can disconnect by invoking the CosEventComm::PullSupplier::disconnect_pull_supplier() operation on the event channel, and the event channel can disconnect the consumer by invoking the CosEventComm::PullConsumer::disconnect_pull_consumer() operation on the consumer.

As event channel connections are not retained persistently, if the event channel fails, the connection must be reestablished. If the event channel fails, pull model event consumer is notified in an exception on their next CosEventComm::PullSupplier::pull or CosEventComm::PullSupplier::try_pull request. Event consumers should catch the CosEventComm::Disconnected exception. This is an indication that the event channel has failed. At that point, the consumer should reconnect before re-pulling the event.

Push model event consumers are never notified if an event channel fails. Instead, they stop receiving any further events. If this is an issue for the consumer, it can periodically attempt to reconnect with the event channel. If the event channel has not failed then the reconnect attempt raises the CosEventChannelAdmin::AlreadyConnected exception with no other consequences.

Event consumers can reside in pure clients. However, since pure clients cannot export object references, then event consumer in pure clients are constrained to only use the pull model of interaction. Further, pure client event consumers are not notified if the event channel decides to disconnect. The event consumer is left to detect the loss of connection with the CosEventComm::Disconnected exception raised on their next pull or try_pull request.

Consuming Events

This procedure demonstrates how to consume an event from an event channel. To consume an event, you have to first locate and connect to an event channel that is intended to handle your event topic. The event service supports the push and pull models of interaction between event consumers and event channels. If your event consumer resides in a pure client, you must use the pull model.

Consume an event from the event channel using the following steps:

1. Locate an event channel. You need an event channel to connect with. The easiest approach is to simply obtain an already existing event channel that has been registered in the system name space. In addition, you can create a new event channel, or use the Component Broker system management facilities to configure a new event.
2. Connect to the event channel. Follow the procedure described in "Connecting to an Event Channel" on page 31 to connect with the event channel.
3. Consume the event. As a pull model consumer, you can use the CosEventComm::PullSupplier::pull() or CosEventComm::PullSupplier::try_pull() method to consume an event. If you use the pull() method, your request blocks until an event is ready to be returned. If you use the try_pull() method, your request always returns immediately, and indicates in a boolean return value whether an event was available to return. As a push model consumer, you must implement the CosEventComm::PushConsumer::push() method. This method is invoked whenever or not an event is available for you to consume.

The following example demonstrates how to connect as a pull consumer to the AgentActions event channel created in "Creating an Event Channel" on page 28 and consume events using the pull() method. This example assumes you are your own pull-consumer object, and that you are operating in a server process.

```
// Declare an intermediate Object, the AgentActions event channel,
// a consumer admin object, and a pull supplier proxy.

CORBA::Object_var intermediateObject;
CosEventChannelAdmin::EventChannel_var agentActionsEC;
CosEventChannelAdmin::ConsumerAdmin_var agentActionsCA;
CosEventChannelAdmin::ProxyPullSuplier_var agentActionsPPS;

// Assuming an event structure has been declared in IDL, declare
// an instance of that event structure for receiving the agent
// actions, and a CORBA any for consuming it with.

ActionEventStructure_var agentActionEvent;
```

```
::CORBA::Any_var eventAny;

// Locate the AgentActions event channel, obtain the consumer
// admin, and obtain a pull supplier proxy.

intermediateObject =
CBSeriesGlobal::nameService()->resolve_with_string(
  "/resources/event-channels/AgentActions");
agentActionsEC=
  CosEventChannelAdmin::EventChannel::_narrow(intermediateObject);
agentActionsCA = agentActionsEC->for_consumers();
agentActionsPPS = agentActionsCA->obtain_pull_supplier();

// Connect to the event channel proxy.

agentActionsPPS->connect_pull_consumer(this);

// Consume an event.
// Pull the event

eventAny = agentActionsPPS->pull();

// Obtain the event from the Any

eventAny >>= agentActionEvent;

// Handle the fields of the agentActionEvent
  ...
```

Event Channels

Event channels have two forms. In their abstract form, an event channel is a broker of event messages, consuming them from their connected suppliers, and supplying them to their connected consumers. In their concrete form, an event channel is composed of the following object types:

CosEventChannelAdmin::EventChannel
This is the anchor point for the other event channel objects. EventChannel objects define the abstract event channel, and are the objects registered in the system name space that enable you to find an event channel.

CosEventChannelAdmin::SupplierAdmin
SupplierAdmin objects broker connections between suppliers and the event channel.

CosEventChannelAdmin::ConsumerAdmin
ConsumerAdmin objects broker connections between consumers and the event channel.

CosEventChannel::ProxyPushConsumer
ProxyPushConsumer objects define a specific connection between a supplier and the event channel. An instance of a ProxyPushConsumer is created for each supplier that connects to the event channel using the push-model of interaction.

CosEventChannel::ProxyPullConsumer
ProxyPullConsumer objects define a specific connection between a supplier and the event channel. An instance of a ProxyPullConsumer is created for each supplier that connects to the event channel using the pull-model of interaction.

CosEventChannel::ProxyPushSupplier
ProxyPushSupplier objects define a specific connection between a consumer and the event channel. An instance of a ProxyPushSupplier is created for each consumer that connects to the event channel using the push model of interaction.

CosEventChannel::ProxyPullSupplier
ProxyPullSupplier objects define a specific connection between a consumer and the event channel. An instance of a ProxyPullSupplier is created for each consumer that connects to the event channel using the pull model of interaction.

Event channels can support multiple simultaneous connections of suppliers and consumers using any mixture of push model or pull model interactions. In Component Broker, event channels are managed objects with persistent references. Thus they must reside in a Component Broker server process, and can be registered in the system name space. All suppliers and consumers that resolve the same event channel reference get to the same instance of event channel. Event channels are automatically reactivated in the Component Broker server when they are first referenced.

As brokers of event messages, event channels are in fact both event consumers and event suppliers (consumers to their connected event suppliers, and suppliers to their connected event consumers), proxies are used to mediate between consumers and suppliers, and between push and pull models of interaction.

Event channels multicast all of the event messages they receive. That is, when a supplier provides an event message to the event channel, that event message is supplied to all of the consumers that are currently connected to the event channel. The event message is not removed from the event channel queues until it has been consumed by all of its connected consumers. However, in Component Broker, event channels are transient. They do not retain either supplier or consumer connections persistently, nor do they retain event messages persistently. Connections and pending event messages are lost whenever the event channel is passivated or terminated.

Component Broker automatically creates a single *default event channel* that is registered in the system name space in `/.:/resources/event-channels/cell-default`. This event channel can be used for any purpose, but to allow for proper interoperation between all of the applications that could end up using it, all event messages using the event channel in a production environment must use the data type as CORBA::Any.

If you need an event channel within your application, you should introduce your own event channel for your own purposes. See "Event Topics" on page 21 for more information that may be useful in deciding how to divide up your event system topology. Having done so, you should design an appropriate structure for your event messages, as discussed in "Events" on page 20. You can create a new event channel programmatically using the standard Component Broker programming model for managed objects, as described in "Creating an Event Channel" on page 28.

Having created the event channel you should be sure to register it in the system name space so that your suppliers and consumers can find it at run-time. This is done for you automatically if you use the IExtendedEventChannelAdmin::IEventChannelHome::createVisibleEventChannel() operation. Otherwise, you can use the IExtendedEventChannelAdmin::IEventChannelHome::createEventChannel() operation and manually bind the event channel in the system name space.

You can also use the Component Broker system management facility to configure a new event channel. This is described in more detail in "Configuring an Event Channel" on page 30. This process automatically register the event channel in the system name space so that your suppliers and consumers can find it at run-time. The Component Broker system name space includes naming contexts where you can register event channels by name at the following locations:

- `/host/resources/event-channels/workgroup/resources/event-channels`

- /.:/resources/event-channels

Alternately, you can register your event channels in your own application name tree.

Locating an Event Channel

This procedure demonstrates how you can locate an event channel by name in the system name space. This is useful to both event suppliers and event consumers who are finding an event channel they can use to exchange event messages.

You can locate an event channel in the fashion demonstrated here only if the event channel already exists and has been bound in the system name space. You must know the name of the event channel to use this procedure.

Use the following steps to locate an event channel:

1. Determine the name of the event channel you want to use. This may be the name of the default event channel automatically created and registered in the system name space by Component Broker installation. Or it could be an event channel that your application created and bound in the system name space at some earlier point in time.
2. Resolve the event channel from the system name space. Use the naming service operations to resolve that event channel from the system name space, by the name that you determined in the previous step.

The default event channel is created automatically during Component Broker installation.The following example shows how to obtain the default event channel:

```
// Declare the targeted event channel

CORBA::Object_var intermediateObject;
CosEventChannelAdmin::EventChannel_var defaultEC;

// Obtain the default event channel and narrow it to an event
// channel

intermediateObject=CBSeriesGlobal::nameService()
   ->resolve_with_string(
   " /.:/resources/event-channels/cell-default");
defaultEC = CosEventChannelAdmin::EventChannel::_narrow(
   intermediateObject);
```

Creating an Event Channel

An event channel is created essentially in the same way that any other managed object is created, that is, by first obtaining a factory finder with a desired location scope. By extension, such a factory finder must exist. Component Broker provides a set of default factory-finders that it creates and registers in the system name space during Component Broker installation. These are found in the following locations:

- /host/resources/factory-finders/host-scope
- /workgroup/resources/factory-finders/workgroup-scope
- /.:/resources/factory-finders/cell-scope

In addition, Component Broker automatically creates a home for event channels in every server process. However, the least granularity of scoping that any of the default factory finders supports is a host scope. Therefore, if you want the event channel created in a more specific server you must create a new factory finder with a corresponding location scope that narrows to that server.

Create an event channel using the following steps:

1. Obtain a factory finder with the desired location scope. You need a factory finder with which to create your new event channel. Alternately, you can create a non-managed factory finder to use for finding the new event channel's factory.

2. Use the factory finder to find a factory (a Home) for event channels. Having obtained a factory finder, you can now use it to find a factory for factory finders. You do this with the find_factory, find_factories(), find_factory_from_string(), or find_factories_from_string() methods. The event channels interface is IEventChannelAdminManagedClient::EventChannel. This is the principal interface name that you is passed in to the find_factory* or find_factories* methods.

3. Create the event channel. The factory specialization for event channels introduces the createEventChannel() and createVisibleEventChannel() methods which you can use to create the new event channel. You must narrow to the IExtendedEventChannelAdmin::IEventChannelHome interface to use either of these new methods.

4. Register the event channel in the system name space. This step is optional. When you've created an event channel, often you want to retain this object for future use in your application to be shared by event suppliers and consumers. How you do this in your application is up to you, but the typical approach is to bind the event channel in the system name space. Again, where you bind it in the system name space is up to you. One obvious and commonly used choice is to bind it in `/host/resources/event-channels`, `/workgroup/resources/event-channels`,or `/.:/resources/event-channels` depending on what visibility you want to give it. Another choice is to bind it under your own application, contexts within `/host/applications`, `/workgroup/applications`, or `/.:/applications`. Typically, event channels are bound with the event topic name for the types of events they are intended to broker.

   If you use the IExtendedEventChannelAdmin::IEventChannelHome::createVisibleEventChannel() method, you can specify the relative name (the event channel's topic name), and a boolean flag for the name spaces in which you want the event channel registered. The specialized home automatically registers the new event channel into the name space in the indicated locations.

The example that follows demonstrates creating a new event channel, and binding it in the system name space under /host/resources/event-channels with the name AgentActions. The event channel is created within the local host.

```
// Declare an intermediate Object, the event-channels naming
// context, the targeted factory finder where the new event
// channel will be created,a event channel factory, and the
// new event channel.

CORBA::Object_var intermediateObject;
IExtendedNaming::NamingContext_var eventChannelsNC;
IExtendedLifeCycle::FactoryFinder_var hostScopeFF:
IExtendedEventChannelAdmin::IEventChannelHome_var factoryOfEC;
CosEventChannelAdmin::EventChannel_var myNewEC;
ByteString_var key;

// Obtain the default factory finder with a host-scope and
// narrow to an IExtendedLifeCycle::FactoryFinder so that we
// can use the find_factory_from_string operation.

CBSeriesGlobal::Initialize();
//Initialize the CBSeries environment

intermediateObject = CBSeriesGlobal::nameService()
  ->resolve_with_string(
  "/host/resources/factory-finders/host-scope");
```

```
hostScopeFF = IExtendedLifeCycle::FactoryFinder::_narrow(
  intermediateObject);

// Find a factory for event channels and narrow to the factory
// specialization

intermediateObject = hostScopeFF->find_factory_from_string(
  "IEventChannelAdminManagedClient.object interface");
factoryofEC =
  IExtendedEventChannelAdmin::IEventChannelHome::_narrow
  (intermediateObject);

// Use the factory to create a new event channel.

myNewEC = factoryOfEC->createEventChannel(key);

// Bind the new event channel in the system name space.

intermediateObject = CBSeriesGlobal::nameService->resolve(
  "/host/resources/event-channels");
eventChannelsNC =
  IExtendedNaming::NamingContext::_narrow(intermediateObject);
eventChannelsNC->bind_with_string("AgentActions", myNewEC);
```

The last four statements could have been combined into the following statement:

```
myNewEC = factoryOfEC->createVisibleEventChannel(key,
  "AgentActions", 0, 1, 0);
```

Configuring an Event Channel

This procedure demonstrates how to configure a new event channel using the Component Broker system management facility. This is useful for when you need an event to support a new event topic. This procedure is entirely administrative and does not involve any programming.

Configure a new event channel using the following steps:

1. Navigate to the desired server. The new event channel must be configured within a specific server. Use the system management user interface to navigate to the host and server on which you want the factory finder configured.
2. Create a event channel model. Insert an event channel model within the server.
3. Set event channel model attributes. Use the attributes notebook to fill in the event channel model attribute value. This includes the system management name for the event channel (don't confuse this with the name of the event channel in the system name space, although these can be set to the same value), the name of the event channel in the system name space, and the Home of the event channel.
4. Apply the model changes. Select the apply function for the server, host, or zone where you've created the event channel model. This results in a corresponding event channel object being automatically created in the targeted server and registered in the system name space.

Connecting to an Event Channel

This procedure demonstrates how to connect to an event channel. You need to connect to an event channel before you can supply or consume events. The event channel must have already been created and registered in a way that you can find it.

Connect to an event channel using the following steps:

1. Locate an event channel. You need an event channel with which to connect. The easiest approach is to simply obtain an already existing event channel that has been registered in the system name space. Otherwise, you can create a new event channel, or use the Component Broker system management facilities to configure a new event.
2. Acquire an event channel administration object. Use the for_suppliers() or for_consumers() operation to get an event channel administration object, depending on whether you want connecting to be an event supplier or an event consumer.

   If you are an event supplier, then use the for_suppliers() operation to get back a CosEventChannelAdmin::SupplierAdmin object.

   If you are an event consumer, then use the for_consumers() operation to get back a CosEventChannelAdmin::ConsumerAdmin object.
3. Acquire an event channel proxy object. Use the obtain_push_consumer(), obtain_pull_consumer(), obtain_push_supplier(), or obtain_pull_supplier() operation on the corresponding event channel administration object to get an event channel proxy object, depending on whether you are an event supplier or event consumer, and depending on whether you are going to use the push-model or the pull-model of communication.

   If you are a supplier using the push model, then use the obtain_push_consumer() operation to get back a CosEventChannelAdmin::ProxyPushConsumer object.

   If you are a supplier using the pull model, then use the obtain_pull_consumer() operation to get back a CosEventChannelAdmin::ProxyPullConsumer object.

   If you are a consumer using the push model, then use the obtain_push_supplier() operation to get back a CosEventChannelAdmin::ProxyPushSupplier object.

   If you are a consumer using the pull model, then use the obtain_pull_supplier() operation to get back a CosEventChannelAdmin::ProxyPullSupplier object.
4. Connect with the proxy. Use the connect_push_supplier(), connect_pull_supplier(), connect_push_consumer(), or connect_pull_consumer() method to connect to the event channel proxy, depending on whether you are a supplier or consumer, and whether you are using the push or pull model of communication.

   If you are a push supplier, then use the connect_push_supplier on your ProxyPushConsumer.

   If you are a pull supplier, then use the connect_pull_supplier on your ProxyPullConsumer.

   If you are a push consumer, then use the connect_push_consumer on your ProxyPushSupplier.

   If you are a pull consumer, then use the connect_pull_consumer on your ProxyPullSupplier.

Normally, you have to supply a reference to yourself , namely your supplier or consumer object, on the connect request. This is used either to pull or push on you, as well as to inform you when the connection is being terminated. However, if you are connecting from a pure-client you are not able to use the connect_pull_supplier() or connect_push_consumer() methods. Also, you will have to supply a NIL object reference in either the connect_push_supplier() or connect_pull_consumer() requests. This basically indicates to the event channel that you are operating from a pure-client and avoids the issuing of any disconnect requests.

The example that follows demonstrates how to connect as a push supplier to the AgentActions event channel that was created in “Creating an Event Channel” on page 28. This example assumes you are your own push-supplier object, and that you are operating in a server process.

```
// Declare an intermediate Object, the AgentActions event
// channel, a supplier admin object, a push consumer proxy.

CORBA::Object_var intermediateObject;
CosEventChannelAdmin::EventChannel_var agentActionsEC;
CosEventChannelAdmin::SupplierAdmin_var agentActionsSA;
CosEventChannelAdmin::ProxyPushConsumer_var agentActionsPPC;

// Locate the AgentActions event channel, obtain the supplier
// admin, and obtain a push consumer proxy.

CBSeriesGlobal::Initialize();
//Initialize the CBSeries environment

intermediateObject =CBSeriesGlobal::nameService()
  ->resolve_with_string(
  ".:/resources/event-channels/AgentActions");
agentActionsEC=
  CosEventChannelAdmin::EventChannel::_narrow(intermediateObject);
agentActionsSA = agentActionsEC->for_suppliers();
agentActionsPPC = agentActionsSA->obtain_push_consumer();

// Connect to the event channel proxy.

agentActionsPPC->connect_push_supplier(this);
```

Disconnecting from an Event Channel

Disconnecting from an event channel is useful for when you want to stop supplying or consuming events. It essentially un-registers your event supplier or event consumer with the event channel. After disconnecting, push model suppliers can no longer push, pull model suppliers can no longer be pulled, push model consumers can no longer be pushed, and pull model consumers can no longer pull.

If you are already connected to an Event Channel, do the following to disconnect:

Use the disconnect_push_consumer(), disconnect_pull_consumer(), disconnect_push_supplier(), or disconnect_pull_supplier() method to disconnect from the event channel, depending on whether you are a supplier or consumer, and whether you are using the push model or pull model of interaction.

- As a push supplier, use the CosEventComm::PushConsumer::disconnect_push_consumer on your push consumer proxy.
- As a pull supplier, use the CosEventComm::PullConsumer::disconnect_pull_consumer on your pull consumer proxy.
- As a push consumer, use the CosEventComm::PushSupplier::disconnect_push_supplier on your push supplier proxy.
- As a pull consumer, use the CosEventComm::PullSupplier::disconnect_pull_supplier on your pull supplier proxy.

The following example demonstrates how to disconnect from the AgentActions event channel that was previously connected to in “Connecting to an Event Channel” on page 31. This example assumes this is being done from a push supplier.

```
// Assuming we've already connected to the AgentActions event
// channel as push supplier
...
agentActionPPC->disconnect_push_consumer();
```

Event Channel Samples

A complete non system managed object sample is provided. The system managed object sample will be available when Event Services are supported by Object Builder.

A push model stock application is shown here. First, a Stock object is created. The stock price is changed by prompting for user input. The amount of stock price changing which can be either a positive or a negative number (long for simplicity) is entered by the user. When the stock price falls to 0, an exception “InvalidPrice” is thrown and the application deletes the Stock object and terminates.

The following example illustrates the Stock.cpp:

```
#include "Stock.ih"
#include <stdio.h>
void main()
{
   Stock_Impl *Stock;
   char str[10];
   long amount;

   try
   {                                  // create Stock object
      Stock = new Stock_Impl;
      while (1)
      {
         cout << "Enter the amount: << endl;
         gets(str);
         amount = atoi(str);          // convert string to long
         Stock->changePrice(amount);  // change the stock price
      }
   }
   catch (Stock::InvalidPrice)
   {
      cout << "InvalidPrice exception !" << endl;
   }
   catch (...)
   {
      cout << "unknown exception !" << endl;
   }
   delete(Stock);
}
```

In the push module, a Customer application is also created as an ORB server. The ORB server is first initialized, the Customer object is then created and the server is waiting for some action.

The following example illustrates the Customer.cpp:

```
#include "Customer.ih"
void main(int argc, char *argv[])
{
   CORBA::ImplDef *imp;
   CORBA::ORB_var op;
   static CORBA::BOA_var bp;
```

```
    Customer_Impl *Customer;
                // Initialize the server's ImplDef, ORB, and BOA
    imp = new CORBA::ImplDef();
    imp->set_protocols("SOMD_TCPIP");
    op = CORBA::ORB_init(argc, argv, "DSOM");
    bp = op->BOA_init(argc, argv, "DSOM_BOA");
    bp->impl_is_ready(imp, 0);

    Customer = new Customer_Impl;    // create Customer

    cout << " ... Server Listening..." << endl; cout.flush();
    bp->execute_request_loop(CORBA::BOA::SOMD_WAIT);
 }
```

The Stock object is inherited from the CosEventComm::PushSupplier class which has a disconnect_push_supplier() method defined. An InvalidPrice exception and a changePrice() method are introduced by the Stock interface.

The following example illustrates the Stock.idl:

```
#include <CosEventComm.idl>
interface Stock : CosEventComm::PushSupplier
{
   exception InvalidPrice {};
   void changePrice(in long amount) raises (InvalidPrice);
};
```

In the Stock object implementation header, a constructor is added. Two instance variables, *price* and *pxyPushC* are included. The instance variable *price* is used to hold the stock price. The *pxyPushC* is a CosEventChannelAdmin::ProxyPushConsumer pointer which is used to communicate to the Event Channel.

The following example illustrates the Stock.ih:

```
#include <CosEventChannelAdmin.hh>
#include <Stock.hh>
class Stock_Impl : public virtual Stock_Skeleton
{
   public:
       Stock_Impl();                              // constructor
       CORBA::Void changePrice(CORBA::Long amount);
       CORBA::Void disconnect_push_supplier();

   protected:
       long price;
       CosEventChannelAdmin::ProxyPushConsumer_var pxyPushC;
};
```

In the Stock object implementation file, the “constructor” initializes the stock price to 100. The Event Channel home “ecHome” is located, and the Event Channel “ec” is created. The object reference of the Event Channel is then converted into a string and saved in a file to be used by other applications. The Supplier Admin is then obtained through the Event Channel and the ProxyPushConsumer is obtained through the Supplier Admin. Finally the Stock object is connected to the Event Channel through the ProxyPushConsumer. A NULL is passed through the connect_push_supplier() method call to indicate that the Stock object is a pure client application.

The changePrice() method updates the price change for the Stock object and throws an InvalidPrice exception when the stock price falls below 0.

The disconnect_push_supplier() method is not implemented because the Stock object is a pure client application and cannot accept any method calls.

The following example illustrates the Stock_i.cpp:

```
#include "Stock.ih"
#include <IExtendedEventChannelAdmin.hh>
#include <IExtendedLifeCycle.hh>
#include <CBSeriesGlobal.hh>
#include <fstream.h>
Stock_Impl::Stock_Impl()
{
   CORBA::Object_var intermediateObject;
   IExtendedLifeCycle::FactoryFinder_var hostScopeFF;
   IExtendedEventChannelAdmin::IEventChannelHome_var ecHome;
   ByteString_var key;
   CosEventChannelAdmin::EventChannel_var ec = NULL;
   CosEventChannelAdmin::SupplierAdmin_var sa = NULL;
   char *ec_stringref;
   ofstream fout("..\\ec.dat");         // file contains the ec object reference
   CORBA::ORB_var orbp;
              cout << "Enter - constructor" << endl;
   price = 100;         // initial price
                        // initialize the CBSeries environment
   CBSeriesGlobal::Initialize();
                        // obtain the default factory finder with a host scope
   intermediateObject = CBSeriesGlobal::nameService()->resolve_with_string(
                                "host/resources/factory-finders/host-scope");
                        // narrow to a factory finder
   hostScopeFF = IExtendedLifeCycle::FactoryFinder::_narrow(intermediateObject);
                        // find the event channel factory
   intermediateObject = hostScopeFF->find_factory_from_string(
            "IEventChannelAdminManagedClient::EventChannel.object interface");
                        // narrow to the event channel home
   ecHome = IExtendedEventChannelAdmin::IEventChannelHome::_narrow(
                                                        intermediateObject);
                                      cout << "ecHome is found!" << endl;
                        // use the factory in the event channel home to create
                        // a new event channl
   ec = ecHome->createEventChannel(key);
                        // write the object reference out to a file
   ec_stringref = orbp->object_to_string(ec);
                                      cout << ec_stringref << endl;
   fout << ec_stringref;
   fout.close();
                        // Get Supplier Admin through Event Channel
   sa = ec->for_suppliers();
                        // Get ProxyPushConsumer through Supplier Admin
   pxyPushC = sa->obtain_push_consumer();
                        // Connect to the Event Channel
   pxyPushC->connect_push_supplier(NULL);
}

CORBA::Void Stock_Impl::changePrice(CORBA::Long amount)
{
   CORBA::Any ev;
   char *str = CORBA::string_alloc(100);
           cout << "Enter - changeBalance: price = " << price << " amount = " << amount << endl;
```

```
      price = price + amount;
      if (price < 0)
      {
         price = 0;
         cout << "throw InvalidPrice exception !" << endl;
         throw Stock::InvalidPrice();
      }
      else
      {
         itoa(price, str, 10);
         ev <<= str;
         pxyPushC->push(ev);
      }
   }

   CORBA::Void Stock_Impl::disconnect_push_supplier()
   {
   }
```

The Customer object is inherited from the CosEventComm::PushConsumer class which has two methods defined: the push() method and the disconnect_push_consumer() method. No additional methods are added in the Customer object.

The following example illustrates the Customer.idl:

```
#include <CosEventComm.idl>
interface Customer : CosEventComm::PushConsumer
{
};
```

In the Customer object implementation header, only a constructor is added.

The following example illustrates the Customer.ih:

```
#include "Customer.hh"
class Customer_Impl : public virtual ::Customer_Skeleton
{
   public:
       Customer_Impl();
       CORBA::Void push (const CORBA::Any & data);
       CORBA::Void disconnect_push_consumer ();
};
```

In the Customer object implementation file, the “constructor” initializes the ORB. The Event Channel object reference created by the Stock application is obtained from the file. The Consumer Admin is then obtained through the Event Channel and the ProxyPushSupplier is obtained through the Consumer Admin. Finally the Customer object is connected to the Event Channel through the ProxyPushSupplier. The current Customer object is passed through the connect_push_consumer() method call to indicate that the Customer object is a server application. The Event Channel can communicate to the Customer server through the Customer object reference.

The push() method displays the event received from the Event Channel which is the stock price.

The disconnect_push_consumer() method displays a message to indicate thate the Customer application is just disconnected by the Event Channel.

The following example illustrates the Customer_i.cpp:

```
#include "Customer.ih"
#include <CosEventChannelAdmin.hh>
#include <IExtendedLifeCycle.hh>
#include <CBSeriesGlobal.hh>
#include <fstream.h>
#include <time.h>
Customer_Impl:: Customer_Impl()
{
   int argc;
   char **argv = NULL;
   CORBA::ORB_var op;
   char objref[1024];
   ifstream fin_ec("..\\ec.dat");
   CORBA::Object_var optr;
   CosEventChannelAdmin::EventChannel_var ec = NULL;
   CosEventChannelAdmin::ConsumerAdmin_var ca = NULL;
   CosEventChannelAdmin::ProxyPushSupplier_var pxyPushS;
   CORBA::Object_var intermediateObject;
   IExtendedLifeCycle::FactoryFinder_var hostScopeFF;
   short i;
                                cout << "Enter - constructor" << endl;
                         // initial ORB
   op = CORBA::ORB_init(argc, argv, "DSOM");
                         // Get Notify Channel through file ec.dat
   memset(objref, 1024, '\0');
   fin_ec >> objref;
   optr = op->string_to_object(objref);
   ec = CosEventChannelAdmin::EventChannel::_narrow(optr);
                         // Get Consumer Admin through Event Channel
   ca = ec->for_consumers();
                         // Get ProxyPushSupplier through Consumer Admin
   pxyPushS = ca->obtain_push_supplier();
                         // Connect to the Event Channel!
   pxyPushS->connect_push_consumer(this);
                                cout << "Exit  - constructor" << endl;
}

CORBA::Void Customer_Impl::push(const CORBA::Any & data)
{
   char *str;
                cout << "Enter - push" << endl;
   data >>= str;
   cout << str << endl;
}

CORBA::Void Customer_Impl::disconnect_push_consumer()
{
   cout << "Enter - disconnect_push_consumer" << endl;
}
```

Chapter 3. Notification Service

The following chapter is platform-dependent and does NOT apply to OS/390 Component Broker.

The Component Broker Notification Service is based on the Component Broker event service implementation with additional capabilties like Filtering and Quality of Services. Therefore, most of the following information is similar to the Chapter 2, Event Service chapter.

A Notification Service allows objects to dynamically register or unregister their interest in specific events. An event is an occurrence within an object that is specified to be of interest to one or more objects. The Notification Service creates a loosely joined communication channel between objects that are unfamiliar with each other.

The purpose of a Notification Service is to enable objects to freely register or unregister their interest in certain events. A Notification Service decouples communication between objects by defining two roles for objects: supplier objects and consumer objects. Suppliers produce events, while consumers process events.

Events are communicated among suppliers and consumers using standard CORBA requests. A Notification Service contains event channels that act as supplier and consumer objects. These event channels allow multiple suppliers to communicate with multiple consumers asynchronously and without knowing about each other.

In this document, the event channel and the notification channel both imply the Notification Service event channel.

Communicating Asynchronous Events

The Component Broker Notification Service enables you to exchange asynchronous event messages between different objects in the distributed system. This is useful for communicating about events that occur in one part of your application that another part of application needs to know about. The asynchronous and loosely coupled nature of the event service allows the same event to be communicated to many different parts of your application that may be interested in the same thing; neither part of your application needs to know directly of the other parts.

The Notification Service introduces several key concepts:

Structured Events

A structured event is a well-defined data structure into which a wide variety of event types can be mapped. An event is a specific instance of an event message about a particular event. For instance, an event message may be generated to report that an Insurance Agent has closed a contract for an insurance policy. This event may be monitored by one program that maintains statistics on the number of contracts that are closed on average per hour, and by another program that logs all of the activities of each agent.

Event messages are discrete, relating only to one event. However, events can be replicated to report the same event information to multiple consumers of that event.

The Notification Service implemented uses only the structured events for communication.

Event topics
An event topic defines a specific event type, or a family of related event types. For instance, the events that report when agents have closed their contracts are all of the same type, even though there may be many instances of this, one for each time an agent closes a contract.

Event suppliers
An event supplier is an object that generates event messages: it is a supplier of events, or more literally, the messages that report on that event.

Event consumers
An event consumer is an object that receives event messages, making it a consumer of events.

Filters
A Filter is an object that is used by the consumers to receive only the events that they are interested in and not all the events that are being supplied.

Event channels
An event channel is a broker of event messages. Notification suppliers provide their events to an event channel, and event consumers obtain those events from the same event channel. The event channel is responsible for ensuring that all events that it receives are provided to all of its connected consumers. It is also responsible for mediating between the push and pull communication models.

Each event channel is actually composed of the following seven types of objects: *EventChannel*, which anchors the set of other related event channel objects; *SupplierAdmin* and *ConsumerAdmin* which are administrative objects for mediating event connections; and *StructuredProxyPushConsumer*, *StructuredProxyPullConsumer*, *StructuredProxyPushSupplier*, and *StructuredProxyPullSupplier* objects which serve to represent a specific connection between individual suppliers and consumers of the event channel.

Communication models
The Component Broker Notification Service supports both a push model of communication as well as a pull model of communication. The push model allows an event supplier to push its events to the event channel. The pull model allows an event channel to pull events from its event suppliers. Likewise, the push model allows an event channel to push events on its event consumers. And the pull model allows an event consumer to pull events from its event channel. An event channel can simultaneously support all communication models between all of its suppliers and consumers.

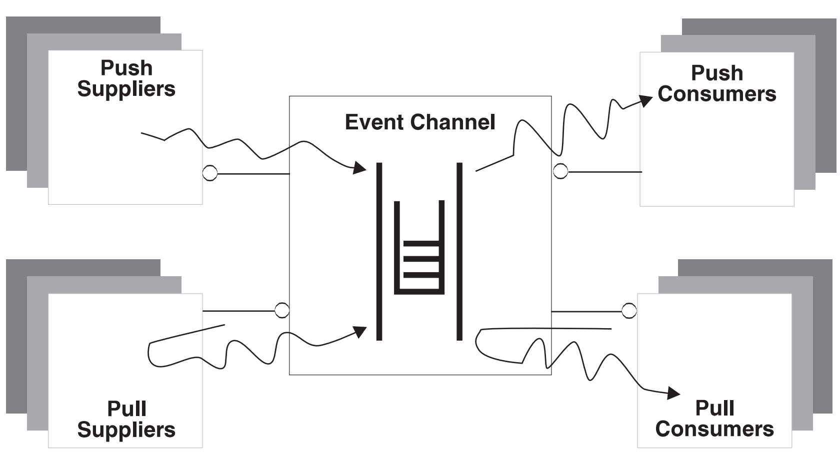


Figure 2. Notification Service Relationship Model

Push suppliers use an event channel to push their event messages. Event channels use pull suppliers to pull their event messages. Event channels queue up all the events they receive from all of their suppliers. Event channels use consumers to push all of the events queued up in the channel. Pull consumers use event channels to pull all of the events queued up in the channel.

Communication Models

The event service can be used with either a push model or a pull model of interaction. Event suppliers can either push or pull events with the event channel. Likewise consumers can either push or pull events with the event channel.

A push supplier, having connected with the event channel, can push an event message on the event channel whenever the event occurs, or whenever it is appropriate for the supplier to present the event message to the event channel after the occurrence of the event. The push supplier can push its event(s) using the CosNotifyComm::StructuredPushConsumer::push_structured_event() method supported by the StructuredProxyPushConsumer that it obtained from the SupplierAdmin during the event channel connection process.

A pull supplier, having connected with the event channel, will have events pulled from it periodically. The event channel does this by invoking a pull operation on the pull supplier. The pull supplier must support the CosNotifyComm::StructuredPullSupplier interface, and in particular implement the pull_structured_event and try_pull_structured_event operations. The pull_structured_event() operation should be implemented to block and return an event message when the event has occurred. The try_pull_structured_event() operation should never block, but rather should return an event message and a boolean return value of TRUE if an event has occurred, and to return a null message and a boolean return value of FALSE if not.

The event channel will perform its pull operations on a separate thread for each pull supplier. Nonetheless, the pull supplier should be implemented to return from the pull operation as quickly as possible (after an event is available) to avoid consuming resources in the event channel that could eventually affect its throughput.

Even though the event channel in Component Broker only uses the pull operation, both operations should be implemented as other event channel implementations may invoke either. These methods should be implemented to work together so either method can be used interchangeably and yet only produce one event message for an event occurrence.

A push consumer, having connected with the event channel, will have events pushed on it whenever the event message is supplied to the event channel. When an event message is supplied to the event channel, the event channel iterates through its full list of connected push consumers and pushes the same event on each of those consumers.

The push consumer must support the CosNotifyComm::StructuredPushConsumer interface, and in particular implement the push_structured_event operation. It is up to the push consumer to decide what to do with the event when it arrives. Often, consumers are implemented to spawn a separate thread of their own to process the event. Each push occurs on a separate thread to isolate the effect that different consumers can have on each other. Nonetheless, push consumers should return from the push operation as quickly as possible to avoid consuming resources in the event channel that could eventually effect its throughput.

A pull consumer, having connected with the event channel, can pull or try_pull an event from the event channel whenever it is ready to receive the next event message. The pull operation is a blocking request and will only return when the event channel has another event message to supply to the pull consumer.

The try_pull operation is not blocking and will return an event-message if one is available, or simply return FALSE if not. The pull consumer can pull its event(s) using the CosNotifyComm::StructuredPullSupplier::pull_structured_event or CosNotifyComm::StructuredPullSupplier::try_pull_structured_event methods supported by the StructuredProxyPullSupplier obtained from the ConsumerAdmin object during the event channel connection process.

Since the CosNotifyComm::StructuredPullSupplier::pull_structured_event() operation is intended to be a blocking method, and since some events may take a long time to actually occur, it is possible that the communication network will fail or time-out before the supplier has the chance to return from the pull. This can be a significant problem for some applications. If the pull request times out, the consumer will be notified through an exception that it can respond to, usually by simply re-invoking the pull request, and perhaps re-connecting to the event channel if necessary. On the other hand, the supplier is not necessarily informed of the error. Typically the supplier is programmed to present an event on return from the pull method. However, if the connection from the consumer has timed out, then the return will occur without actually supplying anything to the consumer, and the event will be lost.

You can reduce the chances of this happening by setting the ORB time-out value for the communication session between the consumer and supplier to zero (no time-out). However, this does not guard against other potential communication errors that could have the same effect. Thus, you should avoid the pull consumer model if it is important to avoid lost event messages.

Structured Events

A structured event is an event that is encapsualted into a well-defined data structure. An event is a specific instance of an event message about a particular event. When an instance of an event occurs, an event supplier can produce an event message representing the occurrence of that event. The event message can contain as much or as little information about that occurrence as is relevant to your application.

The Notification Service defines an event message as a structured event. Each structured event is comprised of two main components: a header and a body. The header part mainly consists information about the name of the event, the type of the event and the various (optional) Quality of Services (QoS) that are applicable to the event message. The body consists of the actual contents of the event instance upon which the consumer is most likely to base filtering decisions.

The suppliers and the consumers in the Notification Service are defined such that the structured events can be transmitted directly, without any repackaging needed.

The structure of the event message can be as elaborate or as simple as is appropriate for your application's needs provided it follows the format for the structured event. At one extreme, the event message can be a simple integer containing an event identifier, a value that can be used to uniquely identify the occurrence of the event with no QoS related information. At this extreme, the event message does not convey anything more about the event instance except that it occurred and a handle that uniquely identifies that occurrence. Event consumers might be able to use this event identifier later to correlate back to a separate repository containing more information about the event.

At the other extreme, the event message may contain a number of QoS properties like the priority of the event, the time when the channel should discard the event, and so on.

The following IDL represents an example of a more sophisticated event message structure:

```
typedef CosTrading::PropertySeq FilterableEventBody;
typedef struct Event_s {

   // Part 1: Header
        // Fixed Header
   string                          domain_type;
   string                          event_type;
   string                          event_name;
        // Variable Header
   short                           Priority;
   TimeBase::UtcT                  StopTime;
   TimeBase::UtcT                  Timeout;

   // Part 2: Filterable Event Data

   FilterableEventBody             filterable_data;

   // Part 3: Un-filterable Event Data

   any                             unfilterable_data;
}
StructuredEvent;
};
```

This event structure has provisions in it for defining the type and name of the event instance; a set up quality-of-service controls: Priority, StopTime and Timeout. In addition, this event structure can include event data (in the filterable_data field) that can be used to filter the event message.

This type of structure might be useful in situations where event processing is central to the overall architecture of your application structure and processes, where not only being able to distinguish essential information about the event occurrence itself is important, but also where being able to monitor the handling of the event message is important, and where having sufficient robustness to ensure the longevity of the event handling even in the presence of further evolutions in your application is important too. However, this structure may be overly complicated for other application situations.

In this implementation three types of QoS properties are supported. They are Priority, StopTime and Timeout.

Priority indicates the relative priority of the event compared to other events in the channel in terms of delivery. According to the OMG Notification Service specification it should take a value between -32,767 and 32,767 with -32,767 being the lowest priority, 32,767 being the highest, and 0 being the default. Internally, in our implementation we treat all the priorities less than 1 (that is, 0 to -32,767) to be 1, priorities greater than 9 (10 to 32,767) to be 10. All other priorities (1 to 9) have their original priority numbers assigned.

StopTime is an absolute time (for example, 12/12/99 at 23:59) when the channel should discard the event.

Timeout is a relative time (for example, 10 minutes from time received) when the channel should discard the event.

One can set the QoS at the following levels of scope: notification channel, admin objects, individual proxy objects and the event itself. Accessor operations (set_qos and get_qos) are available at each of these levels (except for the event where the QoS is set explicitly in its message as shown in the Structured Event example above) to set and get the various QoS properties. These levels of scope form a simple hierarchy, reflecting the ability to override QoS at various levels. The QoS properties set at the event level take higher precedence, followed by the QoS properties set at the individual proxy levels, followed by the

QoS properties set at the admin objects level, followed by the QoS properties set at the notification channel level.

The samples provided at the end of this document illustrates a Structured Event (define_event() method) and the use of the QoS settings on a per-event basis in the header field of this event.

This event structure has provisions in it for defining the type and name of the event instance; a set up quality-of-service controls, including priority. In addition, this event structure can include event data that can be used to filter the event message.

This type of structure might be useful in situations where event processing is central to the overall architecture of your application structure and processes, where not only being able to distinguish essential information about the event occurrence itself is important, but also where being able to monitor the handling of the event message is important, and where having sufficient robustness to ensure the longevity of the event handling even in the presence of further evolutions in your application is important too. However, this structure may be overly complicated for other application situations.

The define_event() method in the sample at the end of this document provides an example of a structured event.

When designing the contents for your event messages you should consider the following:

- How much information do your event consumers need to know about the event instance, and what information will they use in the handling of that event?
- Are you likely to introduce other event consumers in the future? What information will they likely need?
- How will you evolve the schema for the event message without affecting backwards compatibility of existing event consumers and suppliers? Are you willing to modify your event suppliers and consumers whenever you change the event schema?
- How often are these events likely to occur? Will they happen so frequently that having too much information in them will likely affect system throughput?
- How often will consumers need all of the information you supply in the event? Would it be better to supply only a little information in the event message, including correlation information that can be used later to obtain the rest of the detailed information from a separate repository if and when it is actually needed?
- How do you want to group event types in an event topic, and what is the relationship of those event topics to event channels? Different event channels can be used for different event topics. Likewise, different event topics can be used to group one or more event types. All of these can be used to separate different event types, thus reducing the amount of information that you have to include in the event message itself.
- How much extra event handling information do you need? Do you need, for instance, to track how long, on average, it takes to process an event message from the time that it is produced to the time that it is consumed? Is there a maximum lifetime for the event handling, a point beyond which if the event is not handled it is no longer relevant and should be discarded? Do you need to prioritize the event? Do you want to correlate related events?
- Which data is filterable and which is not?

Event Topics

The idea of an event topic is an abstract concept introduced by Component Broker to help you consider the relationship between event instances, event types, and event channels. Within the running system there may be many occurrences of many different types of events. Likewise, you can introduce as many different event channels as you like. Designing an effective event schema requires achieving the right balance between system performance, integrity, and programming and administrative simplicity.

Single Event Channel Schemas

If you use only one event channel for all events supplied and consumed in your application, then administration will be fairly straight-forward: you need to define one event channel and share that same event channel with all of your suppliers and consumers. However, using a single event channel raises the following concerns:

- The event channel can become a single point of failure. Because you are only dealing with one event channel, if that event channel should fail then all of your suppliers and consumers are affected.
- Event suppliers must be able to identify the type and instance of event message they are producing.
- Event consumers need to identify the type (or types) and instance (or instances) of the event message they are interested in processing, filtering out all those in which they are not interested, and sorting through the various types and instances in which they are interested, if there is more than one type.

Multiple Event Channel Schemas

Another strategy is to have a different event channel for every type of event message, and possibly a different event channel for each set of event messages coming from different groups of either or both suppliers and consumers. This has the obvious consequence of proliferating event channels, and in the latter case significantly increasing administrative complexity for associating groups of either or both event suppliers and consumers to determine which ones should be attached to which event channel instance. By extension, event suppliers and consumers may have to connect to numerous event channels for all of the types of events they handle.

In many cases, you will find there are a set of event types that are highly related. For instance, you may have a different event type for each of the steps an insurance agent performs. Each of these event types may be related by virtue that they all pertain to the steps an agent performs. This grouping may be relevant, for instance, if you have an event consumer that tracks all of an agent's actions, as a sort of audit trail to ensure they've followed all of the right procedures or to monitor their productivity.

You can group these related event types into an event topic. This is an artificial grouping, not supported in any formal sense by the event service, that you can use at your discretion and for your convenience. Having identified one or more event topics, you can determine how many event channels you will need. A common practice is to define a distinct event channel for each event topic. Each topic is given a label and each event channel is registered in the system name space with this topic name. Thus a supplier can connect to a particular event channel based on the topic (or topics) for which it supplies events. Similarly, a consumer can connect to a particular event channel based on the topic (or topics) the consumer handles. Thus, if an event channel fails, only suppliers and consumers of that topic are affected. Likewise, suppliers and consumers can concentrate on the topics that they are programmed to handle and in doing so avoid the system overhead associated with dealing with events not relevant to them.

Event Suppliers

An event supplier is an object that supplies event messages to an event channel. An event supplier can use either the push or pull model of interaction with the event channel. The same object can be a supplier to more than one event channel concurrently, however if the supplier uses the pull model there is no way for it to distinguish which event channel is pulling an event. Push model event suppliers must support the CosNotifyComm::StructuredPushSupplier interface. Pull model event suppliers must support the CosNotifyComm::StructuredPullSupplier interface. It is up to you to provide an implementation for the appropriate interface if you are introducing an event supplier.

Event suppliers must create a connection to their event channel before they can begin to supply events. To do this, they must first obtain the appropriate event channel. In most cases, event channels are registered in the system name space when they are created, and therefore obtaining an event channel is a matter of resolving its appropriate name in the system name space. As discussed in "Event Topics" on page 45, a common strategy is to register event channels with the name of the event topic they broker. Thus you can use the event topic name to resolve the appropriate event channel. Having located an event channel, the supplier must then connect to it. At this point, the supplier can supply any number of event messages, until the connection is terminated.

Push-model event suppliers can supply events using the CosNotifyComm::StructuredPushConsumer::push_structured_event() operation on their event channel. Pull-model event suppliers can supply events when they are invoked with either the CosNotifyComm::StructuredPullSupplier::pull_structured_event() or CosNotifyComm::StructuredPullSupplier::try_pull_structured_event() operation. The connection with the event channel can be terminated by either the supplier or by the event channel. If the supplier is using the push-model it can disconnect by invoking the CosNotifyComm::StructuredPushConsumer::disconnect_structured_push_consumer() operation on the event channel, and the event channel can disconnect the supplier by invoking the CosNotifyComm::StructuredPushSupplier::disconnect_structured_push_supplier() operation on the supplier. If the supplier is using the pull-model it can disconnect by invoking the CosNotifyComm::StructuredPullConsumer::disconnect_structured_pull_consumer() operation on the event channel, and the event channel can disconnect the supplier by invoking the CosNotifyComm::StructuredPullSupplier::disconnect_structured_pull_supplier() operation on the supplier.

As event channel connections are not retained persistently, if the event channel fails, the connection will have to be reestablished. In the case of an event channel failure, push model event suppliers will be notified in an exception on their next CosNotifyComm::StructuredPushConsumer::push_structured_event() request. Event suppliers should catch the CosEventComm::Disconnected exception. This is an indication that the event channel has failed. At that point, the supplier should re-connect before re-pushing the event.

Pull model event suppliers are never notified if an event channel fails. Instead, pull model event suppliers will simply stop being invoked for any further events. If this is an issue for the supplier, it can periodically attempt to reconnect with the event channel. If the event channel has not failed then the reconnect attempt will simply raise the CosEventChannelAdmin::AlreadyConnected exception with no other consequences.

Event suppliers can reside in pure clients. However, since pure clients can not export object references, event suppliers in pure clients are constrained to only use the push model of interaction. Further, pure client event suppliers will not be notified if the event channel disconnects. If the event channel disconnects, the event supplier is left to detect the loss of connection with the CosEventComm::Disconnected exception raised on their next push request.

Supplying Events

Supplying events requires you to first locate and connect to an event channel that is intended to handle your event topic. The event service supports two models of interaction between event suppliers and event channels: the push model and the pull model. If your event supplier will reside in a pure client, you must use the push model.

Supply events using the following steps:

1. Locate an event channel. You will need an event channel with which to connect. The easiest approach is to simply obtain an already existing event channel that has been registered in the system name space. In addition, you can create a new event channel, or use the Component Broker system management facilities to configure a new event.
2. Connect to the event channel. Follow the procedure described in “Connecting to an Event Channel” on page 57 to connect with the event channel.
3. Supply the event. As a push-model event supplier, you can use the CosNotifyComm::StructuredPushConsumer::push_structured_event() method to push your event on the event channel. As a pull-model event supplier, you must implement the CosNotifyComm::StructuredPullSupplier::pull_structured_event() and CosNotifyComm::StructuredPullSupplier::try_pull_structured_event() methods. The pull method should block until ready to return an event. The try_pull method should always return immediately; returning a boolean value of TRUE and the event message if one is ready, or returning a boolean value of FALSE and a null event message if not.

The following example demonstrates how to connect as a push supplier to the AgentActions event channel created in “Creating an Event Channel” on page 54 and supply methods using the push method. This example assumes that you are your own push-supplier object and that you are operating in a server process.

```
// Declare an intermediate Object, the AgentActions event channel,
//   a supplier admin object and a push consumer proxy.

CORBA::Object_var intermediateObject;
CosNotifyChannelAdmin::EventChannel_var agentActionsEC;
CosNotifyChannelAdmin::SupplierAdmin_var agentActionsSA;
CosNotifyChannelAdmin::StructuredProxyPushConsumer_var agentActionsSPPC;

// Declare the ID that the StructuredProxyPushConsumer object is assigned
//   when it is created.
CosNotifyChannelAdmin::ProxyID SPPCid;

// Define an event of type Structured Event that needs to be pushed.
CosNotification::StructuredEvent structuredEvent_var = new CosNotification::StructuredEvent;

// Locate the AgentActions event channel, obtain the supplier admin,
//   and obtain a structured push consumer proxy.

intermediateObject = CBSeriesGlobal::nameService()
  ->resolve_with_string(
  "/host/resources/notify-channels/AgentActions");
agentActionsEC=
  INotifyChannelAdminManagedClient::EventChannelFactory::_narrow(intermediateObject);
agentActionsSA = CosNotifyChannelAdmin::SupplierAdmin::_narrow(agentActionsEC->default_supplier_admin());
agentActionsPPC = CosNotifyChannelAdmin::StructuredProxyPushConsumer::_narrow(
                        agentActionSA->obtain_notification_push_consumer(
                            CosNotifyChannelAdmin::STRUCTURED_EVENT, SPPCid));

// Connect to the event channel proxy.

agentActionsPPC->connect_structured_push_supplier(this);

// Do some activity for the Insurance agent

  ...

// Supply an event indicating the completion of that action.
           // Fill in the fields of the structured event (structuredEvent)
           // Shown in the sample program at the end of the document.

          ...

           // Push the event
          agentActionsPPC->push_structured_event(structuredEvent);
```

Event Consumers

An event consumer is an object that consumes event messages from an event channel. An event consumer can use either the push or pull model of interaction with the event channel. The same object can be a consumer of more than one event channel concurrently, however, and if the consumer uses the push model there is no way for it to distinguish which event channel is pushing an event. Push model event consumers must support the CosNotifyComm::StructuredPushConsumer interface. Pull model event consumers must support the CosNotifyComm::StructuredPullConsumer interface. It is up to you to provide an implementation for the appropriate interface if you are introducing an event consumer.

Event consumers must first create a connection to their event channel before they can begin to consume events. To do this, they must first obtain the appropriate event channel. In most cases, event channels are registered in the system name space when they are created, and obtaining an event channel is simply a matter of resolving its appropriate name in the system name space. As discussed in “Event Topics” on page 45, a common strategy is to register event channels with the name of the event topic they broker. Thus you can use the event topic name to resolve the appropriate event channel.

Having located an event channel, the consumer must then connect to it. If the consumer is interested in filtering events then it should also create a filter object and use it to connect to the supplier proxies so that only the events that match the constraints specified in the filter objects are deliverd to it. At this point, the consumer can consume any number of event messages, until the connection is terminated. Push model event consumers can consume events when they are invoked with the CosNotifyComm::StructuredPushConsumer::push_structured_event() operation. Pull model event consumers can consume events using either the CosNotifyComm::StructuredPullSupplier::pull_structured_event() or CosNotifyComm::StructuredPullSupplier::try_pull_structured_event() operation on their event channel.

The connection with the event channel can be terminated by either the consumer or by the event channel. If the consumer is using the push model, it can disconnect by invoking the CosNotifyComm::StructuredPushSupplier::disconnect_structured_push_supplier() operation on the event channel, and the event channel can disconnect the consumer by invoking the CosNotifyComm::StructuredPushConsumer::disconnect_structured_push_consumer() operation on the consumer. If the consumer is using the pull model it can disconnect by invoking the CosNotifyComm::StructuredPullSupplier::disconnect_structured_pull_supplier() operation on the event channel, and the event channel can disconnect the supplier by invoking the CosNotifyComm::StructuredPullConsumer::disconnect_structured_pull_consumer() operation on the consumer.

As event channel connections are not retained persistently, if the event channel fails, the connection will have to be reestablished. If the event channel fails, pull model event consumer will be notified in an exception on their next CosNotifyComm::StructuredPullSupplier::pull_structured_event() or CosNotifyComm::StructuredPullSupplier::try_pull_structured_event() request. Event consumers should catch the CosEventComm::Disconnected exception. This is an indication that the event channel has failed. At that point, the consumer should reconnect before re-pulling the event.

Push model event consumers are never notified if an event channel fails. Instead, they will simply stop receiving any further events. If this is an issue for the consumer, it can periodically attempt to reconnect with the event channel. If the event channel has not failed then the reconnect attempt will simply raise the CosEventChannelAdmin::AlreadyConnected exception with no other consequences.

Event consumers can reside in pure clients. However, since pure clients cannot export object references, then event consumer in pure clients are constrained to only use the pull model of interaction. Further, pure client event consumers will not be notified if the event channel decides to disconnect. The event consumer is left to detect the loss of connection with the CosEventComm::Disconnected exception raised on their next pull or try_pull request.

Consuming Events

This procedure demonstrates how to consume an event from an event channel. To consume an event, you have to first locate and connect to an event channel that is intended to handle your event topic. The event service supports the push and pull models of interaction between event consumers and event channels. If your event consumer will reside in a pure client, you must use the pull model.

Consume an event from the event channel using the following steps:

1. Locate an event channel. You will need an event channel to connect with. The easiest approach is to simply obtain an already existing event channel that has been registered in the system name space. In addition, you can create a new event channel, or use the Component Broker system management facilities to configure a new event.
2. If the consumer is interested in filtering events then it should create a filter object, add its required constraints to the filter object and use it to connect to the event channel.
3. Connect to the event channel. Follow the procedure described in "Connecting to an Event Channel" on page 57 to connect with the event channel.
4. Consume the event. As a pull model consumer, you can use the CosNotifyComm::StructuredPullSupplier::pull_structured_event() or CosNotifyComm::StructuredPullSupplier::try_pull_structured_event() method to consume an event. If you use the pull method, your request will block until an event is ready to be returned. If you use the try_pull method, your request will always return immediately, and will indicate in a boolean return value whether an event was available to return. As a push model consumer, you must implement the CosNotifyComm::StructuredPushConsumer::push_structured_event() method. This method will be invoked whenever an event is available for you to consume.

The following example demonstrates how to connect as a pull consumer to the AgentActions event channel created in "Creating an Event Channel" on page 54 and consume events using the pull method. This example assumes you are your own pull-consumer object, and that you are operating in a server process.

```
// Declare an intermediate Object, the AgentActions event channel,
//   a consumer admin object and a pull supplier proxy.

CORBA::Object_var intermediateObject;
CosNotifyChannelAdmin::EventChannel_var agentActionsEC;
CosNotifyChannelAdmin::ConsumerAdmin_var agentActionsCA;
CosNotifyChannelAdmin::StructuredProxyPullSuplier_var agentActionsPPS;

// Declare the ID that the StructuredProxyPullSupplier object is assigned
//   when it is created.
CosNotifyChannelAdmin::ProxyID SPPSid;

// Declare an event of type Structured Event that needs to be pulled.
CosNotification::StructuredEvent structuredEvent_var;


// Locate the AgentActions event channel, obtain the consumer admin,
//   and obtain a pull supplier proxy.

intermediateObject = CBSeriesGlobal::nameService()
  ->resolve_with_string(
  "/host/resources/notify-channels/AgentActions");
agentActionsEC=
  INotifyChannelAdminManagedClient::EventChannelFactory::_narrow(intermediateObject);
agentActionsCA = CosNotifyChannelAdmin::SupplierAdmin::_narrow(agentActionsEC->default_consumer_admin());
agentActionsPPS = CosNotifyChannelAdmin::StructuredProxyPullSupplier::_narrow(
                        agentActionCA->obtain_notification_pull_supplier(
                            CosNotifyChannelAdmin::STRUCTURED_EVENT, SPPSid));

// Optional: create Filter object, define constraints in the Filter object,
//           add the filter object to the structuredproxyPullSupplier.
// Shown in the sample program at the end of the document.
   .....


// Connect to the event channel proxy.

agentActionsPPS->connect_structured_pull_consumer(this);

// Consume an event.
// Pull the event

structuredEvent = agentActionsPPS->pull_structured_event();

// Handle the fields of the structuredEvent
  ...
```

Event Channels

Event channels have two forms. In their abstract form, an event channel is a broker of event messages, consuming them from their connected suppliers, and supplying them to their connected consumers. In their concrete form, an event channel is composed of the following object types:

CosNotifyChannelAdmin::EventChannel
This is the anchor point for the other event channel objects. EventChannel objects define the abstract event channel, and are the objects registered in the system name space that enable you to find an event channel.

CosNotifyChannelAdmin::SupplierAdmin
SupplierAdmin objects broker connections between suppliers and the event channel. An event channel can have more than one SupplierAdmin.

CosNotifyChannelAdmin::ConsumerAdmin
ConsumerAdmin objects broker connections between consumers and the event channel. An event channel can have more than one ConsumerAdmin.

CosNotifyChannelAdmin::StructuredProxyPushConsumer
StructuredProxyPushConsumer objects define a specific connection between a structured supplier and the event channel. An instance of a StructuredProxyPushConsumer is created for each structured supplier that connects to the event channel using the push-model of interaction.

CosNotifyChannelAdmin::StructuredProxyPullConsumer
StructuredProxyPullConsumer objects define a specific connection between a structured supplier and the event channel. An instance of a StructuredProxyPullConsumer is created for each structured supplier that connects to the event channel using the pull-model of interaction.

CosNotifyChannelAdmin::StructuredProxyPushSupplier
StructuredProxyPushSupplier objects define a specific connection between a structured consumer and the event channel. An instance of a StructuredProxyPushSupplier is created for each structured consumer that connects to the event channel using the push model of interaction.

CosNotifyChannelAdmin::StructuredProxyPullSupplier
StructuredProxyPullSupplier objects define a specific connection between a structured consumer and the event channel. An instance of a StructuredProxyPullSupplier is created for each structured consumer that connects to the event channel using the pull model of interaction.

Event channels can support multiple simultaneous connections of suppliers and consumers using any mixture of push model or pull model interactions. In Component Broker, event channels are managed objects with persistent references. Thus they must reside in a Component Broker server process, and can be registered in the system name space. All suppliers and consumers that resolve to the same event channel reference will get to the same instance of event channel. Event channels are automatically reactivated in the Component Broker server when they are first referenced.

As brokers of event messages, event channels are in fact both event consumers and event suppliers (consumers to their connected event suppliers, and suppliers to their connected event consumers), proxies are used to mediate between consumers and suppliers, and between push and pull models of interaction.

The transmission of events from the event channel to the consumers depend on the filter objects that are attached by the consumers to supplier proxies. Only the events that satisfy the constraints or conditions in the filter object will be transmitted to that consumer (which attached the filter object). If a consumer does not attach a filter object to the supplier proxy or if the filter object attached does not contain any constraints then all the events received by the event channel will be transmitted to that consumer. Also, the delivery of the event also depends on the quality of services (QoS) attached to the message and/or to the proxy. For example, if StopTime is set in the QoS then the event channel will discard the event if it has not been delivered before the StopTime.

Also, in Component Broker, event channels are transient. They do not retain either supplier or consumer connections persistently, nor do they retain event messages persistently. Connections and pending event messages will be lost whenever the event channel is passivated or terminated.

Component Broker automatically creates a single default event channel that is registered in the system name space in:/.:/resources/notify-channels/cell-default. This event channel can be used for any purpose, but to allow for proper interoperation between all of the applications that could end up using it, all event messages using the event channel in a production environment must follow the following structure:

```
module DefaultEventStructure {
   typedef struct Event_s {

      // Part 1: Header

      const unsigned short       version=1;

      // structure version

      string                     domain_type;;
      string                     event_type;
      string                     event_name;
      CosTrading::PropertySeq    quality_of_services;
      CosTrading::PropertySeq    filterable_data;

      // Part 2: Un-filterable Event Data

      any                        unfilterable_data;
   } StructuredEvent;
};
```

If you need an event channel within your application, you should introduce your own event channel for your own purposes. See “Event Topics” on page 45 for more information that may be useful in deciding how to divide up your event system topology. Having done so, you should design an appropriate structure for your event messages, as discussed in “Structured Events” on page 42. You can create a new event channel programmatically using the standard Component Broker programming model for managed objects, as described in “Creating an Event Channel” on page 54.

Having created the event channel you should be sure to register it in the system name space so that your suppliers and consumers can find it at run-time. This will be done for you automatically if you use the INotifyChannelAdminManagedClient::EventChannelFactory::createVisibleEventChannel() operation. Otherwise, you can use the INotifyChannelAdminManagedClient::EventChannelFactory::createEventChannel() operation and manually bind the event channel in the system name space.

You can also use the Component Broker system management facility to configure a new event channel. This is described in more detail in “Configuring an Event Channel” on page 56. This process automatically registers the event channel in the system name space so that your suppliers and consumers can find it at run time. The Component Broker system name space includes naming contexts where you can register event channels by name at the following locations:

- /host/resources/notify-channels/workgroup/resources/notify-channels
- /.:/resources/notify-channels

Alternately, you can register your event channels in your own application name tree.

Locating an Event Channel

This procedure demonstrates how you can locate an event channel by name in the system name space. This is useful to both event suppliers and event consumers who are finding an event channel they can use to exchange event messages.

You can locate an event channel in the fashion demonstrated here only if the event channel already exists and has been bound in the system name space. You must know the name of the event channel to use this procedure.

Use the following steps to locate an event channel:

1. Determine the name of the event channel you want to use. This may be the name of the default event channel automatically created and registered in the system name space by Component Broker installation. Or it could be an event channel that your application created and bound in the system name space earlier.
2. Resolve the event channel from the system name space. Use the naming service operations to resolve the event channel from the system name space by the name that you determined in the previous step.

The default event channel is created automatically during Component Broker installation. The following example shows how to obtain the default event channel:

```
// Declare the targeted event channel

CORBA::Object_var intermediateObject;
CosNotifyChannelAdmin::EventChannel_var defaultEC;

// Obtain the default event channel and narrow it to an event
// channel


intermediateObject=CBSeriesGlobal::nameService()
   ->resolve_with_string(
   " /.:/resources/notify-channels/cell-default");
defaultEC=
  CosNotifyChannelAdmin::EventChannel::_narrow(intermediateObject);
```

Creating an Event Channel

An event channel is created essentially in the same way that any other managed object is created, that is, by first obtaining a factory finder with a desired location scope. By extension, such a factory finder must exist. Component Broker provides a set of default factory-finders that it creates and registers in the system name space during Component Broker installation. These are found in the following locations:

- /host/resources/factory-finders/host-scope
- /workgroup/resources/factory-finders/workgroup-scope
- /.:/resources/factory-finders/cell-scope

In addition, Component Broker automatically creates a home for event channels (called notify—channels in order to differentiate from the Event Service event-channels) in every server process. However, the least granularity of scoping that any of the default factory finders supports is a host scope. Therefore, if you want the event channel created in a more specific server you must create a new factory finder with a corresponding location scope that narrows to that server.

Create an event channel using the following steps:

1. Obtain a factory finder with the desired location scope. You will need a factory finder with which to create your new event channel. Alternately, you can create a non-managed factory finder to use for finding the new event channel's factory.
2. Use the factory finder to find a factory (a Home) for event channels. Having obtained a factory finder, you can now use it to find a factory for factory finders. You do this with the find_factory(), find_factories(), find_factory_from_string(), or find_factories_from_string() methods. The event channels interface is INotifyChannelAdminManagedClient::EventChannel.object. This is the principal interface name that you will pass in to the find_factory* or find_factories* methods.
3. Create the event channel. The factory specialization for event channels introduces the createEventChannel and createVisibleEventChannel methods which you can use to create the new event channel. You will have to narrow to the INotifyChannelAdminManagedClient::EventChannelFactory interface to use either of these new methods.
4. Register the event channel in the system name space. This step is optional. When you've created an event channel, often you will want to retain this object for future use in your application to be shared by event suppliers and consumers. How you do this in your application is up to you, but the typical approach is to bind the event channel in the system name space. Again, where you bind it in the system name space is up to you. One obvious and commonly used choice is to bind it in `/host/resources/notify-channels`, `/workgroup/resources/notify-channels`,or `/.:/resources/notify-channels` depending on what visibility you want to give it. Another choice is to bind it under your own application, contexts within `/host/applications`, `/workgroup/applications`, or `/.:/applications`. Typically event channels are bound with the event topic name for the types of events they're intended to broker.

   If you use the INotifyChannelAdminManagedClient::EventChannelFactory::createVisibleEventChannel method, you can specify the relative name (the event channel's topic name), and a boolean flag for the name spaces in which you want the event channel registered. The specialized home will automatically register the new event channel into the name space in the indicated locations.

The following example demonstrates creating a new event channel, and binding it in the system name space under `/host/resources/notify-channels` with the name AgentActions. The event channel is created within the local host.

```
// Declare an intermediate Object, the event-channels naming
// context, the targeted factory finder where the new event
// channel will be created,a event channel factory, and the
// new event channel.

CORBA::Object_var intermediateObject;
IExtendedNaming::NamingContext_var eventChannelsNC;
IExtendedLifeCycle::FactoryFinder_var hostScopeFF:
INotifyChannelAdminManagedClient::EventChannelFactory_var factoryOfEC;
CosNotifyChannelAdmin::EventChannel_var myNewEC;
ByteString_var key;

// Declare the ID for the event channel being created.
CosNotifyChannelAdmin::ChannelID cid;

// Obtain the default factory finder with a host-scope and
// narrow to an IExtendedLifeCycle::FactoryFinder so that we
// can use the find_factory_from_string operation.

CBSeriesGlobal::Initialize();
//Initialize the CBSeries environment
```

```
intermediateObject = CBSeriesGlobal::nameService()
  ->resolve_with_string(
  "/host/resources/factory-finders/host-scope");
hostScopeFF = IExtendedLifeCycle::FactoryFinder::_narrow(
  intermediateObject);

// Find a factory for event channels and narrow to the factory
// specialization

intermediateObject = hostScopeFF->find_factory_from_string(
  "INotifyChannelAdminManagedClient::EventChannel.object interface");
factoryofEC =
  INotifyChannelAdminManagedClient::EventChannelFactory::_narrow
  (intermediateObject);


// Create the required default quality of services (QoS)
// Shown in the sample program at the end of the document.
CosTrading::PropertySeq qos;
......

// Use the factory to create a new event channel.

myNewEC = factoryOfEC->createEventChannel(key, qos, NULL, cid);

// Bind the new event channel in the system name space.

intermediateObject = CBSeriesGlobal::nameService->resolve(
  "/host/resources/notify-channels");
eventChannelsNC =
  IExtendedNaming::NamingContext::_narrow(intermediateObject);
eventChannelsNC->bind_with_string("AgentActions", myNewEC);
```

The last four statements could have been combined into the following statement:

```
myNewEC = factoryOfEC->createVisibleEventChannel(key,
  "AgentActions", 0, 1, 0);
```

Configuring an Event Channel

This procedure demonstrates how to configure a new event channel using the Component Broker system management facility. This is useful for when you need an event to support a new event topic. This procedure is entirely administrative and does not involve any programming.

Configure a new event channel using the following steps:

1. Navigate to the desired server. The new event channel must be configured within a specific server. Use the system management user interface to navigate to the host and server on which you want the factory finder configured.
2. Create a event channel model. Insert an event channel model within the server.
3. Set event channel model attributes. Use the attributes notebook to fill in the event channel model attribute value. This will include the system management name for the event channel (do not confuse this with the name of the event channel in the system name space, although these can be set to the same value), the name of the event channel in the system name space, and the Home of the event channel.

4. Apply the model changes. Select the apply function for the server, host, or zone where you've created the event channel model. This results in a corresponding event channel object being automatically created in the targeted server and registered in the system name space.

Connecting to an Event Channel

This procedure demonstrates how to connect to an event channel. You need to connect to an event channel before you can supply or consume events. The event channel must have already been created and registered in a way that you can find it.

Connect to an event channel using the following steps:

1. Locate an event channel. You will need an event channel with which to connect. The easiest approach is to simply obtain an already existing event channel that has been registered in the system name space. Otherwise, you can create a new event channel, or use the Component Broker system management facilities to configure a new event.
2. Acquire an event channel administration object. Use the appropriate method from the following methods to get the required administrative object:
   - If you are an event supplier, use the default_supplier_admin() method or the new_for_suppliers() operation to get back a CosNotifyChannelAdmin::SupplierAdmin object.
   - If you are an event consumer, use the default_consumer_admin() method or the new_for_consumers() operation to get back a CosNotifyChannelAdmin::ConsumerAdmin object.
3. Acquire an event channel proxy object. Use the appropriate method from the following methods to get the required proxy object:
   - If you are a structured supplier using the push model, then use the obtain_notification_push_consumer() operation to get back a CosNotifyChannelAdmin::StructuredProxyPushConsumer object.
   - If you are a structured supplier using the pull model, then use the obtain_notification_pull_consumer() operation to get back a CosNotifyChannelAdmin::StructuredProxyPullConsumer object.
   - If you are a structured consumer using the push model, then use the obtain_notification_push_supplier() operation to get back a CosNotifyChannelAdmin::StructuredProxyPushSupplier object.
   - If you are a structured consumer using the pull model, then use the obtain_notification_pull_supplier() operation to get back a CosNotifyChannelAdmin::StructuredProxyPullSupplier object.
4. Connect with the proxy. Use the appropriate method from the following to connect with the proxies:
   - If you are a structured push supplier, then use the connect_structured_push_supplier() method on your StructuredProxyPushConsumer.
   - If you are a structured pull supplier, then use the connect_structured_pull_supplier() method on your StructuredProxyPullConsumer.
   - If you are a structured push consumer, then use the connect_structured_push_consumer() method on your StructuredProxyPushSupplier.
   - If you are a structured pull consumer, then use the connect_structured_pull_consumer() method on your StructuredProxyPullSupplier.

Normally, you have to supply a reference to yourself , namely your supplier or consumer object, on the connect request. This is used either to pull or push on you, as well as to inform you when the connection is being terminated. However, if you are connecting from a pure-client you are not able to use the connect_structured_pull_supplier() or connect_structured_push_consumer() methods. Also, you will have to supply a NULL object reference in either the connect_structured_push_supplier() or connect_structured_pull_consumer() request. This basically indicates to the event channel that you are operating from a pure-client and avoids the issuing of any disconnect requests.

The following example demonstrates how to connect as a push supplier to the AgentActions event channel that was created in "Creating an Event Channel" on page 54. This example assumes you are your own push-supplier object, and that you are operating in a server process.

```
// Declare an intermediate Object, the AgentActions event
// channel, a supplier admin object, a push consumer proxy.

CORBA::Object_var intermediateObject;
CosNotifyChannelAdmin::EventChannel_var agentActionsEC;
CosNotifyChannelAdmin::SupplierAdmin_var agentActionsSA;
CosNotifyChannelAdmin::StructuredProxyPushConsumer_var agentActionsSPPC;

// Declare the ID that the StructuredProxyPushConsumer object is assigned
// when it is created.
CosNotifyChannelAdmin::ProxyID SPPCid;

// Define an event of type Structured Event that needs to be pushed.
CosNotification::StructuredEvent structuredEvent_var =
  new CosNotification::StructuredEvent;


//Initialize the CBSeries environment
CBSeriesGlobal::Initialize();

// Locate the AgentActions event channel, obtain the supplier
// admin, and obtain a structured push consumer proxy.
intermediateObject = CBSeriesGlobal::nameService()
  ->resolve_with_string(
  "/host/resources/notify-channels/AgentActions");
agentActionsEC=
  INotifyChannelAdminManagedClient::EventChannelFactory::_narrow(intermediateObject);
agentActionsSA =
  CosNotifyChannelAdmin::SupplierAdmin::_narrow(agentActionsEC->default_supplier_admin());
agentActionsPPC = CosNotifyChannelAdmin::StructuredProxyPushConsumer::_narrow(
                      agentActionSA->obtain_notification_push_consumer(
                            CosNotifyChannelAdmin::STRUCTURED_EVENT, SPPCid));

// Connect to the event channel proxy.

agentActionsPPC->connect_structured_push_supplier(this);
```

Disconnecting from an Event Channel

Disconnecting from an event channel is useful for when you want to stop supplying or consuming events. It essentially un-registers your event supplier or event consumer with the event channel. After disconnecting, push model suppliers can no longer push, pull model suppliers will no longer be pulled, push model consumers will no longer be pushed, and pull model consumers can no longer pull.

If you are already connected to an Event Channel, use the appropriate method from the following methods to disconnect:

- As a structured push supplier, use the CosNotifyComm::StructuredPushConsumer::disconnect_structured_push_consumer() method on your structured push consumer proxy.
- As a structured pull supplier, use the CosNotifyComm::StructuredPullConsumer::disconnect_structured_pull_consumer() method on your structured pull consumer proxy.
- As a structured push consumer, use the CosNotifyComm::StructuredPushSupplier::disconnect_structured_push_supplier() method on your structured push supplier proxy.
- As a structured pull consumer, use the CosNotifyComm::StructuredPullSupplier::disconnect_structured_pull_supplier() method on your structured pull supplier proxy.

The following example demonstrates how to disconnect from the AgentActions event channel that was previously connected to in "Connecting to an Event Channel" on page 57. This example assumes that this is being done from a push supplier.

```
// Assuming we've already connected to the AgentActions event
// channel as push supplier
...
agentActionPPC->disconnnect_structured_push_consumer();
```

FilterFactory and Filters

The FilterFactory creates the filter objects. The Filter encapsulates the constraints which will be used by a proxy object associated with a notification channel in order to make decisions about which events to forward, and which to discard. Each object supporting the Filter interface can encapsulate a sequence of any number of constraints. Each event received by a proxy object which has one or more objects supporting the Filter interface associated with it must satisfy at least one of the constraints associated with one of its associated Filter objects in order to be forwarded (either to another proxy object or to the consumer, depending on the type of proxy the filter is associated with), otherwise it will be discarded.

Each constraint encapsulated by a filter object is a structure comprised of two main components. The first component is a sequence of data structures, each of which indicates an event type comprised of a domain and a type name. The second component is a boolean expression over the properties of an event, expressed in the constraint grammar.

For a given constraint, the sequence of event type structures in the first component nominates a set of event types to which the constraint expression in the second component applies. Each element of the sequence can contain strings which will be matched for equality against the domain_name and type_name fields of each event being evaluated by the filter object when determining if the boolean expression should be applied to the event, or the event should simply be discarded without even attempting to apply the boolean expression.

The constraint expressions associated with a particular object supporting the Filter are expressed as strings which obey the syntax of a particular constraint grammar (that is, a BNF). This implementation supports constraint expressions expressed in the constraint grammar shown in the "Appendix A. Default Filter Constraint Language" of the *Component Broker Programming Reference*.

The Filter interface supports the operations required to manage the constraints associated with an object instance which supports the interface, along with a readonly attribute which identifies the particular constraint grammar in which the constraints encapsulated by this object have meaning. In addition, the Filter supports the match_structured() operation which can be invoked by an associated proxy object upon receipt of an event to determine if the event should be forwarded or discarded, based on whether or not the event satisfies at least one criteria encapsulated by the filter object.

Create, define and attach a Filter to a proxy using the following steps:

1. 1. Obtain a Filter Factory. This is similar to the Event Channel Factory creation process as explained before. The following steps illustrate this process.

```
CosNotifyChannelAdmin::StructuredProxyPushSupplier_var pxyPushS;
   CORBA::Object_var intermediateObject;
   IExtendedLifeCycle::FactoryFinder_var hostScopeFF;
   INotifyFilterManagedClient::FilterFactory_var fFactory = NULL;
   CosNotifyFilter::Filter_var fi = NULL;
   CosNotifyFilter::ConstraintExpSeq *cl;
   CosNotifyFilter::ConstraintInfoSeq *cis;
   CosNotifyFilter::FilterID fid;
                    // initial ORB
   CBSeriesGlobal::Initialize();
                    // obtain the default factory finder with a host scope
    intermediateObject = CBSeriesGlobal::nameService()->resolve_with_string(
                                "host/resources/factory-finders/host-scope");
                    // narrow to a factory finder
   hostScopeFF = IExtendedLifeCycle::FactoryFinder::_narrow(
                                     sintermediateObject);
                    // find the filter factory
   intermediateObject = hostScopeFF->find_factory_from_string(
                          "INotifyFilterManagedClient::Filter.object interface");
                    // narrow to the filter factory
   fFactory = INotifyFilterManagedClient::FilterFactory::_narrow(
                                          intermediateObject);
```

2. 2. Create a Filter from the Filter Factory. The create_filter method is used to create a filter. The constraint grammar is passed as the input string parameter.

```
    fi = fFactory->create_filter("IBM_NTF_CTG");
```

3. 3. Define the contents (constraints) of the filter and add them to the filter. The add_constraints method is used to add the constraints to the filter. Events will be delivered to the consumers only when these constraints of the filter match with that of the event.

```
CosNotifyFilter::ConstraintExpSeq *cl = new CosNotifyFilter::ConstraintExpSeq;
(*cl).length(1);
(*cl)[0].constraint_expr = CORBA::string_alloc(100);
                              // define constraint
strcpy((*cl)[0].constraint_expr, "($COMPANY == IBM) and ($PRICE > 150)");
                              // add constraint to the filter
cis = fi->add_constraints(*cl);
```

4. 4. Add the filter to the proxy which is expected to deliver the events. The client after creating the filter with the necessary constraints should use the add_filter method of the appropriate proxy suppliers to attach the filter to the proxy. Once attached only the events whose filterable data matches the constraints in the filter will be delivered to the client by the proxy.

```
id = pxyPushS->add_filter(fi);
```

The Customer_Impl() method in the following sample illustrates the procedure for creating, defining and attaching a Filter to a proxy.

Managed Object-Based Sample

In this scenario a Push Supplier is created as a Component Broker server. The Push Supplier object is called Account. This object contains two attributes. One is the accountNumber to hold an account number. This will be the primary key. The other attribute in this Account object is called balance which holds the current content of this accountNumber in the bank. (We discuss only one account in this sample.) The Account object also has a method called changeBalance which when invoked will update the balance and push the new balance to the event channel (The default event channel is considered in this sample. For a user created event channel, see "User-Defined Event Channel" on page 74 for further information.) The changeBalance method will be invoked by a pure C++ client (called PushSupplier) which prompts the user with the amount to be added/subtracted from the balance.

On the consumer side, a Pull Consumer is implemented as a pure C++ client (called PullConsumer). This consumer creates a filter with the necessary requirements (in this case to notify it if the balance is less than $1,000) and pulls the events from the event channel using the try_pull method.

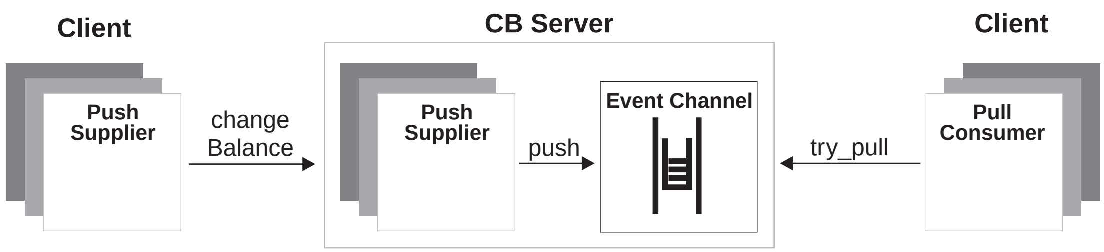


Figure 3. Notification Service Managed Object-Based Sample

We will go through the above process in three steps. In step one, we implement and build the server. In step two, we implement and build the PushSupplier and the PullConsumer clients. In step three, we deploy and run the sample.

The following instructions are for Windows NT and AIX. Some platform-specific notes are included.

Step 1: Implement the Application Server (Push Supplier Server object)

Implementing the server application consists of two major steps:

1. Specify all the interfaces and implementations of the Business Object and the Data Object, including the helper objects using the Component Broker Object Builder (OB).
2. Build the application by running the code emitter, compiler and linker.

Create the Model using the Object Builder (OB)

AIX The DLL files are called Shared Library files and are in the format lib*.so. For any reference to a DLL file, substitute shared library file.

Note: The following instructions assume that the Object Builder is up and running.

1. **Create a new file Account.**
   a. Select User-Defined Business Objects → Add File.
   b. Type `Account`.
   c. Click on the **Finish** button.
2. **Add a new interface to the file.**

a. Select Account → Add Interface.

b. Type `AccountInterface`.

c. Click on the **Next** button.

d. Add an exception, **NotEnough** using the Constructs page of the AccountInterface.

   1) On the Constructs page, select Constructs → Add Exception.

   2) Type `NotEnough`.

   3) Click on the **Refresh** button.

   4) Click on the **Next** button.

e. Add a second parent interface, CosNotifyComm::StructuredPushSupplier, using the Interface Inheritance page of the AccountInterface wizard.

   1) On the Interface Inheritance page, select Parents →Add.

   2) Type `CosNotifyComm CosNotifyComm::StructuredPushSupplier` for Parent Interface.

   3) Click on the **Refresh** button.

   4) Click on the **Finish** button.

3. **Add properties to the interface.**

   a. Select AccountInterface → Properties...

   b. Go to the Attributes page, select Attributes → Add.

      1) Add the attribute *accountNumber* using the following procedure:

         a) Type `accountNumber` in the Attribute Name field.

         b) Select string in the **Type** list.

         c) Type `10` in the **Size** field.

         d) Click on Add Another.

      2) Add the attribute *balance* using the following procedure:

         a) Type `balance` in the Attribute Name field.

         b) Select double in the **Type** list.

         c) Click on the **Refresh** button.

         d) Click on the **Next** button.

   c. Add the method changeBalance using the following procedure:

      1) On the Methods page, select Method → Add.

      2) Type `changeBalance` in the **Method Name** field.

         a) Select void in the **Return Type** list.

         b) Click on the **Refresh** button.

         c) Select Parameters →Add.

         d) Type `anAmount` in the **Parameter Name** field.

         e) Select double from the **Type** list.

         f) Click on the **Refresh** button.

         g) Select Exceptions → Add.

h) Select Account AccountInterface NotEnough for Exception Name.

i) Click on **Refresh** button.

j) Click on the **Finish** button.

4. **Create a Key helper using the** *accountNumber* **as the Primary Key.**

   a. Select AccountInterface → Add Key.

   b. Click on *accountNumber* on the left.

   c. Click on the **>>** button.

   d. Click on the **Finish** button.

5. **Create a Copy helper with the attribute of** *accountNumber***.**

   a. Select AccountInterface → Add Copy Helper.

   b. Select *accountNumber*.

   c. Click on the **>>** button.

   d. Click on the **Finish** button.

6. **Add Business Object implementation.**

   a. Select AccountInterface → Add Implementation.

   b. Click on the **Finish** button.

7. **Add the StructuredProxyPushConsumer to the Business Object.**

   a. Select AccountInterfaceBO → Properties.

      1) On the Attributes page, select Attributes → Add.

      2) Type `ProxyPushConsumer` in the **Attribute Name** field.

      3) Type `CosNotifyChannelAdmin CosNotifyChannelAdmin::StructuredProxyPushConsumer` in the **Type** field.

      4) Click on the **Refresh** button.

      5) Click on the **Next** button.

   b. Override methods disconnect_structured_push_supplier and subscription_change.

      1) Go to the Methods to Override page.

      2) Select disconnect_structured_push_supplier and subscription_change in the **method** list on the left and move them to the right by pressing the **>>** button.

      3) Click on the **Next** button.

   c. Add attributes *accountNumber* and *balance* to the Data Object Interface.

      1) Select *accountNumber* and *balance* in the Business Object Attributes list on the left and move them to the right by clicking the **>>** button.

      2) Click on the **Finish** button.

   d. Add implementation to changeBalance, initForCreation and uninitForDestruction methods. The implementation of these three methods are shown below. Copy this code into three different files in the Model directory and add them to the Model using the following procedure:

      1) Select changeBalance in the Methods window. → Properties
      2) Select Use an external file.
      3) Click on the **Browse** button, and select the file that implements the changeBalance() method in the Model directory.

4) Repeat for initForCreation() and uninitForDestruction() methods.

changeBalance()

```
CORBA::Double newBalance;
CosNotification::StructuredEvent *event;
CORBA::Short Priority;
time_t Timeout;
tm t1;
                        // change the balance
newBalance = iDataObject->balance() + anAmount;

if (newBalance < 0)
      throw NotEnough();
else                    // update the balance and generate event
{
   iDataObject->balance(newBalance);
   event = new CosNotification::StructuredEvent;
                        // Define the event
   event->header.fixed_header.domain_type = CORBA::string_alloc(100);
   strcpy(event->header.fixed_header.domain_type, "dt");
   event->header.fixed_header.event_type = CORBA::string_alloc(100);
   strcpy(event->header.fixed_header.event_type, "et");
   event->header.fixed_header.event_name = CORBA::string_alloc(100);
   strcpy(event->header.fixed_header.event_name, "en");
                        // Set the Quality of services (QoS)
   event->header.variable_header.length(3);
                        // Set Priority
   event->header.variable_header[0].name = CORBA::string_alloc(100);
   strcpy(event->header.variable_header[0].name, "Priority");
   Priority = 6;
   event->header.variable_header[0].value <<= Priority;
                        // Set Timeout = 2 days in 100 nanoseconds
   event->header.variable_header[1].name = CORBA::string_alloc(100);
   strcpy(event->header.variable_header[1].name, "Timeout");
   Timeout = 2*24*60*60*10000000;
   event->header.variable_header[1].value <<= Timeout;
                        // Set StopTime = 1999 Dec 4, 12.01
   event->header.variable_header[2].name = CORBA::string_alloc(100);
   strcpy(event->header.variable_header[2].name, "StopTime");
   t1.tm_year = 99;
   t1.tm_mon  = 11;    // month is zero-based
   t1.tm_mday = 4;     // day is one-based
   t1.tm_hour = 12;
   t1.tm_min  = 1;
   t1.tm_sec  = 0;
   event->header.variable_header[2].value <<= mktime(&t1);
                       // Set filterable data
   event->filterable_data.length(2);
   event->filterable_data[0].name = CORBA::string_alloc(20);
   strcpy(event->filterable_data[0].name, "accountNumber");
   event->filterable_data[0].value <<= "123456";
   event->filterable_data[1].name = CORBA::string_alloc(20);
   strcpy(event->filterable_data[1].name, "balance");
   event->filterable_data[1].value <<= newBalance;
                       // Push the event to the event channel
   iProxyPushConsumer->push_structured_event(*event);
}
```

initForCreation()

```
CosNotifyChannelAdmin::EventChannel_var ec;
CosNotifyChannelAdmin::SupplierAdmin_var sa;
CosNotifyChannelAdmin::ProxyID proxy_id;

iDataObject = AccountInterfaceDO::_narrow(theDO);
AccountInterfaceBO_Impl::initializeState();
                        // initialize the CBSeries environment
CBSeriesGlobal::Initialize();
                        // get default event channel
ec = CosNotifyChannelAdmin::EventChannel::_narrow(
             CBSeriesGlobal::nameService()->resolve_with_string(
                          ".:/resources/notify-channels/cell-default"));
                        // get default SupplierAdmin
sa = ec->default_supplier_admin();
                        // get ProxyPushConsumer
iProxyPushConsumer = CosNotifyChannelAdmin::StructuredProxyPushConsumer::
        _narrow(sa->obtain_notification_push_consumer(
                CosNotifyChannelAdmin::STRUCTURED_EVENT, proxy_id));
                        // connect to the ProxyPushConsumer
iProxyPushConsumer->connect_structured_push_supplier(this);
```

uninitForDestruction()

```
iProxyPushConsumer->disconnect_structured_push_consumer();
```

8. **Add additional include files for AccountInterfaceBO.**

   a. Select AccountInterfaceBO

   b. At the bottom of the Methods window, select File Adornments →Prologue.

   c. Type the following in the bottom window:

   ```
   #include <CBSeriesGlobal.hh>
   #include <INotifyChannelAdminManagedClient.hh>
   #include <IExtendedLifeCycle.hh>
   #include <time.h>
   ```

9. **Add a Data Object Implementation.**

   a. Select AccountInterfaceDO → Add Implementation→.

   b. Go to the behavior page.

   c. Select the following: BOIM with any key, Transient, Home name and key.

   d. Click on the **Finish** button.

10. **Add a Managed Object to the AccountInterfaceBO.**

    a. Select AccountInterfaceBO → Add Managed Object

    b. Click on the **Finish** button.

11. **Generate the code.**

    Select User-Defined Business Objects → Generate → All.

12. **Build the Server Application.** In the Build Configuration folder, execute the following steps.

    AIX only: The DLL files are called Shared Library files and are in the format lib*.so. For any reference to a DLL file, substitute shared library file.

    a. Add a client DLL named accountC and include all account objects in the DLL.

       1) Select Build Configuration → Add Client DLL....

2) Type `accountC` in the **Name** field.

3) Click on the **Next** button.

b. On the Client Source Files page, select the following and move from Items Available (on left) to Items Chosen (on right) by clicking the **>>** button.

1) **AccountCopy**

2) **AccountKey**

3) **Account**

4) Click on the **Finish** button.

c. Add a server DLL named accountS and include all account objects to the DLL. Also, link the client library accountC to it.

1) Select Build Configuration → Add Server DLL....

a) Type `accountS` in the **Name** field.

b) Click on the **Next** button.

2) On Server Source Files page, perform the following tasks:

a) Click on **All>>** (to select all Account* objects to move).

b) Click on the **Next** button.

3) On the Libraries to Link With page, select the **accountC** and click on the **>>** button.

4) Click on the **Finish** button.

d. Generate the makefiles. Select **Build Configuration** → **Generate** → **All** → **C++ Default Targets**.

e. Build the server application. Select **Build Configuration** → **Build** → **Out-of-Data Targets** → **C++**.

13. **Generate the DDL using procedures from the** *Component Broker for Windows NT and AIX Quick Beginnings* **.** The following instructions were used to generate the DDL for our test. However, since these instructions can change you need to always refer to the *Component Broker for Windows NT and AIX Quick Beginnings* to get the latest information.

a. Add Application Family.

1) Select **Application Configuration** → **Add Application Family...**.

2) In the **Name** field, type `AccountAppFam`.

3) Click on the **Finish** button.

b. Define a Server Application.

1) Select **AccountAppFam** → **Add Application...**.

2) In the **Application Name** field, type `accountS`.

3) Click on the **Finish** button.

c. Configuring the Managed Object.

1) Open **AccountAppFam** → Select **accountS** → **Add Managed Object...** → **In the Managed Object** field to ensure that **AccountInterfaceMO** is selected.

2) Click on the **Next** button.

3) In Data Object Implementations page → **Add Another**.

4) Select **AccountDOImpl AccountInterfaceDOImpl** in the **Data Object Implementation** field if not already selected.

5) Select **accountS** in the **DLL for Data Object Implementation** field, if not already selected.

6) Click on the **Refresh** button.

7) Click on the **Finish** button.

d. Generate the DDL File → Open **AccountAppFam** → **Generate**.

Note: The DDL files should be generated in the `Working/NT/AccountAppFam` directory for Windows NT and `Working/AIX/AccountAppFam` directory for AIX.

Step 2 : Implement the C++ Client Code (PushSupplier and PullConsumer)

This section provides sample code for the PushSupplier and the PullConsumer.

PushSupplier C++ Client Code

In this sample, the Account object in the server is going to generate events on the event channel each time its changeBalance method is invoked. As mentioned earlier, a pure C++ client (PushSupplier) is used to invoke the changeBalance method on the Account object. The PushSupplier program prompts the user for the amount of the balance to be changed. The balance is then passed as a parameter to the changeBalance method. The following code illustrates the implementation of this client.

The PushSupplier client code creates an object using AccountKey and uses the object to call the changeBalance method in the Account application server that then pushes the event (balance in this case) to the Event Channel. When this code is run it prompts for the user to input an amount to be added to the balance of the Account.

```
#include <CBSeriesGlobal.hh>
#include <IExtendedLifeCycle.hh>
#include <IManagedClient.hh>
#include "Account.hh"
#include "AccountKey.hh"

int main(int argc, char *argv[])
{
   CORBA::ORB_ptr op;
   IExtendedLifeCycle::FactoryFinder_var myFinder;
   IManagedClient::IHome_var accountHome;
   AccountInterfaceKey_var theKey;
   ByteString* theKeyString;
   IManagedClient::IManageable_var moPtr;
   AccountInterface_var account;
   CORBA::Double anAmount;
                     // Global Initializer
   CBSeriesGlobal::Initialize();
   op = CBSeriesGlobal::orb();
                     // find a Factory
   myFinder = IExtendedLifeCycle::FactoryFinder::_narrow(
              CBSeriesGlobal::nameService()->resolve_with_string(
                  "host/resources/factory-finders/host-scope"));
   accountHome = IManagedClient::IHome::_narrow(
                     myFinder->find_factory_from_string(
                         "AccountInterface.object interface"));
                     // create an instance of a AccountInterfaceKey
   theKey = AccountInterfaceKey::_create();
                     // create a account from the Key class
```

```
    theKeyString = theKey->toString();
                        // Checking to see if the object already exists
    try
    {
       cout << "Checking to see if the object already exists on the Server" << endl;
       moPtr = accountHome->findByPrimaryKeyString(*theKeyString);
    }
    catch (IManagedClient::INoObjectWKey &nowk)
    {
       cout <<  "Expected ERROR in findByPrimaryKeyString call: " << nowk.id() << endl;
    }
    if (!moPtr)
       moPtr = accountHome->createFromPrimaryKeyString(*theKeyString);
                        // Narrow to the Account interface
    account = AccountInterface::_narrow(moPtr);

    try
    {
       while (1)
       {
          cout << "Enter the amount of Balance to be changed" << endl;
          cin >> anAmount;
          cout << "anAmount = " << anAmount << endl;
          if (anAmount != 0)
               account->changeBalance(anAmount);
       }
    }
    catch (AccountInterface::NotEnough)
    {
       cout << "NotEnough exception thrown" << endl;
    }
    catch (...)
    {
       cout << "Unknown Exception thrown" << endl;
    }

    CORBA::release(op);
    delete theKeyString;
    return 0;
 }
```

PullConsumer C++ Client Code

The consumer client code is also implemented in C++. The consumer in this case is only interested in the event the balance in the account falls below $1000. A filter is created to have this requirement so that the consumer client will be notified in case the balance is less than $1000. In this sample the consumer uses the try_pull method in a loop to continuously monitor the events from the event channel (balance in this case). The following code illustrates the implementation of this client.

The PullConsumer client code pulls events from the event channel by invoking the try_pull_structured_event method. A filter is created with the constraints such that it receives events only when the accountNumber is 123456 and the balance in the account is less than $1000.

```
#ifdef _WIN32
#include <windows.h>
#endif
#include <CBSeriesGlobal.hh>
#include <CosNotifyChannelAdmin.hh>
#include <INotifyFilterManagedClient.hh>
#include <IExtendedLifeCycle.hh>
#include <IExtendedNaming.hh>

int main( )
{
   CORBA::ORB_ptr orb;
   IExtendedNaming::NamingContext_var rootNC;
   CosNotifyChannelAdmin::EventChannel_var ec = NULL;
   CosNotifyChannelAdmin::ConsumerAdmin_var ca;
   CosNotifyChannelAdmin::ProxyID proxy_id;
   CosNotifyChannelAdmin::StructuredProxyPullSupplier_var PxyPullS;
   IExtendedLifeCycle::FactoryFinder_var hostScopeFF;
   INotifyFilterManagedClient::FilterFactory_var ff = NULL;
   CosNotifyFilter::Filter_ptr fi;
   CosNotifyFilter::ConstraintExpSeq *cl = new CosNotifyFilter::ConstraintExpSeq;
   CosNotifyFilter::ConstraintInfoSeq *cis = new CosNotifyFilter::ConstraintInfoSeq;
   CORBA::Boolean has_event;
   CosNotification::StructuredEvent* event;
   CORBA::Double newbalance;
                     // call the Global Initializer
   CBSeriesGlobal::Initialize();
   orb = CBSeriesGlobal::orb();
                     // get the root Naming Context
   rootNC = CBSeriesGlobal::nameService( );
                     // get the default event channel
   ec = CosNotifyChannelAdmin::EventChannel::_narrow(
           rootNC->resolve_with_string(".:/resources/notify-channels/cell-default"));
                     // get consumer admin
   ca = ec->default_consumer_admin();
   PxyPullS = CosNotifyChannelAdmin::StructuredProxyPullSupplier::_narrow(
                 ca->obtain_notification_pull_supplier(
                     CosNotifyChannelAdmin::STRUCTURED_EVENT, proxy_id));
                     // get factory finder
   hostScopeFF = IExtendedLifeCycle::FactoryFinder::_narrow(
                    rootNC->resolve_with_string(
                        "host/resources/factory-finders/host-scope"));
                     // get filter factory
   ff = INotifyFilterManagedClient::FilterFactory::_narrow(
          hostScopeFF->find_factory_from_string(
              "INotifyFilterManagedClient::Filter.object interface"));
                     // create a filter
   fi = ff->create_filter("IBM_NTF_CTG");
                     // define the constraint
   (*cl).length(1);
   (*cl)[0].constraint_expr = CORBA::string_alloc(100);
   strcpy((*cl)[0].constraint_expr, "($accountNumber == '123456') and ($balance < 1000)");
                     // define the filter
   cis = fi->add_constraints(*cl);
                     // add the filter to the Proxy
   PxyPullS->add_filter(fi);
                     // connect the PullConsumer to the event channel
   PxyPullS->connect_structured_pull_consumer(NULL);
```

```
    cout << "About to pull events" << endl;
    while (1)
    {
       event = PxyPullS->try_pull_structured_event(has_event);
       if (has_event)
       {
          event->filterable_data[1].value >>= newbalance;
          cout << "The Account Balance is: " << newbalance << endl;
       }
       delete (event);
    }
 }
```

Makefile for C++ Client's Code on Windows NT

WIN This makefile will compile and link the client applications on Windows NT. Make sure you set the ACCOUNTDIR below to the Object Builder Working directory.

Note: Both AccountC.dll and AccountS.dll need to be copied into the bin path.

```
ACCOUNTDIR = ..\Working\NT

LLIBS = \
   $(ACCOUNTDIR)\AccountC.lib \
   somosa1i.lib \
   sompmg1i.lib \
   sompmcii.lib \
   somorori.lib

.all: \
   .\PullConsumer.exe .\PushSupplier.exe

.\PullConsumer.obj: \
   .\PullConsumer.cpp
   @echo " Compile "
   icc.exe /Fo".\%|fF.obj" /Gm+ /Ti+ /I $(ACCOUNTDIR) /C .\PullConsumer.cpp

.\PushSupplier.obj: \
   .\PushSupplier.cpp
   @echo " Compile "
   icc.exe /Fo".\%|fF.obj" /Gm+ /Ti+  /I $(ACCOUNTDIR) /C .\PushSupplier.cpp

.\PullConsumer.exe: .\PullConsumer.obj
   @echo " Link "
   icc.exe @<<
    /B" /de" /Gm+ /Ge+ /Gd+
    /FePullConsumer.exe
    .\PullConsumer.obj
    $(LLIBS)
<<

.\PushSupplier.exe: \
   .\PushSupplier.obj
   @echo " Link "
   icc.exe @<<
    /B" /de"
    /FePushSupplier.exe
    .\PushSupplier.obj
```

```
    $(LLIBS)
<<

clean:
   erase *.exe *.obj
```

Makefile for C++ Client's Code on AIX

AIX This makefile will compile and link the client applications on AIX. Make sure you set the ACCOUNTDIR below to the Object Builder Working directory.

Note: Both libaccountC.so and libaccountS.so need to be copied into the $HOME/lib directory from the Working/AIX directory.

```
# The actions included in this make file are:
# Compile and Link

# include make rules file
include /usr/lpp/CBToolkit/lib/samples.mk

ACCOUNTDIR      = ../Working/AIX
LOCAL_INCDIRS   = -I$(ACCOUNTDIR)
LOCAL_LIBPATH   = -L$(ACCOUNTDIR)

LIBS            = $(LOCAL_LIBPATH) $(LIBPATH)
INCS            = $(INCDIRS) $(LOCAL_INCDIRS)

#-------------------------------------------------------------------
# tools and build environment
# make sure CLASSPATH is defined in the environment variable
#-------------------------------------------------------------------

CC_FLAGS        = $(INCS) -D__IBMCPP__ -qlangvl=ansi
LDFLAGS         = -brtl

CLEAN_FILES = PushSupplier.o PushSupplier PullConsumer.o PullConsumer

.SUFFIXES: .o .cpp

.cpp.o:
   $(CCC) -c -o$@ $(CC_FLAGS) $<

all: PushSupplier PullConsumer

PushSupplier.o: PushSupplier.cpp
PullConsumer.o: PullConsumer.cpp

PushSupplier: PushSupplier.o
     $(CCC) $(LDFLAGS) $(CONST_LD_FLAGS_DEBUG) -o$@ PushSupplier.o \
     $(LIBS) -lsompmci -lsompmg1 -lsomosa1 -laccountC -lsomoror

PullConsumer: PullConsumer.o
     $(CCC) $(LDFLAGS) $(CONST_LD_FLAGS_DEBUG) -o$@ PullConsumer.o \
     $(LIBS) -lsompmci -lsompmg1 -lsomosa1 -laccountC -lsomoror

clean:
     $(REMOVE) -f $(CLEAN_FILES)
```

Step 3: Running the Sample

The first process in running the sample is to load and configure the application. The *Component Broker for Windows NT and AIX Quick Beginnings* provides a sample (for Claim object) to do this. Follow the procedures to load and configure the AccountAppFam application.

The following instructions were used to load and configure the application in our test scenario. However, since these instructions can change always refer to the *Component Broker for Windows NT and AIX Quick Beginnings* for the latest information.

Loading the Application onto System Management

1. Start the System Manager User Interface.
2. From the System Manager User Interface menu, select view → User Level → Expert.
3. Expand Host Images and select **myhost** (that is, your hostname).
4. Open the menu for **myhost** and select Load Application.
5. Click on the **Browse** button, and select AccountAppFam.ddl.

Configuring the Application

1. **Configure the application with a management zone.**

   a. **For accountS:**

      1) Expand Available Applications and select accountS.

      2) Open the pop-up menu of the accountS application and select **Drag**.

      3) Expand Management Zones → Sample Cell and Workgroup Zone → Configurations, and select Sample Configuration.

      4) Open the pop-up menu of Sample Configuration, and select Add Application.

   b. **For iDefaultCellNotifyChannel:**

      1) Expand Available Applications and select iDefaultCellNotifyChannel.

      2) Open the pop-up menu of the iDefaultCellNotifyChannel application and select **Drag**.

      3) Expand Management Zones → Sample Cell and Workgroup Zone → Configurations, and select Sample Configuration.

      4) Open the pop-up menu of Sample Configuration, and select Add Application.

   c. **For iNotificationService:**

      1) Expand Available Applications and select iNotificationService.

      2) Open the pop-up menu of the iNotificationService application and select **Drag**.

      3) Expand Management Zones → Sample Cell and Workgroup Zone → Configurations, and select Sample Configuration.

      4) Open the pop-up menu of Sample Configuration, and select Add Application.

   Note: The accountS, iDefaultCellNotifyChannel and the iNotificationService applications were added to the Applications folder within the Configurations folder.

2. **Configure the server.**

   a. Expand Management Zones → Sample Cell and Workgroup Zone → Configurations, and select Sample Configuration.

b. Open the pop-up menu of Sample Configuration, and select **New** → Server Group. A dialog box is displayed.
c. Type `AccountServerGroup` as the name for the server group.
d. Click the **OK** button. The AccountServerGroup is displayed under Server Groups, which is under sample configurations.
e. Open the pop-up menu of AccountServerGroup, and select New → Server member of group. A dialog box is displayed.
f. Type `AccountServer` as the name for the server.
g. Click the **OK** button. The AccountServer is displayed under AccountServerGroup.

3. **Associate the configured application with the server.**
   a. **For accountS:**
      1) Expand Management Zones → Sample Cell and Workgroup Zone → Configurations → Sample Configuration → Applications and select accountS.
      2) Open the pop-up menu of accountS and select **Drag**.
      3) Expand Management Zones → Sample Cell and Workgroup Zone → Configurations → Sample Configuration → Server Groups and select AccountServerGroup.
      4) Open the pop-up menu of AccountServerGroup and select Configure Application.
   b. **For iDefaultCellNotifyChannel:**
      1) Expand Management Zones → Sample Cell and Workgroup Zone → Configurations → Sample Configuration → Applications and select iDefaultCellNotifyChannel.
      2) Open the pop-up menu of accountS and select **Drag**.
      3) Expand Management Zones → Sample Cell and Workgroup Zone → Configurations → Sample Configuration → Server Groups and select AccountServerGroup.
      4) Open the pop-up menu of AccountServerGroup and select Configure Application.
   c. **For iNotificationService:**
      1) Expand Management Zones → Sample Cell and Workgroup Zone → Configurations → Sample Configuration → Applications and select iNotificationService.
      2) Open the pop-up menu of accountS and select **Drag**.
      3) Expand Management Zones → Sample Cell and Workgroup Zone → Configurations → Sample Configuration → Server Groups and select AccountServerGroup.
      4) Open the pop-up menu of AccountServerGroup and select Configure Application.

   Note: A Configured Applications folder is displayed under AccountServer. You can expand the folder to display the entries for accountS, iDefaultCellNotifyChannel and iNotificationService.

4. **Configure the server with the host.**
   a. Expand Management Zones → Sample Cell and Workgroup Zone → Configurations → Sample Configuration → Server Groups→ AccountServerGroup → Servers (member of group) and select AccountServer.
   b. Open the pop-up menu of AccountServer and select **Drag**.
   c. Under Hosts, select **myhost** for your current system.
   d. Open the pop-up menu of myhost, and select Configure Server (member of group).

Note: Under the myhost folder, there is now a folder called Configured Servers (members of group) that contains an entry for the AccountServer server.

5. **Activate the configuration.**
   a. Expand Management Zones → Sample Cell and Workgroup Zone → Configurations and select Sample Configuration.
   b. Open the pop-up menu of Sample Configuration, and select Activate.

Running the Application

Make sure the client code is built.

After activating the application, run the PushSupplier client and add some balance into the account (start with > $1000). Then, start the PullConsumer client in another window. As soon as the balance is changed by the PushSupplier to be below $1000 the following statement should appear on the PullConsumer client window followed by the amount remaining in the account. `The Account Balance is:`

1. **To run PushSupplier:**
   a. From a command prompt, change directory to where the PushSupplier is stored.
   b. Type `PushSupplier`
   c. The program will prompt you to add balance to the account with the following statement.
      - `Enter the amount of Balance to be changed`
   d. Type `3000`
   e. Use another command prompt window to run the PullConsumer.
2. **To run PullConsumer:**
   a. From a command prompt, change the directory to where the PullConsumer is stored.
   b. Type `PullConsumer`
   c. Wait for the following output: `About to pull events`.
   d. Go to the PushSupplier window.
3. **Remove money from the account.**
   a. In the PushSupplier window at the following prompt: `Enter the amount of Balance to be changed`
      - Type `-1500`
   b. You should not see any event in the PullSupplier window since the amount is still > 1000.
   c. Next Type `-1000` at the prompt.
   d. You should see the following statement on the PullConsumer window.
      - `The Account Balance is: 500`

User-Defined Event Channel

The sample presented above uses the default event channel. If one needs to use a user-defined event channel, they need to create a visible event channel with a name and use it instead. For example if the name of the event channel is “newev1” then the path name to obtain it is `.:/resources/notify-channels/newev1`. Change the following code snippet in the sample above:

```
// obtain the default event channel    tmp = rootNC->resolve_with_string(
".:/resources/notify-channels/cell-default");
```

Change to:

```
// obtain the user-defined event channel    tmp = rootNC->resolve_with_string(
".:/resources/notify-channels/newev1");
```

Create a User-Defined Event Channel: The following code can be used to create a new user-defined event channel (called newev1).

```
#include <INotifyChannelAdminManagedClient.hh>
#include <IExtendedLifeCycle.hh>
#include <CBSeriesGlobal.hh>
#include <time.h>

void main(int argc, char *argv[])
{
   CORBA::Object_var intermediateObject;
   IExtendedLifeCycle::FactoryFinder_var hostScopeFF;
   INotifyChannelAdminManagedClient::EventChannelFactory_var ecHome;
   CosTrading::PropertySeq qos;
   CORBA::Short Priority;
   time_t Time_out;
   ByteString_var key;
   CosNotifyChannelAdmin::ChannelID cid;
   CosNotifyChannelAdmin::EventChannel_var ec;
                       // initialize the CBSeries environment
   CBSeriesGlobal::Initialize();
                       // obtain the default factory finder with a host scope
   intermediateObject = CBSeriesGlobal::nameService()->resolve_with_string(
                                "host/resources/factory-finders/host-scope");
                       // narrow to a factory finder
   hostScopeFF = IExtendedLifeCycle::FactoryFinder::_narrow(intermediateObject);
                       // find the event channel factory
   intermediateObject = hostScopeFF->find_factory_from_string(
           "INotifyChannelAdminManagedClient::EventChannel.object interface");
                       // narrow to the event channel home
   ecHome = INotifyChannelAdminManagedClient::EventChannelFactory::_narrow(
                                                    intermediateObject);
                       // Create Quality of Services (QoS)
   qos.length(2);
   qos[0].name = CORBA::string_alloc(20);
   strcpy(qos[0].name, "Priority");          // Priority = 6
   Priority = 6;
   qos[0].value <<= Priority;

   qos[1].name = CORBA::string_alloc(20);
   strcpy(qos[1].name, "Timeout");           // timeout = two days
   Time_out = 2 * 24 * 60 * 60 * 10000000;   // in 100 nanoseconds
   qos[1].value <<= Time_out;
                       // use the factory in the event channel home to create
                       // a new event channel
   ec = ecHome->createVisibleEventChannel(key, "newev1", 1, 1, 1, qos, NULL, cid);
}
```

Chapter 4. Externalization Service

The Externalization Service defines protocols and conventions for externalizing and internalizing objects to and from streams. A *stream* has a sequential data holding area with an associated private cursor. To *externalize* an object to a stream is to record the object state in a stream of data (such as in memory, on a disk file, or across the network). To *internalize* an object from a stream is to bring the object back to life at the same or a new destination.

An object that has been externalized can:

- Exist for an indefinite amount of time.
- Be transported by means outside the ORB.
- Be internalized in a different, disconnected ORB.

The Externalization Service lets you export objects outside the ORB environment by:

- Copying state of objects to stream
- Copying the state from the stream into the destination object

The interfaces defined by the Externalization Service provide you with the capability to externalize objects to streams. Streams are import and export mediums that support object copy, move, and pass by value in method calls.

Chapter 5. Identity Service

Component Broker derives an object identity from relative information that positions the object within its Container, Server, Host, and ultimately Domain. This information can be used within the Component Broker Managed Object Framework to uniquely identify it from any other object in the distributed system. The CosObjectIdentity::IdentifiableObject::is_identical() method is implemented to use this information to precisely determine whether two objects are the same object.

If you want to compare whether two objects are the same object, you can use the is_identical() method on one of the objects, passing in the other object. This returns a boolean value indicating whether the two objects are the same object.

Comparing Objects

Object systems, and particularly distributed object systems tend to obscure object identities. It is natural for object oriented designs to define objects which are in fact veneers to other objects. This is the case, for instance, where proxies are introduced to a client process, and the proxies “stand in” for the real object referred to by the client. The proxy appears to be the real object, but in fact the real object is hidden behind and is obscured by the proxy.

This condition makes it difficult to know whether two objects are in fact the same object. If your client program has two object references, you cannot simply compare the pointers to those references to determine whether they are referring to the same object. It is possible for two distinct references to refer to the same object, even though the reference objects themselves (the proxies) are two distinct objects. The references have different memory locations, and they have different pointers. For these reasons, you cannot reliably use the pointer values to determine whether the two objects are the same object.

Further, it is possible that both references contain different state even though they refer to the same object. Thus, you can't reliably compare the values of the references to determine whether the two objects are the same object, either. To resolve this problem, Component Broker introduces an identity service. As part of the service, all managed objects support the CosObjectIdentity::IdentifiableObject interface.

This interface introduces two methods, is_identical() and constant_random_id(), which can be used to determine whether two objects are the same object. The is_identical() method is implemented on the managed object. It uses information intrinsic to the object to determine accurately whether the object is the same as the object to which it is being compared.

Compare Two Objects

This procedure is used to determine whether two objects are the same or different objects. This is useful for avoiding duplicate or circular references. You can only perform object comparisons on objects that support the CosObjectIdentity::IdenticalObject interface.

To perform object comparisons, invoke the is_identical() method. Assuming you have two object references, invoke the is_identical() method on one object, passing in the other object. This returns a boolean value indicating whether the two objects are the same or different.

The following example compares two objects:

```
// Declare two arbitrary business objects --
// this assumes both objects are derived from the CBC
// managed object framework.

SomeBusinessObject_var myBO1, myBO2;

// Create or obtain instances of these objects some how
...
// Compare the two objects.
if (myBO1->is_identical(myBO2))
  // Do something  ...
```

Compare Multiple Objects

This procedure demonstrates how you can compare an object to a collection of objects. This is useful when you maintain a number of objects and want to compare them against another object to determine if the object is already a member of your collection. This procedure only works for objects that support the CosObjectIdentity::IdentifiableObject interface.

Perform an optimized object comparison using the following steps:

1. Get and cache the constant_random_id for the collection members. As each member is added to the collection, get the object's constant_random_id and cache in the collection.
2. Obtain the constant_random_id for the additional object. Obtain the constant_random_id for the object you want to compare.
3. Compare constant_random_ids. Compare the constant_random_id of the additional object with the cached constant_random_id for each member of the collection.
4. Invoke the is_identical() method on matched objects. If the constant_random_id values are not the same, then the objects are not the same. However, if the constant_random_id values are the same, then you must invoke the is_identical() method on the two objects to determine precisely whether they are the same.

The following example demonstrates comparing objects using constant_random_ids. This example presumes the existence of a sequence of objects, and their corresponding constant_random_id's, as defined by the following IDL:

```
struct CollectionMember {
  CosObjectIdentity::ObjectIdentifier approximateIdentity;
  CORBA::Object theObject;
};
typedef sequence<CollectionMember> Collection;
```

The remainder of the example compares a passed object with all of the members in the Collection:

```
// Declare the collection (presuming it is set elsewhere), an
// index, a termination flag, and the constant_random_id of the
// passed object, and the passed object itself (presuming it is
// a managed object and is passed in from elsewhere).

Collection_var theCollection;
unsigned long index;
boolean matchingObjectFound = 0;
SomeBusinessObject_var myBO1;
CosObjectIdentity::ObjectIdentifier myBO1ApproximateIdentity;

// Get the constant_random_id for the passed object.
```

```
myBO1ApproximateIdentity = myBO1->constant_random_id();

// Iterate through the collection, testing each approximate
// identity, and invoking is_identical on those that appear
// to be the same to determine exactly whether they are the
// same object.

for (index=0;
 (matchingObjectFound == 0) &&
 (index < theCollection.length(); index++)
 {
   if (myBO1ApproximateIdentity ==
       theCollection[index].approximateIdentity)
   {
     // constant_random_ids match, so test for actual identity
     if (myBO1->is_identical
         (theCollection[index].theObject))
     {
       // A match was found, do something and terminate
       // further searching.
       ...
       matchingObjectFound = 1;
     }; // endif
   }; // endif
 }; // endfor
```

Optimizations for Object Collections

If you implement a collection of objects, and want to compare whether some object passed in to you is already in your collection, you can use the CosObjectIdentity::IdentifiableObject::is_identical() operation to compare the passed object against each object in your collection. However, since the is_identical() operation is implemented on managed objects, this implies that you would be invoking the operation on the managed objects themselves.

If the objects in your collection are potentially located on other servers, then invoking the is_identical() method on each object can get expensive in terms of the system resources it consumes. The method request has to be communicated between the servers, potentially over the network, the object has to be reactivated, and the response returned. The expense associated with invoking the is_identical() method increases as more objects are added to the collection. Furthermore, in unique collections, the comparison is destined to return false in all cases, but, at most, one.

To improve the performance of performing object comparisons, the identity service introduces the CosObjectIdentity::Identifiable::constant_random_id attribute. This attribute is defined to return a constant value with the following properties:

- The attribute always returns the same constant value throughout the lifetime of the object.
- The attribute is a unsigned long hash-value that approximates the identity of the object.

In your collection, you can obtain the object's constant_random_id when each object is added to the collection caching the value within your collection. Later, when you want to compare two objects, you can obtain the passed object's constant_random_id and compare it to each of the constant_random_ids that you have already cached in your collection.

Since the values remain constant throughout time, you can be certain that if the two values are not the same, then the two object are not the same. However, if two values are the same, you can't be certain that the two objects are the same object. In this case, you can then invoke the is_identical() operation on just those few objects whose values are the same.

The constant_random_id value is a full unsigned long value with good distribution properties. For most collections, the constant_random_id values have a high probability of being unique. Thus, the set of objects on which you actually have to perform is_identical on is very small, perhaps just one.

Chapter 6. LifeCycle Service

A LifeCycle Service provides operations for creating, copying, moving, and deleting objects. LifeCycle Services define conventions that allow clients to perform life cycle operations on objects in various locations. A LifeCycle Service provides both managed and non-managed object versions of its interfaces used for the factory finding process. The non-managed versions are implemented as local-only objects.

The purpose of a LifeCycle Service is to find factories capable of creating managed objects. A LifeCycle Service maintains a LifeCycle repository that houses information about managed object factories that exist in a network. The LifeCycle repository keeps track of locations where each factory can support creating objects and the interfaces supported by objects that the factory creates.

As factories are created and removed from server processes, the factories call LifeCycle repository interfaces to update the LifeCycle repository accordingly.

LifeCycle of Managed Objects

The Component Broker life cycle model lets you create business objects anywhere in the distributed system, but without being encumbered by the complexity of the distributed system and object implementations.

Although you know the interface of your business object when you create your application, that interface may have changed when you created an instance of that object in a production system. The interface may have been specialized and the implementation may have changed to add new behaviors.

The preceding may be even more true in a distributed system where the business object is used and shared among several different applications, and where each application may apply its own set of requirements to the business object. This is certainly true in the Component Broker programming model where business objects become managed objects between the time the business objects were originally developed and when they're finally deployed in a production system.

The implementation of a business object is also likely to change over time to consider additional business requirements in the form of added behavior, to address new business conditions, priorities, policies, or constraints, or to fix bugs in the original object implementation.

Different enterprises have different needs as to where their business objects are located. In some institutions, life insurance policy objects are created at the insurance agent's branch office. In other institutions, those life insurance policy objects would have been created at the central office. You may not know exactly where (geographically) objects should be created in the distributed system. An enterprise may require that different kinds of objects should be created in different places.

As the enterprise grows it may add new servers to accommodate that growth. In doing so, it may need to redistribute the location of its business objects to maintain some balance over its computational resources. Although life insurance policy objects continue to be created at the central office, they may actually be created on a different server at that office.

The Component Broker life cycle model separates the concern for when to create a given kind of object from where and of what type (specific type and implementation) to create. It does so through the introduction of *factories, factory finders*, and *location scopes*. While the application is responsible for defining the kind of object it wants created and when, the factory object is responsible for encoding the specific type and implementation class for the kind of object(s) it supports. It is also responsible for encoding the specific details for how to create an object of that type. It defines what constructors or initialization methods to invoke and in what order, as well as any other activities that need to be performed for the enterprise or in the distributed system for that kind of object. The location object is responsible for encoding a location scope, which is something like a geographic area representing where objects should be created. Typically this is supplied or configured by the enterprise. Location objects are registered to specific factory-finders. The factory finder is responsible for finding a factory that supports creating the kind of specified object within the location scope registered with it. Thus the factory finder, in collaboration with a location object, is responsible for establishing where to create the object.

LifeCycleObject Interface on Managed Objects

All managed objects in Component Broker support the CosLifeCycle::LifeCycleObject interface. This is introduced by IManagedClient::IManageable. The IDL for CosLifeCycle::LifeCycleObject is as follows:

```
module CosLifeCycle {
        interface FactoryFinder;
        typedef struct NVP {
                CosNaming::Istring name;
                any value;
        } NameValuePair;
        typedef sequence  Criteria;
        exception NoFactory {
        Key search_key;
        };
        exception NotCopyable {
                string reason;
        };
        exception NotMovable {
                string reason;
        };
        exception InvalidCriteria {
                Criteria unmet_criteria;
        };
        exception CannotMeetCriteria {
                Criteria unmet_criteria;
        };
        interface LifeCycleObject {
               LifeCycleObject copy(
                        in FactoryFinder there,
                        in Criteria the_criteria)
                   raises(
                        NoFactory,
                        NotCopyable,
                        InvalidCriteria,
                        CannotMeetCriteria);
               void move(
                        in FactoryFinder there,
                        in Criteria the_criteria)
                    raises(
                        NoFactory,
                        NotMovable,
                        InvalidCriteria,
                        CannotMeetCriteria);
               void remove()
                    raises(NotRemovable);
         };
  };
```

The remove() method can be invoked by any program to destroy the object instance. Doing so erases any persistent storage associated with the managed object, and depending on the implementation of the managed object may remove any sub-objects the object depends on. For this reason, invoking this method should be performed with some care.

Factories

The term *factory* is used loosely to refer to any object that is responsible for creating other objects. For example, a family may decide they need a life insurance policy. They would contact their insurance agent, who would then create their policy. From the perspective of this family, the agent can be thought of as a factory, or perhaps more accurately, a factory representative.

From the perspective of the insurance agent, creating the insurance policy for the family means filling out paperwork (to open the customer account and policy, and to declare the beneficiary), and adding the family to a list of clients. The insurance agent's insurance application is the agent's factory for the new policy.

From the perspective of the insurance application, creating the insurance policy means creating a PolicyHolder object, Beneficiary object, and Policy object, and adding the PolicyHolder as a Customer to the Agent object. The insurance application needs factories for each of the new objects that it creates.

Because PolicyHolder, Beneficiary, and Policy are all managed objects then they have, by definition, corresponding managed object homes. Homes are in fact managed object factories, the most rudimentary of factories. Managed object factories are directly responsible for allocating system resources for the managed object, including any memory the object occupies and its persistent storage. By extension, or in collaboration with the object's implementation, the managed object factories may be responsible for creating other objects the managed object depends on.

To assure the consistency and integrity of the system, all managed objects must be created by a corresponding managed object factory, their home. Consequently, if one managed object depends on another managed object being created at the same time, then the subordinate object should be created through its corresponding managed object factory. This can occur in the implementation of the superior object's factory, or within the implementation of the superior object, perhaps in its initialization method.

Other kinds of factories can exist also. When the life insurance application creates the PolicyHolder, Beneficiary and Policy objects, it is in effect acting as a factory. It may collect all of this logic into an object of its own that understands the mechanics of creating managed objects (through their corresponding homes), thus becoming an application factory.

Any application can introduce its own application factories for its own purposes. If you are going to introduce your own application factory, it may be appropriate for you to introduce this as a managed object and to bind it in the system name space under your own application naming context. As such you can create one instance of the factory and continue to use that in each invocation of your application. However, Component Broker does not yet provide any additional support or assistance for distinctly managing application factories.

Alternately, you could embed the logic for creating the PolicyHolder and Beneficiary as a side-effect of creating the Policy object in the home for the Policy object (testing first for the presence of the PolicyHolder and Beneficiary in the case this isn't the first policy for either of those people). Doing so requires that you customize the home for the Policy object. A customized home is distinguished from an application factory only in that a customized home continues to benefit from the distinct support provided to homes by Component Broker. In particular, a factory finder can be used to find a customized home, but cannot be used to find an application factory, at this point.

Object Creation

How you create an object depends first on whether the object is managed or non-managed. Managed objects are created with a factory. The most rudimentary form of factory is the managed object factory. The home for a managed object is also its managed object factory. Thus the terms managed object factory and home are synonymous in Component Broker.

The home is responsible for allocating system resources needed by the managed object. Typically this includes the memory it occupies when active, and any storage used to retain its state persistently.

The default implementation of home provided by Component Broker can be customized and extended to perform any other functions that need to occur when the object is created, such as registering the object with other objects and resource managers as needed by the system. Alternately, this function can be embedded in the initialization of the object, or it can be performed by an application factory.

Introducing an application factory requires defining the interface for creating objects with that factory. Arguments can be defined at this time to control additional activities that the factory performs while creating managed objects, such as creation methods that represent object creation as a business activity. This gives your application factory more relevance to other applications that use it to perform a business function.

Ultimately, this should result in invoking one of the creation methods on a home for creating the actual managed object instance. This is described in more detail in How to Create a Managed Object in the *Component Broker Programming Guide*.

Non-managed (or local-only) objects are created directly from their native language class. Most often this is done using the mechanisms provided with your programming language for creating native language objects, for instance using the new operator in C++. However, to preserve some language neutrality, non-managed objects provided by Component Broker support a more general approach. Normally this involves using the static class function _create for the class of the non-managed object. The specifics for creating instances of non-managed objects supplied by Component Broker is detailed in the documentation for each of those types of objects.

Object Destruction

You can remove a managed object by invoking the CosLifeCycle::LifeCycleObject::remove() method on the object. When you remove an object (or when your business object is removed by another program) you need to undo all that you did during the object creation process. That is, if you have allocated a set of resources uniquely for your object, either in the object's initForCreation() method or within the creation method in your object's factory (or factories), then you need to free those resources during its destruction. For instance, you may have created a reference collection for use within your object for one-to-many relationships. When your object is removed, that reference collection needs to be removed as well. If you do not remove the reference, then the reference collection is not deleted until an administrator notices the unused resource and removes it.

As with allocating resources during object creation, you have some choices as to where you deallocate those resources during object removal. You can perform the deallocation within your object's uninitForDestruction() method, or you could delegate to your object's Home (managed object factory) to perform the deallocation. If you choose the latter, you should introduce a method on a specialization of your object's Home, and invoke that method from within your object's uninitForDestruction() method. Non-managed (local-only) objects are destroyed using the standard C++ and Java delete methods.

Factory Finders

You can find a factory that supports creating a particular type of object with a factory finder. Factory finders find factories based on the following two criteria: the type of object for which a factory is needed, and a location scope in which to look. On a find_factory or find_factories request, use the factory_key to specify the object type. The location scope is defined in a location object registered with the factory finder when it was created.

Component Broker provides two factory finder implementations, both of which support the IExtendedLifeCycle::FactoryFinder interface. This interface is derived from the CosLifeCycle::FactoryFinder interface. One implementation of factory finder is implemented as a local-only object and thus can be instantiated at run time local to the application, and the other is implemented as a managed object. In the second case, factory finder objects can be created persistently and registered in the system name space, or used remotely.

The IDL for Component Broker factory finders is listed below:

```
#include <CosLifeCycle.idl>
#include <NamingStringSyntax.idl>

module IExtendedLifeCycle {

        interface FactoryFinder;

        typedef NamingStringSyntax::NameString FactoryKeyString;

        interface FactoryFinder : CosLifeCycle::FactoryFinder {
            CosLifeCycle::Factory find_factory(
                        in CosLifeCycle::Key factory_key)
                raises(
                        CosLifeCycle::NoFactory);

            CosLifeCycle::Factory find_factory_from_string(
                        in FactoryKeyString factory_key)
                raises(
                        CosLifeCycle::NoFactory,
                        IllegalStringSyntax,
                        UnMatchedQuote);

            CosLifeCycle::Factories find_factories_from_string(
                        in FactoryKeyString factory_key)
                raises(
                        CosLifeCycle::NoFactory,
                        IllegalStringSyntax,
                        UnMatchedQuote);

            Location get_location();
        };
};
```

For completeness, the interface specification for CosLifeCycle::FactoryFinder is:

```
#include <Naming.idl>

module CosLifeCycle {

        typedef Naming::Name Key;
```

```
        typedef Object Factory;
        typedef sequence Factories;

        exception NoFactory {
              Key search_key;
        };

        interface FactoryFinder {

               Factories find_factories(
                      in Key factory_key)
                  raises(
                       NoFactory);
        };
};
```

Using a Component Broker factory finder you can perform the following tasks:

- Find all of the factories that support creating objects of a specified type.
- Find one factory that supports creating objects of a specified type. If more than one factory could have been found, the factory finder returns only one of them. Which one is returned is indeterminate and may vary.
- Determine what location scope the factory finder operates on.

Because factory keys are CosNaming::Names, which as a sequence of structures of strings can be cumbersome to program, the Component Broker factory finder introduces factory-finding methods that accept the factory key using the name string syntax supported by the naming service.

Factory Repository

To assist in finding factories, the Component Broker life cycle service maintains a factory repository. Managed object factories (homes) are automatically registered in the factory repository when they're created, with the type (the principal interface) of object they support. Thus, you can use factory finders to find any managed object factory configured in the distributed system (given a large enough scope) for a given kind of managed object. The factory repository is partitioned over all three portions of the System Name Space (see “System Name Space” on page 114).

When you create a business object and assemble it into a managed object, a home for that object is automatically configured. That home is registered with Component Broker as supporting your business object's type. Typically this is the fully qualified IDL name given to the principal interface for your business object. For instance, in the Personal Life Insurance Application Example (in *Component Broker Programming Guide*), PolicyHolder is the principal interface name for the policy holder object, which is derived from the Customer and Person interfaces. If the PolicyHolder interface had been embedded in the LifeInsurance module, its fully qualified principal interface name would have been LifeInsurance::PolicyHolder.

The interface name that is registered with the home is important. It is used later when finding a factory that supports objects of the indicated interface. However, given the separation between the registered name and the actual object implementation, the object itself can be further extended to either support other interfaces, or to merely support additional implementation behavior. This can be accomplished without changing the interface name with which the home is registered, and without affecting the ability for applications to find a factory that supports the registered interface name.

When you use the Component Broker system management tools to configure a new home, you can specify what level of visibility to attribute to that home. This determines in which portion(s) of the system name space the home is registered, and consequently who can find that factory. The greater the visibility you assign to the home during its configuration, the more users can find that factory. If you intend for that factory to only be found by users in the same host, then you should restrict its visibility to just the host on which the factory resides. Users in other Hosts can find that factory, but have to do more work to do so. Partitioning the repository in this fashion offers maximum flexibility for controlling how factories are found, and minimizes the potential for single points of failure in the distributed system.

Finding a Factory

To find a factory, you must have a factory finder, either a managed object factory finder which you resolved from the system name space, or by creating a local-only one. The factory finder is then used to find a factory. When the factory finder was created, it had an established location scope. The location scope defines the area over which the factory finder searches for a factory that supports the desired type of managed object.

Using the factory finder, you can find an appropriate factory with the operations listed below, which belong to the IExtendedLifeCycle::FactoryFinder and CosLifeCycle::FactoryFinder interfaces:

- find_factory() operation
- find_factory_from_string() operation
- find_factories() operation
- find_factories_from_string() operation

Either of the first two operations return only one factory that supports the desired type of object, if one can be found. When multiple factories are found supporting the desired type of object, the factory finder determines which one to return to your program. Either of the last two operations returns all of the factories that support the desired kind of object within the location scope. It is then up to you to select the appropriate factory in your program, perhaps based on additional criteria that you define within your application.

This procedure demonstrates how to use a factory finder to find a factory. This is necessary to create a managed object using the Component Broker programming model.

In order to use a factory finder, you must have a factory finder that has been set with the desired location-scope. In addition to having a factory finder, you must know the principal interface of the kind of managed object that you want to create. A factory that is capable of creating the type of object you want must exist within the location-scope that you are searching. If not, you may have to expand your scope.

The following steps describe how to use a factory finder to find a factory:

1. You must have a factory finder that was set with the desired location scope (see “Locations” on page 97). When you create a local-only factory finder, you must supply the location scope. If you obtain a managed object factory finder from the system name space, the factory finder is pre-configured with the appropriate location scope.
2. Determine the principal interface of the type of object you want created. To find an appropriate factory, you need to the know the fully-qualified name of the principal interface of the type of object. This is the type of object the factory you are looking for is able to manufacture. When managed object factories (Homes) are defined to the system, they are registered with the principal interface name of the type of object they can create. This is used by the factory finder to key on the right factory to find; the registered principal interface name must match the name to the type of object you want created.
3. Find a factory that can create the relevant object. Use the find_factory(), find_factories(), find_factory_from_string(), or find_factories_from_string() operation to find the factory for which you are looking, depending on whether you want to find one or all factories that are able to create the type of object you want, and whether you want to specify the factory key with the CORBA standard

CosLifeCycle::Key type or with the more convenient string form (see “Factory Keys” on page 96). You may find that the operation you use most often is the find_factory_from_string() operation.

The example below illustrates how to use a default factory finder with a host-scope to find a factory that can create Policy objects.

```
// Declare a root naming context, a factory finder, and the
// targeted Factory

CORBA::Object_var intermediateObject;
IExtendedLifeCycle::FactoryFinder_var hostScopeFF;
CosLifeCycle::Factory_var policyHome;

// Obtain the default factory finder with a host-scope and
// narrow to a factory finder

intermediateObject = CBSeriesGlobal::nameService()->resolve_with_string(
  "host/resources/factory-finders/host-scope");
 hostScopeFF =
  ExtendedLifeCycle::FactoryFinder::_narrow(intermediateObject);

   // Find a factory that can create Policy objects

policyHome = hostScopeFF->find_factory_from_string(
   "Policy.object interface");
```

The factory finder looks only within its scope for a factory that supports the type of object specified in the factory key. If none can be found the factory finder raises a NoFactory exception. If this happens you should expand the scope boundary to obtain a factory finder with a broader scope and try the request again.

Also, to find the factory, the principal interface name (the *object interface*) specified in the `find_factory_from_string` must match exactly the name of the interface registered with the factory. If you can't find the factory that you expect, check the spelling and case of the principal interface you specified in the factory key. You can use the system management facilities to examine the interface name registered with the corresponding Home if you are uncertain of the exact spelling.

Obtaining a Factory Finder

Typically, once a managed factory finder is created, it is bound in the system name space for further use by other users or applications. Obtaining a factory finder is a matter of looking it up by its name in the system name space.

Component Broker automatically creates a number of factory finders and binds them in the system name space for immediate use (see “System Name Space” on page 114). These factory finders are referred to as the default factory finders. One default factory finder is produced and assigned a corresponding scope for each of the most commonly used scopes. The first set of these factory finders each considers only one location scope when searching for factories. The following is where these default factory finders are bound into the name space and the location scope they consider in their search:

/host/resources/factory-finders/host-scope
Searches for factories in this host.

/host/resources/factory-finders/<server-name>-server-scope
Searches for factories in server <server-name>.

/workgroup/resources/factory-finders/workgroup-scope
Searches for factories in this workgroup.

/workgroup/resources/factory-finders/<server-name>-server-scope
Searches for factories in server <server-name>.

/workgroup/resources/factory-finders/<server-group-name>-server-scope
Searches for factories of workload managed objects in server group <server-group-name>.

/cell/resources/factory-finders/cell-scope
Searches for factories in the cell.

/cell/resources/factory-finders/<server-name>-server-scope
Searches for factories in server <server-name>.

/cell/resources/factory-finders/<server-group-name>-server-scope
Searches for factories of workload managed objects in server group <server-group-name>.

In addition, there is another set of default factory finders which consider multiple location scopes when searching for factories. The following is where these default factory finders are bound into the name space and the location scopes they consider in their search:

/host/resources/factory-finders/host-scope-widened
Searches for factories starting in this host, then in this host's workgroup, then in the cell.

/host/resources/factory-finders/<server-name>-server-scope-widened
Searches for factories starting in server <server-name>, then in this host, then in this host's workgroup, then in the cell.

/workgroup/resources/factory-finders/workgroup-scope-widened
Searches for factories starting in this workgroup, then in the cell.

/workgroup/resources/factory-finders/<server-name>-server-scope-widened
Searches for factories starting in server <server-name>, then in the host that houses this server, then in that host's workgroup, then in the cell.

/workgroup/resources/factory-finders/<server-group-name>-server-scope-widened
Searches for factories of workload managed objects starting in server group <server-group-name>, then in the cell.

/cell/resources/factory-finders/<server-name>-server-scope-widened
Searches for factories starting in server <server-name>, then in the cell.

/cell/resources/factory-finders/<server-group-name>-server-scope-widened
Searches for factories of workload managed objects starting in server group <server-group-name>, then in the cell.

Given the structure of the name tree, you can locate factory finders for a different host or workgroup if you know the name of the host or workgroup. For example, in the paths listed previously, you can make the following substitutions:

- For `/workgroup/resources/` you can substitute `/.:/workgroups/<workgroup-name>/resources/`.
- For `/host/resources/` you can substitute `/.:/hosts/<host-name>/resources/` or `/workgroup/hosts/<host-name>/resources/` (if the host is in the same workgroup as your host).

Obtaining a Managed Factory Finder: The procedure below demonstrates how to obtain an existing factory finder from the system name space. You can only obtain a factory finder as demonstrated here if the name of the factory finder is known, and has been bound in the system name space.

1. Determine which factory finder you want to use: You need to know the name of a factory finder you want to use. This may be the name of the default factory finders automatically created and registered

in the system name space by Component Broker installation. It could also be a factory finder created be an administrator using systems management or possibly a factory finder that your application created and bound in the system name space at some earlier point in time.

2. Resolve the factory finder from the system name space: Use the naming service operations to resolve the named factory finder from the system name space, by the name determined in the previous step.

The following example obtains a default factory finder with host scope that was automatically created and registered during Component Broker installation:

```
// Declare a root naming context and the targeted factory finder

 CORBA::Object_var intermediateObject;
 IExtendedLifeCycle::FactoryFinder_var hostScopeFF;


// Obtain the default factory finder with a host-scope and narrow
// to a factory finder

 intermediateObject = CBSeriesGlobal::nameService()->resolve_with_string(
         "host/resources/factory-finders/host-scope");
 hostScopeFF =
         IExtendedLifeCycle::FactoryFinder::_narrow(
             intermediateObject);
```

Creating a Factory Finder

If none of the default factory finders has the location scope that you need, you can create other factory finders with different location scopes (see “Obtaining a Factory Finder” on page 90).

The first thing you have to decide is whether the factory finder needs to be a managed object, that is, whether you need to use it remotely, whether you want it to be persistent, and/or whether you want to register it in the system name space for others to use, or to use at a later time.

If you decide to create a managed factory finder, you can either create it from your program or you can use the Component Broker system management tools to create and configure one for you. In the former case, you can create one like any other managed object, by finding a factory that creates ILifeCycleManagedClient::FactoryFinder objects. This factory is a specialized home, and provides the createWithLocation() method for creating the factory finder. This method requires that you supply a reference to a managed Location object which defines the location scope of the factory finder being created.

The Component Broker system management application can be used to configure a factory finder. When configuring a new factory finder in this fashion, you also need to configure a Location object and associate it with this factory finder. In addition, you should edit the factory finder to provide information used to bind it into the name space.

If you decide to create a non-managed factory finder (also referred to as a local-only factory finder) you need to create it from your program using the local-only programming model for factory finders.

Creating a Managed Factory Finder: This procedure demonstrates how to create a new managed factory finder. This is useful when you need a factory finder with a new location scope. A managed factory finder is one that is a managed object, and therefore can be retained persistently. Only a managed factory finder can be registered in the system name space.

A managed factory finder is created essentially in the same way that any other managed object is created. First, an existing factory finder is obtained from the name space, and then this is used to find a factory for factory-finders.

The above scenario could lead to a circular dependency, that is you need a factory finder to create other factory finders. Each factory finder must have the desired location-scope for finding the factory finder factory. Usually this dependency is met with the pre-installed factory finders that are automatically created by Component Broker during installation. However, if the dependency chain cannot be met, it may be necessary to create a non-managed factory finder, configured with the appropriate location scope (which can be done without first obtaining a factory finder for it), and then proceed to use this non-managed factory finder to subsequently locate the desired factory-finder factory.

Creating a factory finder includes supplying its location scope. For a managed factory finder, the location scope provided must be a managed Location object. Thus, you have to obtain or create a location object first to supply during the factory finder creation process. Only managed location objects can be used with managed factory finders.

1. Obtain a factory finder with the desired location scope.

   You need a factory finder to find a factory with which to create your new factory finder. Alternately, you can create a non-managed factory finder to use for finding the factory-finder factory.

2. Use the factory finder to find a factory (a home) for factory finders.

   Having obtained a factory finder, you can now use it to find a factory for factory finders. You can do this with the find_factory(), find_factories(), find_factory_from_string(), or find_factories_from_string() methods. The factory-finder interface is ILifeCycleManagedClient::FactoryFinder. This is the principal interface name that you pass in to the find_factory* or find_factories* methods.

3. Obtain a desired location scope for the new factory finder.

   You need to set the location scope for the new factory finder. The desired location scope is defined by a specific location object. Managed factory finders must be set with a managed location scope. If the desired location scope already exists then you can obtain and supply it when creating the new factory finder. Otherwise, you have to create a new location object and set its scope. The procedure for obtaining a managed location object is described in "Obtaining a Managed Location Scope" on page 104 and the procedure for creating a new location object is described in "Creating a Managed Location Scope" on page 107.

4. Create the factory finder.

   The factory for factory finders has been specialized to make creating a factory finder easier. The factory specialization introduces the createWithLocation() method which you can use to create the factory. You need to narrow to the IExtendedLifeCycle::FactoryFinderHome interface to use this new method.

   The createWithLocation() method also allows you to register the resulting factory finder in the name space. This is useful if you want to retain this object for future use in your application. The relativeName parameter takes a string that is used to bind the object into the name space. If the visibleInCellNameTree parameter is 1, the object is bound at /.:/resources/factory-finders/<*relative-name*>. If the visibleInHostNameTree parameter is 1, the object is bound at /host/resources/factory-finders/<*relative-name*>. If the visibleInWorkGroupNameTree parameter is 1, the object is bound at /workgroup/resources/factory-finders/<*relative-name*>. If the relativeName is an empty string or if all three visibleIn* parameters are 0, the object is not registered in the system name space.

The following example demonstrates creation of a new factory finder, setting it with a host-scope, and binding it in the system name space under /host/resources/factory-finders with the name ClaimsProcessingScope. This new factory finder is created within the local host. The result is a new factory finder bound at /host/resources/factory-finders/ClaimsProcessingScope which is equivalent to the factory finder bound at /host/resources/factory-finders/host-scope.

```
// Declare an intermediate Object, the factory finder
// used to find the factory, a location object, factory,
// and the new factory finder.

 CORBA::Object_var intermediateObject;
 IExtendedLifeCycle::FactoryFinder_var hostScopeFF;
 IExtendedLifeCycle::Location_var hostScopeSL;
 IExtendedLifeCycle::FactoryFinderHome_var factoryOfFF;
 IExtendedLifeCycle::FactoryFinder_var myNewFF;


// Obtain the default factory finder with a host-scope and
// narrow to an IExtendedLifeCycle::FactoryFinder so that
// you can use the find_factory_from_string operation.

intermediateObject= CBSeriesGlobal::nameService()->resolve_with_string(
    "/host/resources/factory-finders/host-scope");
hostScopeFF =
    IExtendedLifeCycle::FactoryFinder::_narrow
    (intermediateObject);

// Obtain the default location scope with a host-scope and
// narrow to a host-scope location object

intermediateObject= CBSeriesGlobal::nameService()->resolve_with_string(
     "host/resources/locations/host-scope");
     hostScopeSL =
     IExtendedLifeCycle::Location::_narrow(intermediateObject);

// Find a factory for factory finders and narrow to a factory

intermediateObject = hostScopeFF->find_factory_from_string(
     "ILifeCycleManagedClient::FactoryFinder.object interface");
factoryOfFF = IExtendedLifeCycle::FactoryFinderHome::_narrow(
     intermediateObject);

// Use the factory to create a new factory finder, passing in
// the host location scope. This  also binds the new
// factory finder in the system name space.

myNewFF = factoryOfFF->createWithLocation(hostScopeSL,
     "ClaimsProcessingScope", 0, 1, 0);
```

Creating a Non-Managed Factory Finder: This procedure demonstrates how to create a new non-managed factory finder. This is useful for when you need a factory finder with a new location scope. A non-managed factory finder is a local-only object, and therefore cannot be retained persistently. Creating a managed factory finder is described in “Creating a Managed Factory Finder” on page 92. Only a managed factory finder can be registered in the system name space.

A non-managed factory finder is created as a local-only object. A factory, and by extension a factory-finder, is not required for creating a non-managed factory finder.

Part of creating a factory finder includes setting its location scope (see “Locations” on page 97). When creating a local-only factory finder, the location scope can be provided as a location object (managed or local-only), a scope-structure, a scope string, a sequence of location scopes, a sequence of scope-structures, or a sequence of scope strings.. For local-only factory finder creation, the location scope is most often provided in the form of a scope-string. If a location already exists with the appropriate scope, it can be used when creating the local-only factory finder.

You can create a non-managed factory finder in one of the following ways:

1. Create it with a default non-managed location scope using the ILifeCycleLocalObjectImpl::FactoryFinder::_create static function. This produces a non-managed location scope object set with a scope boundary of "*LOCAL.cell/*LOCAL.workgroup/*LOCAL.host/*ANY.server/*ANY.container/*ANY.home."
2. Create it with a specific managed or non-managed location object using the ILifeCycleLocalObjectImpl::FactoryFinder::_create(Location) static function.
3. Create it with a scope-structure using the ILifeCycleLocalObjectImpl::FactoryFinder::_create(Scope) static function. This produces a non-managed location scope object with a scope boundary set to the values supplied in the Scope structure.
4. Create it with a scope-string using the ILifeCycleLocalObjectImpl::FactoryFinder::_create(ScopeString) static function. This produces a non-managed location scope object with a scope boundary set to the values supplied in the Scope string.
5. Create it with a sequence of managed or non-managed location objects using the ILifeCycleLocalObjectImpl::FactoryFinder::_create(SequenceOfLocation) static function. This produces a non-managed ordered location object with scope boundarys set to the scopes of each location in the sequence.
6. Create it with a sequence of scope-structures using the ILifeCycleLocalObjectImpl::FactoryFinder::_create(OrderedScopes) static function. This produces a non-managed ordered location scope object with a scope boundary set to the values supplied in the OrderedScopes structure.
7. Create it with a sequence of scope-strings using the ILifeCycleLocalObjectImpl::FactoryFinder::_create(OrderedScopeStrings) static function. This produces a non-managed ordered location scope object with a scope boundary set to the values supplied in the Scope strings.

All of these are over-loaded C++ static class functions and can only be invoked locally from a VisualAge C++ program.

In the example below you create a new non-managed factory finder and set it with a host scope using a scope-string:

```
 // Declare the new factory finder.

  IExtendedLifeCycle::FactoryFinder_var myNewFF;

// Create the new factory finder set
// with a host scope for the local host

  myNewFF = ILifeCycleLocalObjectImpl::FactoryFinder::_create(
         "*LOCAL.cell/*LOCAL.workgroup/*LOCAL.host/*ANY.server
         /*ANY.container/*ANY.home");
```

Configuring a Managed Factory Finder

A new managed factory finder can be created by configuring it using the Component Broker system management facility. This is useful for when you need a factory finder with a new location scope. A managed factory finder is one that is a managed object, and therefore can be retained persistently. Only a managed factory finder can be registered in the system name space. This procedure is entirely administrative and does not involve any programming.

Part of configuring a factory finder includes setting its location scope. The location scope is expressed as an object (see “Locations” on page 97). Thus, you need to first configure a location object which then is used during the factory finder configuration process. If an appropriate location object is already configured, you can use it during the configuration process for the factory finder. Otherwise, the process for configuring a location scope is described in the “Configuring a Managed Single-Location Scope” in the *Component Broker for Windows NT and AIX System Administration Guide*.

The procedure for configuring a managed object factory finder is also documented in the *Component Broker for Windows NT and AIX System Administration Guide*.

Factory Keys

A factory key is specified as an argument in each of the factory-finder operations. This key is used to provide information about the factory that you want to get. With Component Broker, you can identify the desired factory based on the following parameters:

- The type of object (principal interface name) that the factory creates
- The home in which the objects created by the factory exist
- The interface name of the factory itself

Depending on the operation, the key may be a CosLifeCycle::Key or an IExtendedLifeCycle::FactoryKeyString. When expressed as a CosLifeCycle::Key, the key is a sequence of structures, actually a CosNaming::Name structure, where each element contains two string fields: an *id* and a *kind* field. When the kind-field of the element is set to “object interface,” then the id-field should be set with the fully qualified interface name of the object type the factory creates. This key type is required. When the kind-field of the element is set to “object home,” then the id-field should be set with the name of the home of the objects which the factory creates. This key type is optional. When the kind-field of the element is set to “factory interface,” then the id-field should be set with the interface ID of the factory itself. The interface ID is a string which is generated by the IDL compiler for each interface in the IDL. This string can be accessed using the <interface name>_RID variable. This key type is optional.

For example, to find a factory capable of creating factory finders, you could create the a key as follows:

```
CosLifeCycle::Key       key(3);
key.length(3);
key[0].kind = CORBA::string_dup("object interface");
key[0].id   = CORBA::string_dup
 ("ILifeCycleManagedClient::FactoryFinder");
key[1].kind = CORBA::string_dup("object home");
key[1].id   = CORBA::string_dup("FactoryFinderFactory");
key[2].kind = CORBA::string_dup("factory interface");
key[2].id   = CORBA::string_dup
 (::IExtendedLifeCycle::FactoryFinderHome::FactoryFinderHome_RID
   );
```

The elements of the key structure may appear in any order. If the kind-field of a key element is not one of the three recognized strings, that element is ignored. No error is generated in this case.

The CosNaming::Name structure is fairly complex and therefore somewhat cumbersome to program. To make it easier to perform, Component Broker introduces two variations of the find_factory() and find_factories() methods that take the factory key as a compound name string. The find_factory_from_string() and find_factories_from_string() methods take this factory key as a string, and use the NamingStringSyntax::StandardSyntaxModel to convert the string into a regular factory key. Thus the factory key string can be specified as “Policy.object interface/PolicyUUIDFactory.object home,” for instance, to find a factory that creates Policy objects.

Locations

Component Broker strives to make managed objects local/remote transparent. This makes it possible for you to program your application without regard to whether the objects you are using are local to your application or remote in another process, or even in another host somewhere across the network. The proximity of the objects you are using only becomes evident when you consider side effects, such as the latency associated with invoking requests on the object.

However, there are times when location does matter, most notably when the object is being created. For a variety of reasons, including performance in the overall system, enterprises want certain kinds of objects created in certain places.

These concerns, including the desire to retain a degree of ambiguity in the way that proximity is communicated, and the need for resolving precision in a given context, exist for proximity evaluation in distributed systems. To assist in this, Component Broker introduces the concept of a location object. A location object is intended to be an abstraction for proximity, establishing a vocabulary with which proximity can be communicated, and yet encapsulating the precision that is needed to make concrete decisions in the distributed computing system.

In a general sense, location objects can be introduced to represent different categories of proximity scopes, including the items listed below:

Infrastructural
: homes, containers, and servers

Topological
: hosts, workgroups, and cells

Physical
: rooms, floors, buildings, sites

Political
: departments, projects, companies, governments

Geographical
: cities, time zones, countries, continents

Proximal
: here, near, far

Temporal
: now, soon, later

Compound
: combining any of the above

Compound-conditional
: representing different scopes based on some condition

Compound-temporal-conditional
representing different scopes at different times

Locations and Factory Finding

Factory finders are always configured with a Location object. Component Broker introduces an abstract interface (IExtendedLifeCycle::Location) which is used by the factory finder. This interface allows the factory finder to determine the proximity within which to perform the factory finding operations. Referencing the categories of proximity described in the previous section, the IExtendedLifeCycle::Location interface allows the factory finder to have a compound scope which combines the infrastructural and topological definitions as they relate to Component Broker. The proximity is defined by a scope structure which is obtained by the factory finder using the get_scopes() operation.

By using the infrastructural and topological location scope information provided by the Location object, the factory finder limits where it searches for factories. If you consider your entire Component Broker distributed network as the universe within which factories can be found, the location scope defines a subset of that universe. The subset it defines can be as large as the entire cell, as small as identifying a specific home, or anywhere in between. Therefore, you can think about factory finding as an operation looking for a factory which satisfies the specified factory key (see “Factory Keys” on page 96) that exists in the subset of the Component Broker distributed network defined by the location scope of the factory finders objects contained Location object.

Location Object Implementations

The IExtendedLifeCycle::Location interface upon which the factory finders depend is an abstract interface. Component Broker provides two different implementations of this interface. These implementations are used to provide default Location objects as part of the Component Broker environment and can also be used to create locations of your own definition.

Single Location
Single Location objects support the interface IExtendedLifeCycle::SingleLocation. This interface defines the scope of location to be defined by a combination of the infrastructural (home, container, server) and topological (host, workgroup, cell) proximities.

Ordered Location
Ordered Location objects support the interface IExtendedLifeCycle::OrderedLocation. This interface defines the scope of location to be an ordered sequence of location scopes provided by other Location objects. This provides a Location object implementation which meets the compound proximity definition.

In addition to these Component Broker provided implementations of location, it is also possible to provide your own implementation of the Location interface to meet your own unique requirements.

Location Object Implementations and Proximity

You can use the Component Broker supplied implementations to create instances of Location objects which satisfy some of the other categories of proximity within your environment. For example, suppose you wanted to have a Location object which represented all of the hosts within a department (political proximity). This can be done by having a single Location object for each host within the department and then have an ordered Location object which contained all of these single Location objects.

There are times when you want to create your own implementation of a Location object. Suppose you wanted a compound-conditional Location object which found factories within the departmental resources of the user for whom the request is being made. You could start by having several of the departmental locations described above. Then provide an implementation of the location interface which contained these departmental location. Your implementation could then determine which departmental location to use, based on the principal ID contained within the context of the current request.

Once a location object is instantiated and set with specific state values that define the boundaries of its actual scope, that location object can then be added to the vocabulary for communicating proximity. This is accomplished by binding the location object with a name in the system name space (see “System Name Space” on page 114).

For example, you could bind the departmental locations described previously in /.:/resources/locations with names like accounting-dept, purchasing-dept, and so on. You can also have a corresponding factory finder for each of these and you could bind them into /.:/resources/factory-finders using the same names (accounting-dept, purchasing-dept, and so on). You can now make statements about creating an object within the accounting department and have a specific programming mechanism to find the appropriate factory (that is, use the factory finder bound at /.:/resources/factory-finders/accounting-dept). In addition, when new hosts are added to the accounting department, the single-location objects defining those hosts can be added to the departmental ordered location. The result is that no changes need to be made to any code to accommodate the configuration changes within the department, yet all the factories on those new hosts are available for use by your applications.

Component Broker Location Scopes

Location scopes operate with six state variables, three of which represent infrastructure scope boundaries, *home, container, and server,* and three of which represent topology scope boundaries, *host, workgroup, and cell.*

Any of the infrastructure boundary-elements can be set with either a name or the keyword *ANY, with the following rule: Once *ANY has been specified for a higher level scope boundary, each of the lower level boundary elements must be set to *ANY as well. For the specification of a server name, use of either *SERVERNAME or *SERVERGROUPNAME is valid as well. The following table defines valid values and resulting scopes that can be specified for the infrastructure boundary elements of a single location object:

Table 9. Single Location Infrastructure Boundary-Element Values/Scopes

Server	Container	Home	Resulting Infrastructure Scope
name, *SERVERNAME, *SERVERGROUPNAME	name	name	A specific home in a specific container in a specific server or server -group
name, *SERVERNAME, *SERVERGROUPNAME	name	*ANY	Any home in a specific container in a specific server or server-group
name, *SERVERNAME, *SERVERGROUPNAME	*ANY	*ANY	Any home in any container in a specific server or server-group
*ANY	*ANY	*ANY	Any home in any container in any server or server-group

Note: The support of *SERVERNAME, *SERVERGROUPNAME and *LOCALNAME may be removed in a future release, and therefore it is best to avoid use of these keywords if possible.

The name specified in each case in the above table is the name for the corresponding component as defined for it when it was configured with the Component Broker system management application. When *SERVERNAME is specified, the Component Broker run time substitutes the name of the current server process. If the current process is not a server process (for example, a client .exe with a local-only Location object) an error is raised.

When *SERVERGROUPNAME is specified, the name of the server group to which the current server process belongs is substituted. When this is the case, the server group must be a workload managed server group or an error is raised by the run time. The semantics of how the rules are applied to these keywords are the same as if the specific name was provided.

Any of the topology boundary elements can be set with either a name or one of the keywords *LOCAL, *LOCALNAME, or *IGNORE, with the following rules:

- Once *LOCAL has been specified for a lower-level scope boundary, each of the higher-level boundary elements must be set to *LOCAL as well
- *LOCALNAME is treated semantically the same as name
- Because Component Broker only supports a single cell, the cell boundary element must always be set to *LOCAL

The topology boundary-element values are used to form a name path. The resulting name path is used to resolve to a portion of the system name space representing a different portion of the distributed system topology. In this way, when used with factory finding, the location object can be used to narrow or expand the scope over which factories are found; finding only factories which have been registered with the corresponding level of visibility.

The following table defines the valid values and resulting scopes that can specified for the topology boundary-elements of a location object:

Table 10. Single Location Topology Boundary-Element Values/Scopes

Cell	Workgroup	Host	Resulting Topology Scope (As a Name Path)
*LOCAL	name, *LOCALNAME	name, *LOCALNAME	/.:/workgroups/<workgroup-name>/hosts/<host-name>
*LOCAL	name, *LOCALNAME	*IGNORE	/.:/workgroups/<workgroup-name>
*LOCAL	*IGNORE	name, *LOCALNAME	/.:/hosts/<host-name>
*LOCAL	*IGNORE	*IGNORE	/.:
*LOCAL	*LOCAL	name, *LOCALNAME	/workgroup/hosts/<host-name>
*LOCAL	*LOCAL	*IGNORE	/workgroup
*LOCAL	*LOCAL	*LOCAL	/host

The name specified in each case in the above table is the name for the corresponding element in the topology as defined for it in the system name space. The resulting name paths represent where resources are located in the system name space, and by extension implying where they are located in the system topology.

*LOCALNAME results in the name of the host or workgroup being substituted by the Component Broker run time when this is a managed Location object. This is important for the case where the managed Location object is contained by a factory finder in a remote host. When the Location object is a local-only object, *LOCAL is substituted for *LOCALNAME. This yields the correct semantic result as the local-only Location object cannot be accessed by a remote factory finder object.

Factory Finding Using Location Scopes

Location objects can be used in factory finding by controlling the scope over which factories are found. The following list contains an example of boundary values for SingleLocation objects:

- cell = “*LOCAL”
- workgroup = “consumer insurance”
- host = “*IGNORE”
- server = “whole life”
- container = “*ANY”
- home = “*ANY”

If you set a location scope with the above boundary values and register this location object with a factory finder, then the factory finder looks in the “whole life” server in the “consumer insurance” workgroup for the desired factory.

For Location objects, the scope boundary is specified in a structure containing fields for each of the boundary elements. The scope boundary values can be specified as a string using the name string syntax supported by the naming service. In this form, scope boundary values can be expressed as in the following example:

```
<cell-value>.cell/<workgroup-value>.workgroup/
    <host-value>.host/<server-value>.server/
        <container-value>.container/<home-value>.home
```

In each name component, the kind field is used to identify the boundary value, and the id field is used to specify the value (denoted in angle-brackets in the above example) to be used for that boundary value. So for the life insurance example above, the scope boundary could be expressed as in the following example:

```
*LOCAL.cell/consumer insurance.workgroup/*IGNORE.host/
        whole life.server/*ANY.container/*ANY.home
```

Obtaining a Location Scope

Typically, when a location scope (specifically, a managed Location object) is created it is bound in the system name space for further use by other users or applications (see “System Name Space” on page 114). Thus, obtaining a location scope is a matter of looking it up by its name in the system name space. The procedure for obtaining a location scope in this way is described in “Obtaining a Managed Factory Finder” on page 91.

Component Broker automatically creates a number of location scopes and binds them in the system name space for immediate use. These are referred to as the *default location scopes*. Each default location scope is initialized to a corresponding scope boundary for the most commonly used scopes. Default scopes and their boundary values are listed following:

/host/resources/locations/host-scope
Limits boundary to the local host. The boundary value is set to:

```
*LOCAL.cell/*LOCAL.workgroup/*LOCALNAME.host
          /*ANY.server/*ANY.container/*ANY.home
```

/host/resources/locations/<servername>-server-scope
Limits boundary to server. The boundary value is set to:

```
*LOCAL.cell/*LOCAL.workgroup/*LOCALNAME.host
          /*SERVERNAME.server/*ANY.container/*ANY.home
```

/workgroup/resources/locations/workgroup-scope
Limits boundary to the local workgroup. The boundary value is set to:

```
*LOCAL.cell/*LOCALNAME.workgroup/*IGNORE.host
           /*ANY.server/*ANY.container/*ANY.home
```

/workgroup/resources/locations/<servername>-server-scope

Limits boundary to server. The boundary value is set to:

```
*LOCAL.cell/*LOCAL.workgroup/*LOCALNAME.host
           /*SERVERNAME.server/*ANY.container/*ANY.home
```

/workgroup/resources/locations/<servergroupname>-server-scope

Searches for Limits boundary to server group. The boundary value is set to:

```
*LOCAL.cell/*LOCALNAME.workgroup/*IGNORE.host
           /*SERVERGROUPNAME.server/*ANY.container/*ANY.home
```

/cell/resources/locations/cell-scope

Limits boundary to the local cell. The boundary value is set to:

```
*LOCAL.cell/*IGNORE.workgroup/*IGNORE.host
           /*ANY.server/*ANY.container/*ANY.home
```

/cell/resources/locations/-server-scope

Limits boundary to server. The boundary value is set to:

```
*LOCAL.cell/*LOCAL.workgroup/*LOCALNAME.host
           /*SERVERNAME.server/*ANY.container/*ANY.home
```

/cell/resources/locations/-server-scope

Limits boundary to server group. The boundary value is set to:

```
*LOCAL.cell/*LOCALNAME.workgroup/*IGNORE.host
           /*SERVERGROUPNAME.server/*ANY.container/*ANY.home
```

In addition, there is another set of default locations which consider multiple location scopes when searching for factories. The following is where these default locations are bound into the name space and the location scopes they consider in their search:

/host/resources/locations/host-scope-widened

Limits boundary to the local host, followed by the local workgroup, followed by the local cell. The boundary value is set to:

```
*LOCAL.cell/*LOCAL.workgroup/*LOCALNAME.host
           /*ANY.server/*ANY.container/*ANY.home
*LOCAL.cell/*LOCALNAME.workgroup/*IGNORE.host
           /*ANY.server/*ANY.container/*ANY.home
*LOCAL.cell/*IGNORE.workgroup/*IGNORE.host
           /*ANY.server/*ANY.container/*ANY.home
```

/host/resources/locations/<servername>-server-scope-widened

Limits boundary to server, followed by the local host, followed by the local workgroup, followed by the local cell. The boundary value is set to:

```
*LOCAL.cell/*LOCAL.workgroup/*LOCALNAME.host
           /*SERVERNAME.server/*ANY.container/*ANY.home
*LOCAL.cell/*LOCAL.workgroup/*IGNORE.host
           /*ANY.server/*ANY.container/*ANY.home
*LOCAL.cell/*LOCAL.workgroup/*LOCALNAME.host
           /*ANY.server/*ANY.container/*ANY.home
*LOCAL.cell/*LOCALNAME.workgroup/*IGNORE.host
           /*ANY.server/*ANY.container/*ANY.home
*LOCAL.cell/*IGNORE.workgroup/*IGNORE.host
           /*ANY.server/*ANY.container/*ANY.home
```

/workgroup/resources/locations/workgroup-scope-widened

Limits boundary to the local workgroup, followed by the local cell. The boundary value is set to:

```
*LOCAL.cell/*LOCALNAME.workgroup/*IGNORE.host
           /*ANY.server/*ANY.container/*ANY.home
*LOCAL.cell/*IGNORE.workgroup/*IGNORE.host
           /*ANY.server/*ANY.container/*ANY.home
```

/workgroup/resources/locations/<servername>-server-scope-widened

Limits boundary to server, followed by the local host, followed by the local workgroup, followed by the local cell. The boundary value is set to:

```
  *LOCAL.cell/*LOCAL.workgroup/*LOCALNAME.host
             /*SERVERNAME.server/*ANY.container/*ANY.home
  *LOCAL.cell/*LOCAL.workgroup/*IGNORE.host
             /*ANY.server/*ANY.container/*ANY.home
  *LOCAL.cell/*LOCAL.workgroup/*LOCALNAME.host
             /*ANY.server/*ANY.container/*ANY.home
  *LOCAL.cell/*LOCALNAME.workgroup/*IGNORE.host
             /*ANY.server/*ANY.container/*ANY.home
  *LOCAL.cell/*IGNORE.workgroup/*IGNORE.host
             /*ANY.server/*ANY.container/*ANY.home
```

/workgroup/resources/locations/<servergroupname>-server-scope-widened

Limits boundary to managed server group, followed by the local workgroup, followed by the local cell. The boundary value is set to:

```
  *LOCAL.cell/*LOCALNAME.workgroup/*IGNORE.host
             /*SERVERGROUPNAME.server/*ANY.container/*ANY.home
  *LOCAL.cell/*LOCALNAME.workgroup/*IGNORE.host
             /*ANY.server/*ANY.container/*ANY.home
  *LOCAL.cell/*IGNORE.workgroup/*IGNORE.host
             /*ANY.server/*ANY.container/*ANY.home
```

/cell/resources/locations/<servername>-server-scope-widened

Limits boundary to server, followed by the local host, followed by the local workgroup, followed by the local cell. The boundary value is set to:

```
  *LOCAL.cell/*LOCAL.workgroup/*LOCALNAME.host
             /*SERVERNAME.server/*ANY.container/*ANY.home
  *LOCAL.cell/*LOCAL.workgroup/*IGNORE.host
             /*ANY.server/*ANY.container/*ANY.home
  *LOCAL.cell/*LOCAL.workgroup/*LOCALNAME.host
             /*ANY.server/*ANY.container/*ANY.home
  *LOCAL.cell/*LOCALNAME.workgroup/*IGNORE.host
             /*ANY.server/*ANY.container/*ANY.home
  *LOCAL.cell/*IGNORE.workgroup/*IGNORE.host
             /*ANY.server/*ANY.container/*ANY.home
```

/cell/resources/locations/<servergroupname>-server-scope-widened

Limits boundary to managed server group, followed by the local workgroup, followed by the local cell. The boundary value is set to:

```
  *LOCAL.cell/*LOCALNAME.workgroup/*IGNORE.host
             /*SERVERGROUPNAME.server/*ANY.container/*ANY.home
  *LOCAL.cell/*LOCALNAME.workgroup/*IGNORE.host
             /*ANY.server/*ANY.container/*ANY.home
  *LOCAL.cell/*IGNORE.workgroup/*IGNORE.host
             /*ANY.server/*ANY.container/*ANY.home
```

Given the structure of the name tree, you can locate locations for a different host or workgroup if you know the name of the host or workgroup. For example, in the paths listed previously, you can make the following substitutions:

- For /workgroup/resources/ you can substitute /.:/workgroups//resources/.
- For /host/resources/ you can substitute /.:/hosts//resources/ or /workgroup/hosts//resources/ (if the host is in the same workgroup as your host).

Obtaining a Managed Location Scope: The following procedure demonstrates how to obtain an existing location scope from the system name space. This is useful when a location scope that you want to use has already been created and registered in the system name space. You can only obtain a location scope in the fashion demonstrated here if the location scope already exists and has been bound in the system name space. You must know the name of that location scope to use this procedure.

1. Determine which location scope you want to use. You need to know the name of the location scope you want to use. This may be the name of the default location scopes automatically created and registered in the system name space by Component Broker installation. Or it could be a location scope that your application created and bound in the system name space earlier.
2. Resolve the location scope from the system name space. Use the naming service operations to resolve that named location scope from the system name space, by the name that you determined in step 1.

In the following example you obtain a default location with host scope, one that was automatically created and registered during Component Broker installation.

```
// Declare a root naming context and the targeted location
// scope

CORBA::Object_var intermediateObject;
IExtendedLifeCycle::Location_var hostScopeL;


// Obtain the default location scope with a host-scope

intermediateObject = CBSeriesGlobal::nameService()->resolve_with_string(
  "/host/resources/locations/host-scope");
hostScopeSL =
   ExtendedLifeCycle::Location::_narrow(intermediateObject);
```

Creating Other Location Scopes: If none of the default location scopes has the scope you need, you can create other location scopes with a different scope boundary. The first thing you have to decide is whether the location scope needs to be a managed object, that is, whether you need to use it remotely, whether you want it to be persistent, and whether you want to register it in the system name space for others to use, perhaps at a later time.

Because the predominant use for location scopes in Component Broker is with factory finding, then to a large extent, how you create the corresponding factory finder drives how you create its corresponding location object.

If you create a managed factory finder, it needs to have a managed location scope registered with it. If you create a non-managed factory finder, it can have either a non-managed location scope or a managed location scope registered with it.

If you configure a factory finder using the Component Broker system management tools, then the corresponding location object must also be configured by the system management tools.

You can create a managed location scope from your program, or by using the Component Broker System Manager user interface.

- From your program, you can create a managed location scope like any other managed object, by finding a factory that creates ILifeCycleManagedClient::SingleLocation objects and using the createWithLocation() method to create one. This is described fully in "Creating a Managed Location Scope" on page 107.
- Using the System Manager user interface to create a managed location scope is described in the "Configuring a Managed Single-Location Scope" topic in the *Component Broker for Windows NT and AIX System Administration Guide*.

A managed location object can be retained persistently. Only a managed location object can be registered in the system name space.

If you decide to create a non-managed location scope (also referred to as a local-only location scope) you have to create it from your program using the local-only programming model for location scopes. This is described in more detail in "Creating a Non-Managed Single-Location Scope" on page 110

Another consideration is whether you need a SingleLocation or an OrderedLocation. If your search area can be defined by a single location scope, then you can use a SingleLocation. This is described fully in "Component Broker SingleLocations." If you cannot limit your search area to one that can be described by a single scope, then you may need the added flexibility of an OrderedLocation. OrderedLocations allow you to specify a search location as an ordered set of location scopes. This is described fully in "Component Broker OrderedLocations" on page 106.

Component Broker SingleLocations: SingleLocations have a scope boundary that is defined by only one scope. A SingleLocation can be used to create a FactoryFinder that searches for factories within the boundary defined by that scope. Two methods are provided to examine the content of the scope. The get_scope() method is the more convenient to use because it returns the scope in a Scope structure. SingleLocation also implements the get_scopes() method inherited from IExtendedLifeCycle::Location. This method returns the scope as the first and only element of an OrderedScopes sequence.

Component Broker provides two SingleLocation implementations, both of which support the IExtendedLifeCycle::SingleLocation interface. One implementation of SingleLocation is implemented as a local-only object, and the other is implemented as a managed object. The first of these two implementations of SingleLocation can be instantiated at run time but is not remoteable, while the second can be created persistently and registered in the system name space, and can be used remotely.

The IDL for Component Broker SingleLocation objects is listed following:

```
#include <CosLifeCycle.idl>
#include <NamingStringSyntax.idl>
module IExtendedLifeCycle {
        interface Location;
        interface SingleLocation;
        struct Scope {
              CosNaming::Istring cell;
              CosNaming::Istring workgroup;
              CosNaming::Istring host;
              CosNaming::Istring server;
              CosNaming::Istring container;
              CosNaming::Istring home;
        };
        typedef sequence OrderedScopes;
        typedef NamingStringSyntax::NameString ScopeString;

        exception InvalidScope {
              Scope scope;
        };
        exception IllegalStringSyntax {
              unsigned long illegal_syntax_position;
              CosNaming::Istring parsed_substring;
        };
        exception UnMatchedQuote {
              unsigned long begin_quote_position;
              CosNaming::Istring ambiguous_substring;
        };
        exception UnrecognizedScopeElement {
              CosNaming::Istring element
        };
        interface ScopeManipulator {
              ScopeString scope_to_string(in Scope scope)
                        raises(InvalidScope);
                 Scope string_to_scope(
                                in ScopeString scope_string)
                        raises(
                                InvalidScope,
                                UnrecognizedScopeElement,
                                IllegalStringSyntax,
                                UnMatchedQuote);
          };

          interface Location {
                  OrderedScopes get_scopes();
          };
          interface SingleLocation :
                        Location {
                  Scope get_scope();
          };
   };
```

Component Broker OrderedLocations: OrderedLocations have a scope boundary that can be defined by multiple other Location objects. An OrderedLocation can be used to create a FactoryFinder that searches for factories within the boundary defined by the first Location scope, followed by the second Location scope, and so on. Such a factory only returns a NoFactory exception if it is unable to find a factory using ANY of the individual Locations that comprise the OrderedLocation. The individual Locations can be examined using the get_locations() method, which returns a SequenceOfLocations. OrderedLocation also implements the get_scopes() method inherited from IExtendedLifeCycle::Location. This method returns all the scopes that define the OrderedLocation boundary in an OrderedScopes sequence.

Component Broker provides two OrderdLocation implementations, both of which support the IExtendedLifeCycle::OrderdLocation interface. One implementation of OrderdLocation is implemented as a local-only object and the other is implemented as a managed object. The first of these two implementations of OrderdLocation can be instantiated at run time but is not remoteable while the second can be created persistently and registered in the system name space, and can be used remotely.

Creating a Managed Location Scope

Only a managed location object can be registered in the system name space. This procedure demonstrates how to create a new location scope object. This is useful for when you need a new location scope. A managed location object can be retained persistently.

A managed location scope is created essentially in the same way that any other managed object is created, by first obtaining a factory finder with the desired location scope and then using the factory finder to find a factory for location scope objects.

Notice that the above scenario could lead to a circular dependency, that is, you need a location scope to create other location scopes. Each factory finder must have the desired location-scope for the succeeding location scope. Usually this dependency is met with the pre-installed factory finders and pre-installed location scopes that are automatically created by Component Broker during installation. However, if the dependency chain cannot be met, the alternative is to create a non-managed location scope (which can be done without first obtaining a factory finder for it), set it with the appropriate scope boundary, and then proceed to use this to subsequently create the desired factory-finder with which to find a factory for the new location scope.

The following steps are used to create a new single-location scope object:

1. Obtain a factory finder with the desired location scope.

   You need a factory finder to find a factory with which to create your new location scope. The procedure for obtaining a factory finder is described in “Obtaining a Managed Factory Finder” on page 91. Alternately, you can create a non-managed factory finder to use for finding the new location scope's factory. The procedure for creating a non-managed factory finder is described in “Creating a Non-Managed Factory Finder” on page 94.

2. Use the factory finder to find a factory (a Home) for location scopes.

   Having obtained a factory finder, you can now use it to find a factory for location scopes. You can do this with the find_factory(), find_factories(), find_factory_from_string(), or find_factories_from_string() methods. These methods require the object interface name as a parameter. If you wish to create a SingleLocation scope, the interface is ILifeCycleManagedClient::SingleLocation. If you wish to create an OrderedLocation scope, the interface is ILifeCycleManagedClient::OrderedLocation.

3. Create the location scope.

   The factories for location scopes have been specialized to make creating a location scope easier.

   The factory specialization for SingleLocation introduces the createWithScope() and createWithScopeString() methods which you can use to create the location scope. These methods let you set the scope boundary at the same time. You need to narrow to the IExtendedLifeCycle::SingleLocationHome interface to use either of these methods.

   The factory specialization for OrderedLocation introduces the createWithLocations(), createWithScopes(), and createWithScopeStrings() methods which you can use to create the location scope. These methods also let you set the scope boundary, either by specifying the scopes directly or by using other existing Location objects which have the desired scopes. You need to narrow to the IExtendedLifeCycle::OrderedLocationHome interface to use either of these methods.

All of these creation methods also allow you to register the resulting Location in the name space. This is useful if you want to retain the object for future use in your application. The relativeName parameter takes a string that is used to bind the object into the name space. The relativeName may contain the reserved strings "$SERVERNAME$" or "$SERVERGROUPNAME$." If "$SERVERNAME$" is part of the relativeName, the name of the server is substituted at run time. If "$SERVERGROUPNAME$" is part of the relativeName, the name of the server group to which the current server process belongs is substituted. The server group must be a workload managed server group or an error is raised by the run time. If the visibleInCellNameTree parameter is 1, the object is bound at `/.:/resources/locations/`. If the visibleInHostNameTree parameter is 1, the object is bound at `/host/resources/locations/`. If the visibleInWorkGroupNameTree parameter is 1, the object is bound at `/workgroup/resources/locations/`. If the relativeName is an empty string or if all three visibleIn* parameters are 0, the object is not registered in the system name space.

In the following example, you create a new SingleLocation scope, set it with a host-scope, and bind it in the system name space under `/host/resources/locations` with the name ClaimsProcessingScope. You create the new location scope within the local host.

In the following example, you create a new SingleLocation scope, set it with a host-scope, and bind it in the system name space under `/host/resources/locations` with the name ClaimsProcessingScope. You create the new location scope within the local host.

```
// Declare an intermediate Object, a root naming context, the
// locations naming context, the targeted factory finder where
// the new location scope locations will be created, a location
// scope factory, and the new location scope.

CORBA::Object_var intermediateObject;
IExtendedNaming::NamingContext_var locationsNC;
IExtendedLifeCycle::FactoryFinder_var hostScopeFF;
IExtendedLifeCycle::SingleLocationHome_var factoryOfSL;
IExtendedLifeCycle::Location_var myNewSL;


// Obtain the default factory finder with a host-scope and
// narrow to an IExtendedLifeCycle::FactoryFinder so that
// you can use the find_factory_from_string() operation.

intermediateObject= CBSeriesGlobal::nameService()->resolve_with_string(
      "/host/resources/factory-finders/host-scope");
 hostScopeFF =
      IExtendedLifeCycle::FactoryFinder::_narrow
(intermediateObject);

// Find a factory for location scopes and narrow to a factory

intermediateObject = hostScopeFF->find_factory_from_string(
     "ILifeCycleManagedClient::SingleLocation.object interface");
 factoryOfFF = IExtendedLifeCycle::SingleLocationHome::_narrow
      (intermediateObject);

// Use the factory to create a new location scope, passing
// in the hostscope boundary.

myNewSL = factoryOfSL->createWithScopeString(
      "*LOCAL.cell/*LOCAL.workgroup/*LOCAL.host/*ANY.server
```

```
      /*ANY.container/*ANY.home",
                              "ClaimsProcessingScope",// relativeName
                              0,       // not visibleInCell
                              1,      // visibleInHostNameTree
                              0);    // not visibleInWorkgroup
```

In the following example, you create a new OrderedLocation scope, set it with the local server's scope, followed by the host-scope, and bind it in the system name space under `/host/resources/locations` with the name *server-name*Scope (where *server-name* is the name of the local server). You create the new location scope within the local host.

```
// Declare an intermediate Object, a root naming context, the
// locations naming context, the targeted factory finder where
// the new location scope locations will be created, a location
// scope factory, and the new location scope.

CORBA::Object_var intermediateObject;
IExtendedNaming::NamingContext_var locationsNC;
IExtendedLifeCycle::FactoryFinder_var hostScopeFF;
IExtendedLifeCycle::OrderedLocationHome_var factoryOfOL;
IExtendedLifeCycle::OrderedLocation_var myNewOL;


// Obtain the default factory finder with a host-scope and
// narrow to an IExtendedLifeCycle::FactoryFinder so that
// you can use the find_factory_from_string() operation.

intermediateObject= CBSeriesGlobal::nameService()->resolve_with_string(
      "/host/resources/factory-finders/host-scope");
 hostScopeFF =
      IExtendedLifeCycle::FactoryFinder::_narrow
(intermediateObject);

// Find a factory for location scopes and narrow to a factory

intermediateObject = hostScopeFF->find_factory_from_string(
     "ILifeCycleManagedClient::OrderedLocation.object interface");
 factoryOfOL = IExtendedLifeCycle::OrderedLocationHome::_narrow
      (intermediateObject);

// Use the factory to create a new location scope, passing
// in the hostscope boundary.
IExtendedLifeCycle::OrderedScopeStrings         oss(2); // 2 scope strings
oss[0] = CORBA::string_dup("*SERVERNAME.server"); // local server scope
oss[1] = CORBA::string_dup("");                          // defaults to host scope

myNewOL = factoryOfOL->createWithScopeStrings(
                                      oss,
                              "$SERVERNAME$Scope", // relativeName
                              0,                  // not visibleInCell
                              1,                 // visibleInHostNameTree
                              0);               // not visibleInWorkgroup
```

Creating a Non-Managed Single-Location Scope

This procedure demonstrates how to create a new non-managed location scope. A non-managed location scope is a local-only object, and therefore cannot be retained persistently. Only a managed location scope can be registered in the system name space.

A non-managed location scope is created as a local-only object. A factory, and by extension a factory-finder, is not required for creating a non-managed location scope.

There are three static functions for creating local-only SingleLocations, and three for creating local-only OrderedLocations. All of these are overloaded C++ static class functions and can only be invoked locally from a VisualAge C++ program.

The following steps demonstrate different ways to create a non-managed SingleLocation scope:

- Create it with a default scope boundary using the ILifeCycleLocalObjectImpl::SingleLocation::_create static function. This produces a non-managed location scope object set with a scope boundary of "*LOCAL.cell/*LOCAL.workgroup/*LOCAL.host/*ANY.server/*ANY.container/*ANY.home."
- Create it with a scope-structure using the ILifeCycleLocalObjectImpl::SingleLocation::_create(Scope) static function. This produces a non-managed location scope object with a scope boundary set to the values supplied in the Scope structure.
- Create it with a scope-string using the ILifeCycleLocalObjectImpl::SingleLocation::_create(ScopeString) static function. This produces a non-managed location scope object with a scope boundary set to the values supplied in the Scope string.

The following example creates a new non-managed SingleLocation scope and sets it with a host scope using a scope-string:

```
// Declare the new location scope.
IExtendedLifeCycle::SingleLocation_var myNewSL;

// Create the new location scope set with a workgroup scope
myNewSL = ILifeCycleLocalObjectImpl::SingleLocation::_create(
   "*LOCAL.cell/*LOCAL.workgroup/*LOCAL.host/*ANY.server
         /*ANY.container/*ANY.home");
```

The following steps demonstrate different ways to create a non-managed OrderedLocation scope:

- Create it with a sequence of scope-structures using the ILifeCycleLocalObjectImpl::OrderedLocation::_create(Scopes) static function. This produces a non-managed OrderedLocation object with a scope boundary set to the first scope supplied in the Scope structure, followed by the second scope, and so on.
- Create it with a sequence of scope-strings using the ILifeCycleLocalObjectImpl::OrderedLocation::_create(ScopeStrings) static function. This produces a non-managed OrderedLocation scope object with a scope boundary set to the first scope supplied in the ScopeStrings structure, followed by the second scope, and so on.
- Create it with a sequence of already existing Locations using the ILifeCycleLocalObjectImpl::OrderedLocation::_create(SequenceOfLocations) static function. The locations in the sequence can be either local-only or managed. They can be SingleLocations, other OrderedLocations, or a any implementation of the IExtendedLifeCycle::Location abstract interface. This produces a non-managed OrderedLocation scope object with a scope boundary set to the scopes of the first Location in the SequenceOfLocations, followed by the scopes of the second, and so on.

The example below creates a new non-managed OrderedLocation scope and sets it with the host scope, followed by the workgroup scope using a sequence of scope-strings:

```
// Declare the new location scope.
IExtendedLifeCycle::OrderedLocation_var myNewOL;

IExtendedLifeCycle::OrderedScopeStrings    oss(2);  // 2 scope strings
oss[0] = CORBA::string_dup(
       "*LOCAL.cell/*LOCAL.workgroup/*LOCAL.host/*ANY.server/*ANY.container/*ANY.home");
oss[1] = CORBA::string_dup("*IGNORE.host");      // workgroup scope

// Create the new location scope
myNewOL = ILifeCycleLocalObjectImpl::OrderedLocation::_create(oss);
```

Chapter 7. Naming Service

A Naming Service is the main mechanism for objects on the ORB to locate other objects by name. A name is a humanly recognizable value that identifies an object. The Naming Service maps names to object references.

A name-to-object association is called a *name binding*. A *naming context* is a namespace in which the object name is unique. Every object has a unique reference ID.

You can optionally associate one or more names with an object reference. You always define a name relative to its naming context.

The Naming Service lets you create naming hierarchies so you can easily locate objects. Clients can navigate through different naming context trees in search of objects they want.

How you decide to implement a Naming Service depends on how you plan to use the service in conjunction with other services to locate objects. A Naming Service can be used as the backbone of an enterprise-wide filing system to construct large naming graphs where Naming Contexts model “directories” or “folders” and other names identify “document” or “file” kinds of objects. A Naming Service can also be used in a more limited role and have less sophisticated implementation, where naming contexts represent the types and locations of services that are available in the system.

You can implement a Naming Service to be application specific, or to be based on a variety of naming systems currently available on system platforms.

Naming Objects in the Distributed Object System

Business objects and other resources can be assigned a name in the system name space. This is called binding an object. After you bind an object with a name you can find that object or resolve it by its name.

Binding an object has several advantages. Most notably it provides end-users and programmers a way to talk about particular objects. Names essentially form human-identities for objects. These names can be passed between people and their programs either through user interfaces or in program code.

The name service has these primary uses for locating:

- System resources, including collections of business objects.
- Business objects grouped in application naming contexts.

In both instances, the naming service is used to form an enterprise-wide (or at least workgroup-wide) name space from which named objects can be reliably found.

A fundamental concept in the Component Broker naming service is that the entire name space is composed of objects bound in one or more naming contexts. Each naming context is itself an object and can be bound to other naming contexts to form a tree. In this fashion, the name space can be structured into a hierarchy of names. Any object then has both a relative name, their name within a naming context, and a compound name, the name path representing a particular traversal through the name hierarchy from a higher-level naming context to that object.

To further exemplify the placement of objects and naming contexts in the name tree consider the name tree depicted in the diagram that follows. This name tree is composed of a hierarchy of naming contexts and objects (naming contexts contain other naming contexts and/or objects). Notice that only the object bindings have names and not the objects themselves. Thus an object name is by its very nature contextual. The name of an object only exists within a given context, and then only if the object is bound to that context. The context at the top of the tree does not have a name at all (by virtue of not being bound to any other context). This document refers to this as the root of the tree.

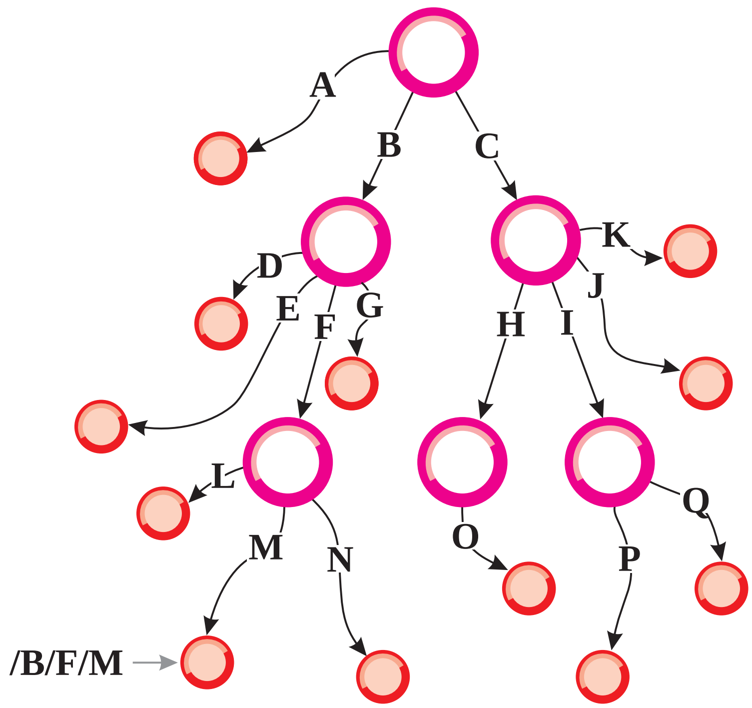


Figure 4. General Name Tree Organization

Name trees are useful for managing large numbers of named-objects. You can partition the name space into categories of related objects that are meaningful to you or your application. Such categorization makes it easier to find an object because you only have to remember the category and the name of the object within that context.

A consequence of instituting name trees in this fashion is that the same object can be bound multiple times with different names or in different contexts. There are potentially positive and negative aspects to this. An object can have different names for different applications. This might be useful for aliasing or transparent resource sharing. In particular, if an object falls naturally within more than one category it can be bound by the same or different name in all categories to which it pertains. On the other hand, being bound multiple times introduces graphs and potential cycles in the name space. This can make traversing the name space more complex.

System Name Space

The system name space is the predefined name space structure that is delivered and installed with Component Broker. This is useful for ensuring that objects can be bound and located by well known name paths. The Component Broker system name space conforms to the Interoperable Naming Service specification. Thus it forms a broadly agreed to structure for interoperability and portability. The system name space is depicted in the diagrams that follow.

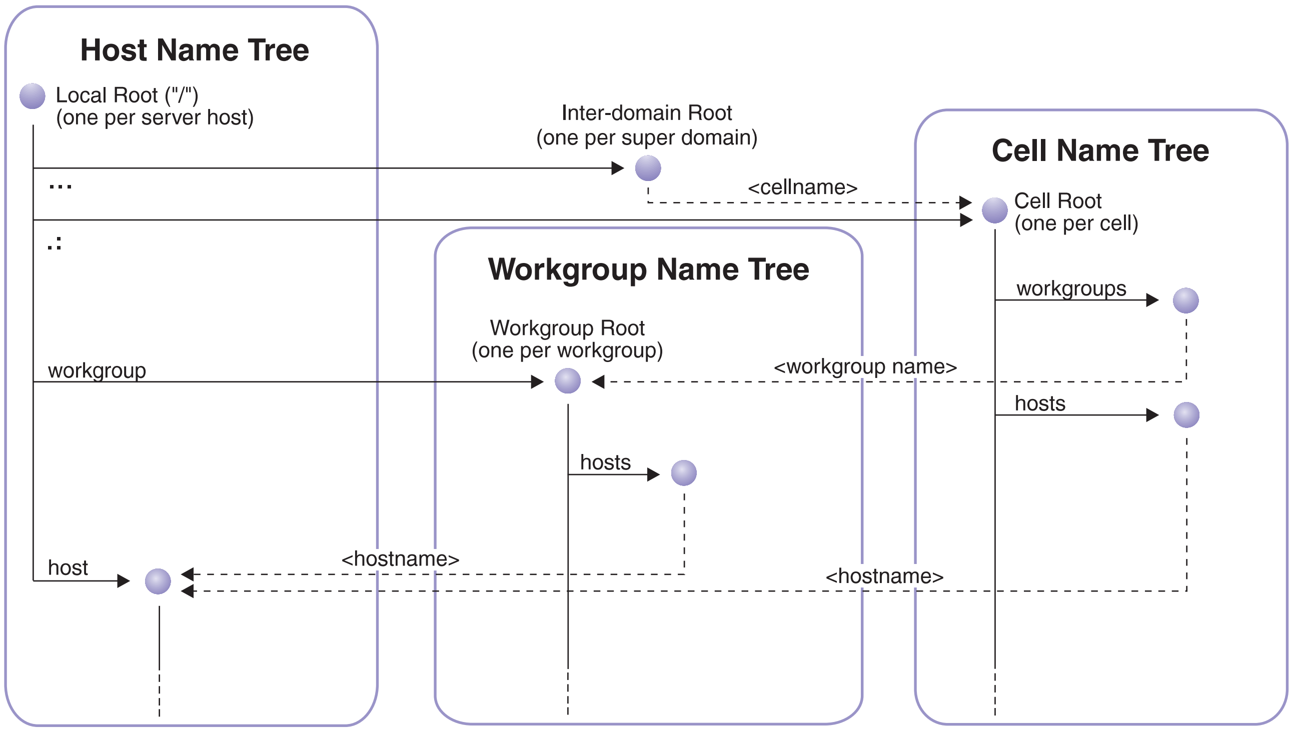


Figure 5. Name Space

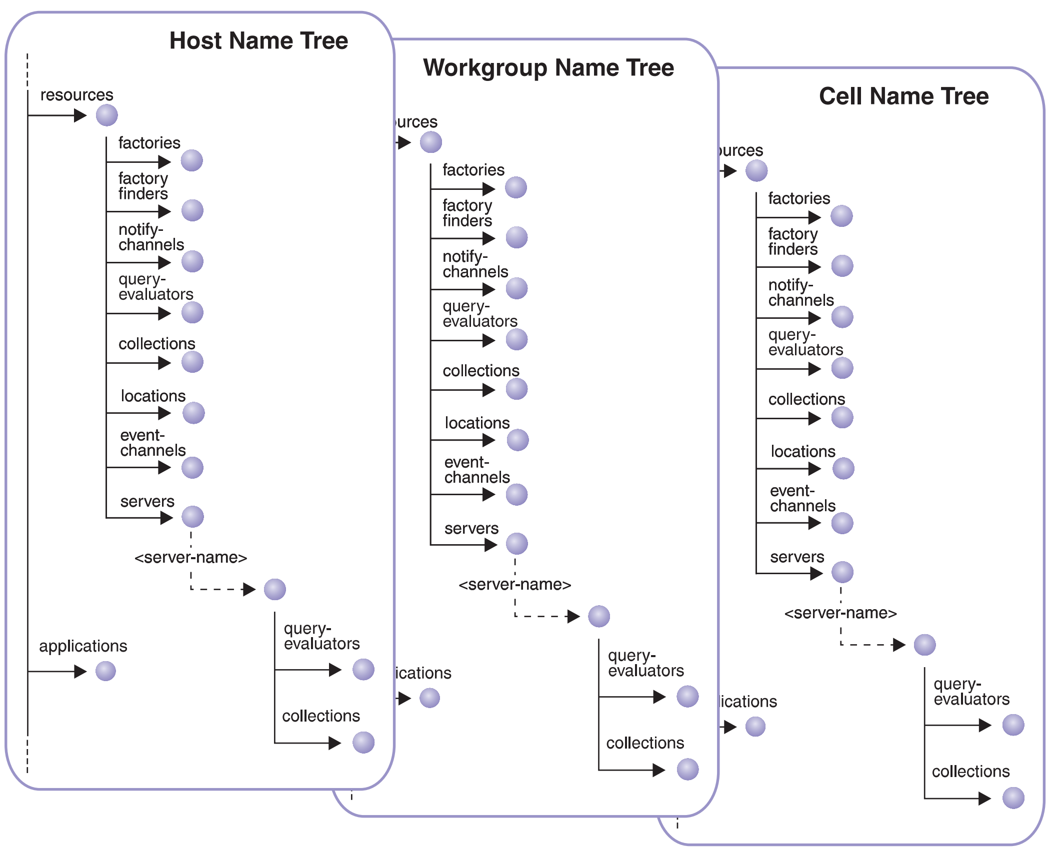


Figure 6. Name Space (continued)

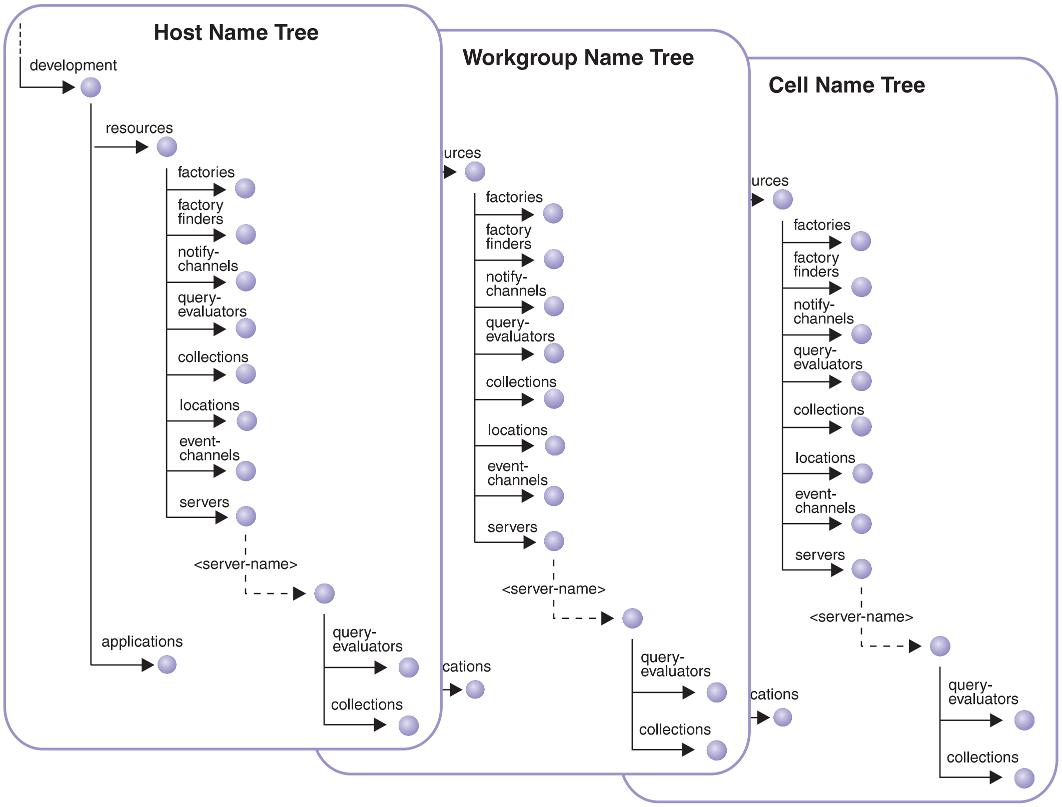


Figure 7. Name Space (continued)

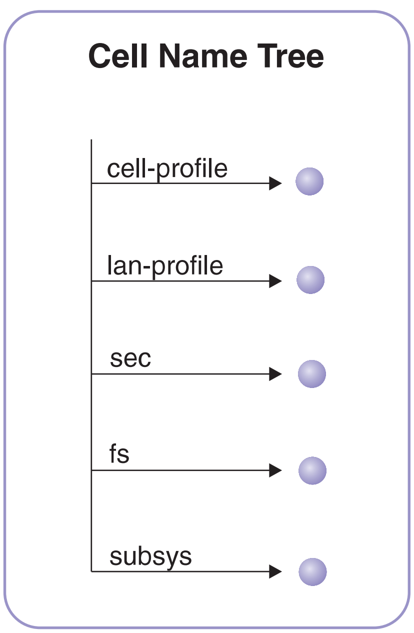


Figure 8. Name Space (continued)

The name space is composed of three distinct parts, a *local name tree*, a *workgroup name tree*, and a *cell name tree*. In addition, the inter-domain root can be used to locate resources across cells. The system name space is modeled somewhat on the UNIX file system, that is every host is intended to contain a local name space in which a distributed name space can be mounted. The local name tree contains the local name space. The workgroup and cell name trees are distributed and shared name spaces. These other name trees are in effect *mounted* to the local name tree.

Choosing where to bind or find named objects in the system name space is a function of the type of the resource in question, and the visibility that should be attributed to the resource.

Visibility of Named Objects

Each portion of the system name space, the host name tree, workgroup name tree, and cell name tree, provides a different scope of visibility or sharing for named objects. Objects bound in the host name tree are specific to the host machine on which the host name tree resides. Objects bound in the workgroup name tree are specific to that workgroup. And likewise, objects bound in the cell name tree are specific to the cell. Conversely, these name trees also represent the scope over which resources bound in each respective tree can be shared.

Before binding an object in the system name space, you should first consider the extent to which you want that object shared. If you want to keep it relatively specific to your host machine, then bind it in the appropriate context under the host name tree. If you want it shared within your workgroup, then bind it in the workgroup name tree. And if you want it shared across your cell, then bind it in the cell name tree.

Likewise, when you go to resolve a named object, consider what scope you want to find it in. You may find different objects bound with the same name in different name trees. You may have to look at more than one name tree to find the named object. One strategy you may find useful is to always start by looking in the host name tree. If the object is not found there, then look in the workgroup name tree, and finally the cell name tree. In this way, you can find an object that is most specific to where your program is running.

Local and Host Name Tree

An instance of the local name tree exists on every (server) host. In general this includes any node capable of being configured to contain server processes, including machines that are otherwise clients. Local name trees can be shared amongst a group of pure client machines, that is machines that are configured to not have any server processes. However, this latter approach may limit the ability for client machines to build and maintain private name spaces. Thus, if it is necessary for a client machine to have a private name space, this should be created under a pseudo-host root for that machine within the **workgroup/hosts** and/or **cell/hosts** contexts.

The sub-tree in the local name tree bound to **host**, while local to the host, is distinguished and can be made visible to other hosts. This is referred to as the host name tree.

Resources belonging to a host should be bound in the **host/resources** context of the local name tree. This context can be further organized by resource type or whatever is appropriate for an installation, according to the following rules:

- Factories should be bound in the **resources/factories** context.
- Factory finders should be bound in the **resources/factory-finders** context.
- Location objects should be bound in the **resources/locations** context.
- Event channels should be bound in the **resources/event-channels** context.
- Notification channels should be bound in the **resources/notify-channels** context.
- Query evaluators should be bound in the **resources/query-evaluators** context.
- Collections should be bound in the **resources/collections** context.

A naming context for each server in the host is bound in **resources/servers** by the server name. This can be used to bind resources that are specific to a particular server. Query evaluators are bound in **resources/servers/<server-name>/query-evaluators** for the server in which they exist. Collections are bound in **resources/server/<server-name>/collections** for the server in which they exist.

Prior to deployment, resources which are used in a development environment can be bound under **host/development/resources** context to keep them separate from production resources. The resources sub-tree is repeated under the **host/development/resources** context to assist to binding development resources there.

A naming context for each application installed on the host can be bound in **applications** by the application name. This can be used to bind resources that are specific to that particular application.

Every local name tree contains a binding to the inter-domain root at "**...**", a binding to the cell root at "**.:**", and to the workgroup root at workgroup. These can be used to navigate to other parts of the system name space.

Note that the local root context is not bound to any other naming context. This is also referred to as the absolute root for the host machine on which the local name tree resides. The ORB::resolve_initial_references("NamingService") operation returns the local root for the host machine.

Note in particular that the local root is not bound to any other name tree. Any object bound under the local root naming context and not under the host name tree (that is **host**) cannot be accessed from any other host. These resources, in effect, are private to the host machine. By extension, they cannot be administered remotely by traversal of the system name space.

Workgroup Name Tree

A workgroup is a logical collection of hosts whose aggregation creates some administrative or operational synergy for the business. There is no concrete definition for a workgroup: typically it consists of a departmental or organizational unit of 5 to 200 hosts, although it is certainly not restricted to either of these boundaries.

One workgroup name tree exists per workgroup. Each host belongs to only one default workgroup bound to **workgroup** in the local name tree. Also, each host name tree in a workgroup is bound by host name in the **hosts** context of the workgroup name tree. Thus any host can get to the host name tree of any other host in a workgroup. The **workgroup** binding of the local name trees and the **hosts** context of the workgroup name trees are not strictly synchronized, and so it is possible for the same host to appear in the **hosts** context of more than one workgroup. A host could only discover its complete containment relationship by examining each of the workgroup name trees within a cell.

In the case that a pure client host needs a host name tree that pertains to it, since by definition it does not have a host name tree of its own, can create one in the workgroup name tree. The host name tree should be bound with the host name in the hosts context of the workgroup name tree. This is referred to as a pseudo-host name tree as the host name tree really does not exist on the host machine, a pure client machine in this case.

Resources belonging to a workgroup should be bound in the **resources** context of the workgroup name tree. As with the **resources** context in the host name tree this context can be further organized by resource type or whatever is appropriate for an installation. Likewise, prior to deployment, resources that are used in a development environment can be bound in the **development/resources** context to keep them separate from production resources.

Cell Name Tree

A cell represents an administrative boundary for the name space. A cell contains one or more workgroups, thus it is a super-set of workgroups.

Note that there is no binding in the workgroup name tree to the workgroup cell. Even though only one workgroup name tree exists in a workgroup, it exists physically under one of the local name trees, and logically under the local name trees of all of the hosts in the workgroup. Thus, the cell for the workgroup can always be determined from the local name tree.

Nonetheless, for administrative and visibility purposes, workgroups are bound by workgroup name within the **workgroups** context of one or more cell name trees. Thus, a host can get to the workgroup name tree of any other workgroup in the cell to which they belong.

Similarly, the host name tree for each host in the cell is bound by host name in the **hosts** context of the cell name tree. Thus any host can get to the host name tree of any other host in the cell.

Resources belonging to a cell should be bound in the **resources** context of the cell name tree. As with the **resources** context in the host name tree this context can be further organized by resource type or whatever is appropriate for an installation.

Likewise, prior to deployment, resources which are used in a development environment can be bound in the **development/resources** context to keep them separate from production resources.

The remaining contexts of the cell name tree, that is, **cell-profile**, **lan-profile**, **sec**, **fs**, and **subsys**, match the contents of a standard DCE cell directory name space and can be left empty.

Navigation in the System Name Space

A host name tree exists on every server host machine. Typically one workgroup name tree exists for each business group. This could be a project area, or product, or related business activity. And a cell name tree exists for each major business organization over which administration of information systems is shared, for example, a site in a multi-site enterprise.

The name trees are loosely related in a hierarchy, although this is not necessarily a strict hierarchy, and are interconnected by various bindings. The default cell and workgroup for a given host are bound in the host name tree as "**.:**" and **workgroup**, respectively. Each host in a workgroup is bound by its host name in the **hosts** context of the workgroup name tree. Also, each host in a cell is bound by its host name in the **hosts** context of the cell name tree. Similarly, each workgroup in a cell is bound by its workgroup name in the **workgroups** context of the cell name tree.

A program can resolve to an object on any host in any workgroup. For instance, consider the case where you have two hosts, "host-A" and "host-B," in the same workgroup. In addition, assume you have object "object-O" bound in the **applications/LifeInsurance/Claim** context on host-B. If a program on host-A wants to find object-O on host-B it can resolve to it from its local root context with the path

```
.:/workgroup/hosts/host-B/application/LifeInsurance/Claim/object-O
```

As another example, consider the case where there is a third host, "host-C," which is in a different workgroup, "workgroup-X." Also assume you have an object, "object-P," also in the **applications/LifeInsurance/Claim** context on host-C. You can navigate from the local root context on host-A to object-P with the path

```
.:/workgroups/workgroup-X/hosts/host-C/application/LifeInsurance/Claim/object-P
```

This could have also been done with the path

```
.:/hosts/host-C/application/LifeInsurance/Claim/object-P
```

Because host-C is also a member of the same cell.

Integration of System Name Spaces

In the current implementation of Component Broker there is a tight coupling of the system name space, a DCE cell and the Component Broker hosts managed by a single System Manager. The system name space as built by Component Broker has only one cell and does not provide an inter-domain root as shown in Figure 6 on page 115. As a result, the name space enables you to traverse only through the cell, workgroups, and hosts defined and managed by a single System Manager. This is referred to as your Component Broker network.

It is possible to integrate the name space of your Component Broker network with the name spaces of other Component Broker networks, or even with non-Component Broker name spaces. One way to do this is for your program to obtain an object reference to a name context in another name space (for example, using a stringified object reference) and bind it into a name context within your Component Broker network. However, the Component Broker System Manager provides a mechanism to do this as a configuration option rather than your having to provide a program to accomplish the binding between different name spaces. This is done through an object called a Remote Name Context Binding.

Details of how to configure a Remote Name Context Binding are provided by the *Component Broker for Windows NT and AIX System Administration Guide*. You are required to provide:

- IP address and port used to bootstrap to the remote host
- The name path to a remote name context (from the local root of the remote host)
- The name path to a local name context (from the local root of the host on which you configured the Remote Name Context Binding)
- Whether the local context is to be bound into the remote context or the remote context is to be bound into the local context
- The name used to bind one context into the other

For example, suppose you wanted to bind a host tree for a host in another Component Broker network into a workgroup called cb390hosts in your own Component Broker network. The information you supply would be similar to the following:

- Bootstrap information: **bighost1.pok.ibm.com, port 900**
- Remote name context: **host**
- Local name context: **.:/workgroups/cb390hosts**
- Binding direction: **remote into local**
- Name: **bighost1**

Another example would be if you wanted to tie several Component Broker networks together using an inter-domain root. In this case, you would first have to create a name context within one of the Component Broker networks and bind it at "**...**" in the local root of one of the hosts. You can then bind the cell context for each of the Component Broker networks into the inter-domain root as follows:

- Bootstrap information: **domainmanager.austin.ibm.com, port 900**
- Remote name context: **...**
- Local name context: **.:**
- Binding direction: **local into remote**
- Name: **cell3**

Then for each of the hosts in all of the Component Broker networks you would specify:

- Bootstrap information: **domainmanager.austin.ibm.com, port 900**
- Remote name context: **...**
- Local name context: ***/***
- Binding direction: **remote into local**
- Name: **...**

Naming Contexts

Names are bound to objects in a naming context. Naming contexts are collections of named objects. Within the naming context, each name must be unique. Naming contexts can be used to collect named objects that are related by some common business purpose. This can include, for instance, the customers, policy, and product-derivatives objects that an insurance agent has produced as part of a prospecting analysis.

In some sense, naming contexts are very analogous to file directories that have been expanded to include more than just file-objects. In the same way that a UNIX file directory can contain other directories, so can a naming context. Thus a naming context that is formed to group related named business objects can in turn be grouped into a larger category of related groups.

As each naming context is an object, its implementation is independent of any other naming context object. You can, in fact, introduce different implementations of naming contexts and bind them together within the same name tree. This is referred to as a *federated name tree*. The tree forms a loose federation of naming context implementations. In this way the name tree can be backed by different qualities of service for the variety of requirements that may be needed.

The naming contexts that form the trunk of the system name space may represent an intolerable potential single point of failure. These contexts may need to be backed by a replicated data store, even at the expense of some performance penalty. Other naming contexts may change more frequently and therefore may need to be backed by a high-performance data store, even at the risk of some potential failure.

Component Broker provides one implementation of naming contexts, based on the DCE Cell Directory Service. See "Performance Considerations" on page 133 for important information about how to use the naming service.

Object Names

Objects are named within a naming context. Naming contexts are named within other naming contexts. All names are relative names, and always identify an object relative to a given naming context. An object can either have a *simple name* (the object name within its naming context) or a *compound name* (the object name within a higher-level naming context whose path leads to the object).

The name of an object within its naming context is a simple name. In the example name tree depicted in "Naming Objects in the Distributed Object System" on page 113, "M" is a simple name referring to the object bound with the name "M" in its naming context. This is a one-part name that is divided into two fields: an id field and a kind field. Both the id and the kind fields make up the object name and both contribute to the uniqueness of the name in a naming context. However, the kind field is optional and if not specified is dealt with as a null string.

A simple name can be combined with other simple names to form a compound name. For this reason, a simple name is also referred to as a *name component*.

When a naming context is bound in another naming context, the objects it contains can be referred to from higher-level naming context with a compound name. A compound name is a multi-part name, composed of the names of the intermediate naming contexts, plus the name of the object within its naming context. Referring to the example name tree depicted in “Naming Objects in the Distributed Object System” on page 113, the compound names "B"::"F"::"M" and "F"::"M" can refer to the same object relative to different naming contexts. The components of a compound name are themselves the simple names of each intermediate naming context or target object in the path to the target object.

Any naming context operation accepts either a simple or compound name; the difference is strictly in whether you supply a one or multi-part name. If you supply a compound name in any of the naming context operations, the naming context recursively resolves the intermediate naming contexts before finally performing the operation on the naming context in which the target object is bound.

The CosNaming::NamingContext interface defined by the OMG requires that all names be supplied in the form of a sequence of structures of strings. More specifically, the IDL for a name is as follows:

```
module CosNaming
{
  typedef string Istring;
  struct NameComponent
  {
    Istring id;
    Istring kind;
  };
  typedef sequence<NameComponent> Name;
};
```

As you can imagine, constructing a name can be somewhat cumbersome. For instance, to construct the compound name for "B"::"F"::"M" requires something like the following code in C++:

```
CosNaming::Name_var myName;
myName = new CosNaming::Name;
myName.length=3; // myName will have 3 components.
myName[0].id="B"; // Component 1
myName[0].kind="";
myName[1].id="F"; // Component 2
myName[1].kind="";
myName[2].id="M"; // Component 3
myName[2].kind="";
// Perform some naming context operation with myName ...
```

As you can see, this can make your code somewhat awkward. Component Broker introduces support for name strings. This allows you to form your names into a single string where the components are delimited by a forward (/) or back-slash (\), and where the id and kind fields of a name component are delimited by a period (.). With name strings, the name in the preceding example can be coded as:

```
const char* myName = "B/F/M";
// Perform some naming context operation with myName ...
```

The name components “B,” “F,” and “M” are delimited with forward slashes. Since all of these name components have a null kind field, then the kind field can be omitted and initializes to null automatically.

For every operation introduced by the CosNaming::NamingContext interface, Component Broker has augmented the interface with a corresponding operation, distinguished with the _with_string suffix, that takes a name string. These operations then use the NamingStringSyntax::StandardSyntaxModel object to convert the name string to a CosNaming::Name sequence.

The NamingStringSyntax::StandardSyntaxModel object is a local-only helper object that can be used directly on the Component Broker server. While it is used under the covers of the Component Broker naming context, it can also be used for other purposes as well.

As described previously, name components can be composed of two fields: an ID and a kind. This separation was introduced by the OMG to help create a separation between a name and its semantic. The kind is intended to add descriptive power to the name. Traditionally, operating systems and certain applications establish naming conventions to group related names, usually as part of a name extension. The naming service does not assign its own meanings to the kind field, but both the ID and the kind contribute to the uniqueness of the name.

The kind field could be used, for instance, to distinguish prospecting folders for new accounts versus established customers. Similarly, the kind field could also be used to distinguish different policy scenarios as follows: Given the existence of several prospecting folders such as `Heidi Sutter.new prospect`, `Becky Newcombe.new prospect`, and `Jordan High.established prospect`, and several policy scenarios such as `early retirement.base line`, *career change.variation*, and `late retirement.variation`, a compound name could be formed to Becky's career change policy scenario with the following name string:

```
prospecting folders/Becky Newcombe.new prospect/career change.variation
```

Notice that names can have embedded blanks, and the id and kind field for each name component is separated by a period.

Binding an Object with a Name

The following procedure demonstrates how you can bind an object in the system name space. This is useful for giving an object a human-readable name.

You can only bind an object in an existing naming context. If you use a compound name, all of the naming contexts identified in the name-path must already exist before the object can be bound. The name that you bind must be unique within the naming context. If the name you use is not unique within the target naming context then a CosNaming::AlreadyBound exception is raised.

1. Decide where you want to bind the object name: Where you decide to bind your object in the system name space can result in the requirement to create other naming contexts to build an appropriate name tree for the new object binding. The scope of visibility that you want the new binding to have determines whether the binding should be placed within the Host, Workgroup or Cell name-trees. If necessary, use the procedure described in “Creating a New Naming Context” on page 126 to create a new naming context.

2. Resolve to the target naming context: The target naming context is the naming context in which you want the object to be bound. You can resolve to the target name context with the resolve() operation by means of one of the following choices:

   - If you already have a reference to the target naming context you can skip to step 3 without doing anything further.

   - If you already have a reference to a naming context that is superior to the target naming context then you can invoke the resolve() operation on the superior naming context, supplying the name of the target naming context. This principle can be applied recursively for any of the successively more superior naming contexts.

   - If you do not already have a naming context, you can get the root to the system name space using the ORB::resolve_initial_references(“NamingService”) operation (the CORBA standard approach) or by obtaining it from the CBSeriesGlobal::*nameService* static function (this static function is set by the CBSeriesGlobal::Initialize() method).

Having acquired the root naming context, you can resolve directly to the intended naming context by invoking the resolve() operation and passing the complete path of intermediate naming context names as a compound name.

3. Bind the object: Once you are positioned at the target naming context, you can bind the object with a new name using the bind() or bind_with_string() operation on the target naming context.

You can combine steps 2 and 3 by supplying a compound name that includes the path to the target name context and the name of the object being bound in the name argument on the bind() or bind_with_string() operations. In this case, step 2 is performed implicitly.

The example that follows shows how to create a binding to a Policy object at the root of the system name space with the name “myPolicy”:

```
// Declare a reference to the Policy object
Policy_var myPolicyObject;
// Create an instance of Policy object in the normal manner
...
// Bind my Policy object at the root of the system name space.
CBSeriesGlobal::nameService()->bind_with_string("myPolicy", myPolicyObject);
```

The previous example is not particularly interesting because it does not consider scoping or visibility. The following, more interesting, example binds the object in the cell name tree for use by the life insurance application. Specifically, the following example creates a binding to a Claim object with the name “myClaim” in the “LifeInsurance/Claims” naming context.

```
// Declare a reference to the Claims naming context,
// and to a Claim object.
IExtendedNaming::NamingContext_var claimsNamingContext;
Claim_var myClaimObject;

// Create an instance of Claim object in the normal manner
...
// Resolve to the "Claims" naming context in the cell name tree.
claimsNamingContext =
    CBSeriesGlobal::nameService()->resolve_with_string(
         "/.:/applications/LifeInsurance/Claims");
// Bind my claim object in the Claims naming context.
claimsNamingContext->bind_with_string("myClaim", myClaimObject);
```

The last two statements in the previous example could be combined to form the following single statement:

```
CBSeriesGlobal::nameService()->bind_with_string(
      "/.:/applications/LifeInsurance/Claims/myClaim", myClaimObject);
```

Resolving a Named Object

This procedure demonstrates how you can resolve an object in the system name space. This is useful for finding an object with a human-readable name.Only an object from an existing naming context can be resolved. If you use a compound name, all of the naming contexts identified in the name-path must already exist before the object can be resolved. The name you are resolving should already have been bound.

1. Resolve to the target naming context: The *target naming context* is the target naming context in which you want resolve the object, that is where you expect the object to have been bound. You can resolve to the target name context with the resolve() operation using the following choices:

- If you already have a reference to the target naming context you can skip to step 2 without doing anything further.
- If you already have a reference to a naming context that is superior to the target naming context, you can invoke the resolve() operation on the superior naming context, passing in the name of the target naming context. This principle can be applied recursively for any of the successively more superior naming contexts.
- If you do not already have a naming context, you can get the root to the system name space using the ORB::resolve_initial_references("NamingService") operation (the CORBA standard approach) or by obtaining it from the CBSeriesGlobal::<nameService> static function (this static function is set by the CBSeriesGlobal::Initialize() method).

  Having acquired the root naming context, you can resolve directly to the intended naming context by invoking the resolve() operation and passing the complete path of intermediate naming context names as a compound name.

2. Resolve the object: Once you are positioned at the target naming context, you can resolve the object by its name using the resolve() or resolve_with_string() operation on the target naming context.

You can combine steps 1 and 2 by supplying a compound name that includes the path to the target name context and the name of the object being resolved in the *name* argument on the resolve() or resolve_with_string() operations. In this case, step 1 is performed implicitly.

The following example shows how to resolve a binding to a Policy object at the root of the system name space with the name "myPolicy":

```
// Declare a reference to the Policy object, and
// a general CORBA object for intermediate use.

CORBA::Object_var myObject;
Policy_var myPolicyObject;

// Resolve my Policy object at the root of the system name space.
myObject = CBSeriesGlobal::nameService()->resolve_with_string("myPolicy");

// Initially, the object coming back from the name context is a
// general CORBA object. It must then be narrowed to a Policy object.
myPolicyObject = Policy::_narrow(myObject);

// And the intermediate object reference should be released.
_release(myObject);
```

The next example resolves an object in the cell name tree used by the life insurance application. Specifically, the following example demonstrates how to resolve a binding to a Claim object with the name "myClaim" in the "LifeInsurance/Claims" naming context.

```
// Declare a reference to the Claims naming context,
// and to a Claim object.
IExtendedNaming::NamingContext_var claimsNamingContext;
CORBA::Object_var myObject;
Claim_var myClaimObject;

// Resolve to the "Claims" naming context in the cell name tree.
claimsNamingContext = CBSeriesGlobal::nameService()->resolve_with_string(
        "/.:/applications/LifeInsurance/Claims");

// Resolve my claim object in the Claims naming context.
myObject = claimsNamingContext->resolve_with_string("myClaim");
```

```
// Initially, the object coming back from the name context is a
// general CORBA object. It must then be narrowed to a Policy object.
myClaimObject = Claim::_narrow(myObject);

// And the intermediate object reference should be released.
_release(myObject);
```

The previous two resolve statements into the single statement:

```
myObject = CBSeriesGLobal::nameService()->resolve_with_string(
    "/.:/applications/LifeInsurance/Claims/myClaim");
```

Creating a New Naming Context

This procedure demonstrates how you can create new naming contexts bound in the system name space. This is useful for creating a context for binding related objects, for instance, a prospecting analysis folder or a list of brokerage services.

You can only create a new naming context from an existing naming context. This means you can only create new naming contexts within the system name space. You can get a reference to any naming context in the system name space by first getting the local root context using ORB::resolve_initial_references ("NameService") and subsequently resolving to the naming context where you want to create (and bind) a new naming context.

1. Decide where you want to create the new naming context: Your new naming context is bound in the system name space, but you need to decide where. This may result in needing to create other naming contexts to build an appropriate name tree for the new naming context. Also, be sure to consider the scope of visibility that you want the new context to have . This determines whether the naming context should be placed within the Host, Workgroup, or Cell name-trees.
2. Resolve to the target naming context: The *target naming context* is the naming context in which you want the new naming context to be bound. You can resolve to the target name context with the resolve() operation using one of the following choices:
   - If you already have a reference to the target naming context, you can skip to step 3 without doing anything further.
   - If you already have a reference to a naming context that is superior to the target naming context then you can invoke the resolve() operation on the superior naming context, passing in the name of the target naming context. This principle can be applied recursively for any of the successively more superior naming contexts.
   - If you don't already have a naming context, you can get the root to the system name space using the ORB::resolve_initial_references("NamingService") operation (the CORBA standard approach) or by obtaining it from the CBSeriesGlobal::nameService static function (this static function is set by the CBSeriesGlobal::Initialize() method).

     Having acquired the root naming context, you can resolve directly to the intended naming context by invoking the resolve() operation and passing the complete path of intermediate naming context names as a compound name.
3. Create and bind the new naming context: Once you are positioned at the target naming context, you can create a new naming context and bind it with a new name at the same time using the bind_new_context() or bind_new_context_with_string() operation on the target naming context.

You can combine steps 2 and 3 by supplying a compound name that includes the path to the target name context and the name of the new naming context in the *name* argument on the bind_new_context() or bind_new_context_with_string() operation. In this case step 2 is performed implicitly.

The following example names the new naming context “myNamingContext” and create it at the root of the system name space:

```
// Declare a reference to the new naming context.
IExtendedNaming::NamingContext_var myNewNamingContext;

// Bind a new naming context at the root of the system name space, and
// assign the resulting new naming context to my reference.
myNewNamingContext = CBSeriesGlobal::nameService()->bind_new_context_with_string(
        "myNamingContext");
```

A more interesting example would consider scoping and visibility to create a new naming context in the cell name tree for use by the life insurance application. Specifically, the following example names the new naming context “Claims” in the “LifeInsurance” naming context. By extension, it also creates the “LifeInsurance” naming in the “applcations” naming context.

```
// Declare a reference to the new naming contexts, and the application
// naming context.
IExtendedNaming::NamingContext_var aNewNamingContext;
IExtendedNaming::NamingContext_var applicationsNamingContext;

// Resolve to the "applications" naming context in the cell name tree.
applicationsNamingContext = CBSeriesGlobal::nameService()->resolve_with_string(
        "/.:/applications");

// Create and bind the LifeInsurance naming context.
aNewNamingContext =
        applicationsNamingContext->bind_new_context_with_string(
                "LifeInsurance");

// Create and bind the Claims naming context.
aNewNamingContext =
        aNewNamingContext->bind_new_context_with_string("Claims");
```

The last statement utilized the aNewNamingContext variable. On the right side of the assignment it was used it to reference the 'LifeInsurance' naming context. Having created and bound the new naming context to LifeInsurance, aNewNamingContext was then reassigned to refer to the Claims naming context.

As with any object that you bind to a naming context, new naming context names must also be unique within that naming context. If the name you assign to the naming context you are creating is not unique within the target naming context then a CosNaming::AlreadyBound exception is raised.

Listing the Contents of a Naming Context

The procedure that follows demonstrates how you can list out the contents of a naming context using the CosNaming::NamingContext::list() operation. This is useful if you want to perform some function iteratively over each entry of the naming context. The operation must target an existing naming context.

1. Determine the maximum number of entries you want to handle at a time: When you perform the list() operation in step 3, all of the entries in the target naming context are set aside in an iterator object. You are iterating through this object one or multiple entries at a time, getting that many entries back in a sequence (a subset of the iterator) through which you can then sub-iterate. You need to determine the number of entries you want to get back in the sequence at a time.

   Memory and performance should both be considered when determining how many entries you want to handle at a time. Memory for the subset sequence is allocated based on the number of entries requested. To conserve memory, request fewer entries at a time.

Normally, the naming context you are listing, and therefore the iterator that is returned from the list request exists in a different process than your program, often on a different machine. Each request for another subset of entries is affected by network latency. The higher the number of requests required to get all of the entries in the iterator, the greater the impact on the performance of your program. Requesting fewer entries at a time increases the number of requests you have to make to the iterator to get all of the entries in the iterator. If performance is an issue, request more entries at a time. Requesting 1000 entries at a time may be a reasonable number for many situations.

2. Resolve to the target naming context: The target naming context is the appropriate naming context. You can resolve to the target name context with the resolve() operation, using one of the following choices:

   - If you already have a reference to the target naming context you can skip to step 3.
   - If you already have a reference to a naming context that is superior to the target naming context, then you can invoke the resolve() operation on the superior naming context, passing in the name of the target naming context. This principle can be applied recursively for any of the successively more superior naming contexts.
   - If you do not already have a naming context, you can get the root to the system name space using the ORB::resolve_initial_references("NamingService") operation (the CORBA standard approach) or by obtaining it from the CBSeriesGlobal::nameService static function (this static function is set by the CBSeriesGlobal::Initialize() method).

     Having acquired the root naming context, you can resolve directly to the intended naming context by invoking the resolve() operation and passing the complete path of intermediate naming context names as a compound name.

3. List out the contents of the naming context into an iterator: Once you are positioned at the target naming context, you can list its contents using the list() or list_with_string() operation on the target naming context. To keep your logic relatively simple do not extract any of the entries into a subset sequence; leave that to be included within your while loop. However, at the cost of some additional complexity, you can go ahead and extract the initial subset of entries on this request to reduce (by one) the number of times that you have to return to the iterator.

4. Get the next subset of entries from the iterator: You can do this with either the next_one() or next_n() operation on the iterator, depending on whether you want just one entry or more than one entry at a time.

5. Process a subset of the entries: Iterate through the sub-set of entries performing your function on each entry as appropriate for your application.

6. Repeat steps 4 and 5 until all of the entries in the iterator are exhausted: The next_one() and next_n() operations return a value of `True` if there are still more entries left in the iterator after the operation returns. Steps 4 and 5 should be repeated as long as these operations continue to return `True`.

You can combine steps 2 and 3 by supplying a compound name that includes the path to the target name context and the name of the new naming context in the *name* argument on the list() or list_with_string() operation. In this case step 2 is performed implicitly.

The example that follows demonstrates listing out the contents of a naming context, 1000 entries at a time:

```
// Declare the claims naming context, a bindings
// list, bindings iterator, and sundry control variables.
IExtendedNaming::NamingContext_var claimsNamingContext;
IExtendedNaming::BindingStringList_var bindingsList;
IExtendedNaming::BindingStringIterator_var bindingsIterator;
CORBA::ULong i;
```

```
CORBA::Boolean continueFlag = 1;
const CORBA::ULong maximumEntries = 1000;

// Resolve to the claims naming context
claimsNamingContext = CBSeriesGlobal::nameService()->resolve_with_string(
        "/.:/applications/LifeInsurance/Claims");

// List the contents of the claims naming context into an iterator. Don't
// extract any of the entries yet.
claimsNamingContext->list_with_string(0, bindingsList,bindingsIterator);

// Process the returned entries in bindingsList
while (continueFlag == 1) {
        // Get the next sub-set of entries
        continueFlag = bindingsIterator->next_n(maximumEntries,
                bindingsList);
        // Process each entry in bindingsList one at a time
        for (i=0; i < bindingsList->length; i++) {
                // Process bindingsList[i] ...
        }; // end for
}; // end while
```

Unbinding an Object from a Naming Context

This procedure demonstrates how you can unbind an object from the system name space. You can use this to remove a binding, perhaps as a part of destroying the object itself. You can only unbind an existing object binding. If you use a compound name, all of the naming contexts identified in the name-path must already exist before the object can be unbound.

1. Resolve to the target naming context: The target naming context is the naming context in which you want to unbind an object. You can resolve to the target name context with the resolve() operation using one of the choices that follow:

   - If you already have a reference to the target naming context,you can skip to step 2.
   - If you already have a reference to a naming context that is superior to the target naming context, you can invoke the resolve() operation on the superior naming context, supplying the name of the target naming context. This principle can be applied recursively for any of the successively more superior naming contexts.
   - If you don't already have a naming context, you can get the root to the system name space using the ORB::resolve_initial_references("NamingService") operation (the CORBA standard approach) or by obtaining it from the CBSeriesGlobal::nameService static function (this static function is set by the CBSeriesGlobal::Initialize() method).

     Having acquired the root naming context, you can resolve directly to the intended naming context by invoking the resolve() operation and passing the complete path of intermediate naming context names as a compound name.

2. Unbind the object: Once you are positioned at the target naming context, you can unbind the object using the unbind() or unbind_with_string() operation on the target naming context.

You can combine steps 1 and 2 by supplying a compound name that includes the path to the target name context and the name of the object being unbound in the *name* argument on the unbind() or unbind_with_string() operation. In this case, step 1 is performed implicitly.

The example that follows demonstrates unbinding an object at the root of the system name space. It assumes that a binding to a Policy object at the root of the system name space with the name "myPolicy" already exists. The unbind() operation requires only the name of the binding as an argument.

```
// Unbind my Policy object at the root of the system name space.
CBSeriesGlobal::nameService()->unbind_with_string("myPolicy");
```

The example that follows demonstrates unbinding an object in the cell name tree, specifically a Claim object with the name “myClaim” in the “LifeInsurance/Claims” naming context.

```
// Declare a reference to the Claims naming context.
IExtendedNaming::NamingContext_var claimsNamingContext;

// Resolve to the "Claims" naming context in the cell name tree.
claimsNamingContext = CBSeriesGlobal::nameService()->resolve_with_string(
        "/.:/applications/LifeInsurance/Claims");

// Unbind my claim object in the Claims naming context.
claimsNamingContext->unbind_with_string("myClaim");
```

The last two statements in to the single statement could be combined as follows:

```
CBSeriesGlobal::nameService()->unbind_with_string(
        "/.:/applications/LifeInsurance/Claims/myClaim", myClaimObject);
```

Two caveats apply when unbinding an object from a naming context:

- The name that you unbind must already exist. If the name you specify does not exist then a CosNaming::NotFound exception is raised.
- Naming contexts can be unbound from a superior naming context only if the target naming context had been previously bound using the bind() or bind_with_string() operations. In other words, for two naming contexts A and B, if you create a new naming context, called C, in A (using A->create_new_context_with_string(“C”), for instance) and later bind C in B, then you can unbind C from B. However, you cannot unbind C from A. You can only remove C from A by destroying C, and only after C has been emptied of any bindings it may have contained.

Local Root Naming Context and the Bootstrap Host

The local root context is at the top of every host name tree. This is the entry into the system name space and is the reference returned from the ORB::resolve_initial_references(“NameService”) method.

In some sense, the local root context is like the root of a UNIX file system. Workgroup and cell name trees are bound to the root of the host name tree (the local root context) in the same way that remote, distributed file systems are mounted to the root of the local file system.

Each host machine (each machine with one or more server processes) has its own host name tree. Thus, each host has a local root context. When the resolve_initial_references() method is invoked on a host machine (in a client or server process on that machine), that method returns a reference to the local root context for the host name tree on that host.

However, client machines (those without any server processes) do not have a host name tree. When invoked on a client machine, the resolve_initial_references() method must return a reference to a root naming context on a remote host machine. It does this using a bootstrapping mechanism.

For this to work, you must identify the name of the host whose host name tree root you want to use. This host then is referred to as the *bootstrap-host* for that client machine, the host from which the client is bootstrapped in to the distributed system. The host name tree, in effect, ends up being shared by all of the client machines that identified that host as their bootstrap-host.

You identify your bootstrap-host when you install Component Broker on the client machine. The install utility prompts you for your bootstrap-host, and records that information for later use by the run time.

All of the clients that identify the same bootstrap-host form a workgroup. This may or may not correspond to the workgroup formed by the workgroup name tree, but the two relationships should be kept distinct to avoid confusion. A workgroup of client machines sharing the same bootstrap-host is not necessarily the same as a workgroup of hosts represented by a single workgroup name tree.

Since a number of client machines can resolve their local root context from a common bootstrap host the host name tree effectively becomes a shared resource for those machines. It also becomes a potential single point of failure. If the bootstrap-host is down then the client can not resolve its initial name service reference, and thus can not resolve any other resource from the system name space.

For this reason and to prevent the bootstrap-host from becoming a performance bottle-neck, the number of client machines that target the same bootstrap-host should be limited. As a rule of thumb, no more than 5-10 client machines should use the same bootstrap-host. The actual limit depends on a number of factors such as the reliability and capacity of the bootstrap-host and so you may be able to significantly exceed this rule of thumb in some cases.

Another approach to avoiding the potential single point of failure and performance bottleneck problems is to configure your client as a server machine when you install Component Broker. This results in one or more server processes being configured, and a host name tree being automatically built for your machine. However, this also increases the footprint requirements for your client machine as well.

Absolute and Relative Names

As with traditional file systems, the naming service handles both absolute and relative paths. In fact, all compound names are handled as relative names since they are always used in the context of a specific naming context. However, the Component Broker naming service has been implemented to recognize a leading "/" (forward-slash) or "\" (back-slash) as a special case.

If the first character in a name string is a "/" (forward-slash) or "\," (back-slash) any naming context resolves the local root context, and continues to resolve the remaining name from the local root context. Thus, resolving the name applications/LifeInsurance/Claim from the local root context navigates to the same object as resolving /applications/LifeInsurance/Claim from the hosts context in the cell name tree.

Summary of the Naming Context Interface

The complete Component Broker naming context interface is described in the combination of the CosNaming::NamingContext and IExtendedNaming::NamingContext interfaces. The CosNaming::NamingContext interface is the standard interface for naming contexts and introduces the following operations:

- void bind(name, obj)
- void rebind(name, obj)
- void bind_context(name, naming_context)
- void rebind_context(name, naming_context)
- Object resolve(name)
- void unbind(name)
- NamingContext new_context()
- NamingContext bind_new_context(name)
- void destroy()
- void list(how_many, binding_list, binding_iterator)

The bind() operation can be used to bind a name to any managed object, and the bind_context() operation can be used to bind a name to a sub-context. The rebind() operation can be used to change the object to which a name is bound, and the rebind_context() can be used to do the same for a sub-context. The unbind() operation can be used to remove a binding between a name and an object. The unbind() operation removes the binding from the naming context, but does not remove or destroy the object itself.

The resolve() operation can be used to find what object has been bound to a name. The new_context() operation is generally used to create a new naming context which is not bound to any other naming context.

The bind_new_context() operation can be used create a new naming context which is bound to a name. The destroy() operation can be used to remove the naming context. This is functionally equivalent to the remove() operation on any managed object. However, neither the remove() nor the destroy() operation removes any bindings to the naming context: these must be un-bound separately using the unbind() operation. The list() operation can be used to return an iterator for all of the bindings in the naming context.

In addition, Component Broker extends the CosNaming::NamingContext interface with the sub-interface IExtendedNaming::NamingContext. The IExtendedNaming::NamingContext interface introduces the following operations:

- void bind_with_string(name, obj)
- void rebind_with_string(name, obj)
- void bind_context_with_string(name, naming_context)
- void rebind_context_with_string(name, naming_context)
- Object resolve_with_string(name)
- void unbind_with_string(name)
- NamingContext bind_new_context_with_string(name)
- void list_with_string(how_many, binding_list, binding_iterator)

All of these operations accept names in the form of a name-string and perform exactly the same functions as their counterparts introduced in the CosNaming::NamingContext interface.

To support converting between name-strings and the standard CosNaming::Name name-structures, Component Broker introduces the NameStringSyntax::StringName and accompanying NameStringSyntax::StandardSyntaxModel interfaces with the following operations:

- NameString name_to_string(name)
- CosNaming::Name string_to_name(name)

Implementing the Naming Service

The Component Broker Naming Service has very few configuration requirements. Most of the configuration work that needs to be performed is done automatically during installation and server initialization

The user has control over which naming contexts are replicated and the convergence level for individual naming contexts. These can be controlled using the **cdscp** administration tool supplied with DCE. Component Broker naming contexts map directly to DCE/CDS directories, and so you are effectively navigating the Component Broker system name space by navigating the DCE/CDS directory space. You can then change the operational aspects of a Component Broker naming context by administering its corresponding CDS directory.

You also have control over which bootstrap-host is used by which client machine by specifying this when the client machine is installed. Component Broker administrators should plan out their system topology, denoting which hosts will be server hosts (containing one or more server processes) and which will be client machines (containing no server processes). This can be configured with the Component Broker system management application, see the *Component Broker for Windows NT and AIX System Administration Guide* for more information. As new client machines are added to the topology, the administrator should explain which bootstrap-host that particular client should be using so that this can be entered in during client installation.

You are prompted for a bootstrap-host name even when installing a server host. A host machine, by definition, has its own host name tree. The bootstrap-host name prompted for during installation is never used, and therefore can be left blank. However, you may be able to make use of this value in the future to recover from catastrophic failures or to offer additional configuration flexibility, so a relevant bootstrap-host for the host can be set during installation of host machines as well.

To use the DCE/CDS, Component Broker must update the cds_attr file to include attribute declarations that the naming service relies on. Normally this file is updated automatically during Component Broker installation.

Performance Considerations

The Component Broker naming service is implemented over the DCE Cell Directory Service (CDS), making it very robust and scaleable. You can configure DCE with multiple CDS server replicas. Component Broker automatically takes advantage of these replicas to ensure that the system name space does not represent a single point of failure.

If you enable CDS server replicas, subsequent changes to the system name tree such as binding new naming contexts, creating new object bindings, unbinding objects or naming contexts, or rebinding objects or naming contexts take time to show up in the system name space. The operations themselves return correctly, but the changes do not show up in the system name space right away. The amount of time this takes depends on several conditions, including the following:

- The convergence level that you have configured for the CDS master replica
- Whether all of the replicas are available at the time a skulk is attempted
- The confidence level for CDS data

If you set a high convergence level then a skulk is initiated every hour. Any changes that occurred during that hour are propagated to the replicas that are available at that point. A medium convergence level setting results in a skulk being initiated every 12 hours, and for a low convergence-level a skulk is initiated every 24 hours.

You control the convergence level for any given naming context using the cdscp administration utility supplied with DCE. If a replica is not available at the time the skulk is attempted then another attempt is made to update that replica at the next skulk interval.

Another factor that affects how long it takes the system name space to be updated in CDS is the confidence level selected. Component Broker uses a medium confidence level. In this way, you can optimize the benefit of the DCE cache, and avoid the master replica as a single point of failure.

For these reasons, you should write your application to avoid depending on the name space being updated immediately. One way of doing this is to isolate naming changes to occur during different phases of the operation of your application, for example, during a configuration step. You should allow enough time in your application for the changes to propagate to all of the server replicas.

These delays only exist for those naming contexts (directories in CDS) that you choose to replicate. Non-replicated naming contexts are updated immediately, but also become potential single points of failure in the case the server on which the directory is stored goes down. The trade-off entails immediate updates with the risk of single point of failure, versus delayed updates with essentially no risk of single point of failure.

You should consider the usage scenarios for various naming contexts in your enterprise. For critical, relatively stable naming contexts, you should replicate the corresponding CDS directory. This entails at least the trunk of the system name space plus certain well known and established resources, such as collections. For less critical, but highly dynamic naming contexts, you should not replicate the corresponding CDS directory.

You can control which naming contexts are replicated by controlling their corresponding CDS directory using the **cdscp** command-line utility supplied with DCE.

The String Syntax Object

The string syntax object is introduced by Component Broker to convert name-strings into CosNaming::Name name-structures, and vice-versa. The string syntax object is a helper, local-only object that can be instantiated strictly to convert names back and forth between their two forms. This object was introduced to let you specify names as a string, using embedded delimiters and separators, and easily convert these into a name-structure by parsing the string based on a particular syntax model.

The string syntax object is actually composed of two interfaces. The NamingStringSyntax::StringName is a base-interface that introduces two methods for converting names between their two forms. The NamingStringSyntax::StandardSyntaxModel implements name parsing based on the X/Open Federated Naming (XFN) specification standard. While supporting the XFN syntax model, the standard syntax model also introduces attributes that can be modified to control the parsing algorithms.

Other name syntaxes can be supported by introducing other specializations of the NamingStringSyntax::StringName interface. The Component Broker naming service uses a standard-syntax-model string-syntax-object to convert name-strings supplied in any of the IExtendedNaming::NamingContext() operations.

The complete IDL for the StringName and StandardSyntaxModel interfaces is:

```
#include <CosNaming.idl>
module NamingStringSyntax {
        typedef CosNaming::Istring NSS_Istring;
        typedef NSS_Istring NameString;
        typedef sequence<NSS_Istring> NSS_IstringList;

        exception IllegalStringSyntax {
                unsigned long illegal_syntax_position;
                NameString parsed_substring;
        };
        exception UnMatchedQuote {
                unsigned long begin_quote_position;
                NameString ambiguous_substring;
        };

        interface StringName  {

                // Conversion routines
                NameString name_to_string(
                                in CosNaming::Name name);
```

```
        CosNaming::Name string_to_name(
                        in NameString name)
                raises(
                        IllegalStringSyntax,
                        UnMatchedQuote);
    }; // End StringName interface

    interface StandardSyntaxModel : StringName {
        enum Direction { kLeftToRight, kRightToLeft };
        enum CodeSet { kISOLatin1 };
        enum Locale { kUS_ENG };

        attribute Direction syntax_direction;
        attribute NSS_IstringList syntax_absolute_prefix;
        attribute NSS_IstringList syntax_reserved_names;
        attribute NSS_IstringList syntax_delimiter;
        attribute NSS_IstringList syntax_separator;
        attribute NSS_IstringList syntax_begin_quote;
        attribute NSS_IstringList syntax_end_quote;
        attribute NSS_Istring syntax_escape;
        attribute CodeSet syntax_code_set;
        attribute Locale syntax_locale_info;
    }; // End StandardSyntaxModel interface

};  // End NamingStringSyntax module
```

The string syntax object is a local-only object and must be created with the class for IExtendedNamingStringSyntax::StandardSyntaxModel, the IDL for which is presented below:

```
#include <CosNaming.idl>
#include <NamingStringSyntax.idl>
#include <IManagedLocal.idl>
module IExtendedNamingStringSyntax {

    interface StandardSyntaxModel :
        NamingStringSyntax::StandardSyntaxModel,
        IManagedLocal::ILocalOnly{};

    #pragma meta StandardSyntaxModel localonly

}; // End module IExtendedNamingStringSyntax
```

Standard Syntax Model Grammar: The grammar for the standard syntax model is straight forward for the normal case. Name components are delimited by either a forward-slash (/) or a back-slash (\). The id and kind fields are separated by a period (.). Special characters such as quotes, double quotes, forward-slashes, back-slashes, and periods can be escaped in unquoted strings. Alternately, name components containing any of these special characters can be quoted with either single or double quotes.

In the string syntax interface, formatted strings can be used to specify a compound name, that is, a name that represents a traversal path through the name tree. The syntax for name strings is governed by a set of rules established by a particular syntax model and a set of attributes that play into that model. While a number of different models are plausible, Component Broker implements a single standard model. This model closely resembles the XFN standard syntax model.

The standard syntax model is introduced as a type specialization of the NamingStringSyntax::StringName interface. This allows for other syntax models to be introduced that support different parsing rules and syntax model attributes.

The standard model rules for parsing string names are defined as:

1. Absolute-prefix, reserved-name, delimiter, separator, begin-quote, end-quote and escape strings are distinguished elements. These are specified as attributes of the model.
2. An absolute-prefix at the beginning of the string is parsed as is. That is, it forms its own name component.
3. The escape string immediately preceding a delimiter, separator, begin-quote, end-quote or escape string escapes those elements even within a quoted string.
4. In an un-quoted string, an unescaped delimiter separates two name components.
5. Within a name component, un-quoted reserved names are parsed as is. That is, they are not separated even if they contain a separator.
6. If an escaped delimiter occurs within an un-quoted name component, the delimiter is treated as a character value in the name component.
7. Within an un-quoted name component, an unescaped separator separates the id and kind fields of the name component.
8. If an escaped separator occurs within an un-quoted string, the separator is treated as a character value in the name component.
9. An unescaped begin-quote preceding an id or kind field of a name component must be matched by a unescaped end-quote at the end of the field. If there are multiple values for begin-quote and end-quote, a specific begin-quote value must be matched with its corresponding end-quote value. An unmatched quotation raises an exception.
10. Other quotes (not including the end-quote used to close the quotation) embedded in a quoted string are treated as character values in the id or kind field.
11. Begin-quotes or end-quotes within an un-quoted name component id or kind field are treated as simple characters and do not need to be matched.
12. If an escaped or unescaped delimiter occurs within a quoted string, the delimiter is treated as a character value in the name component id or kind field.
13. If an escaped or unescaped separator occurs within a quoted string, the separator is treated as a character value in the name component id or kind field.
14. If an escaped escape occurs within a quoted or unquoted string, the escape is treated as a character value in the name component id or kind field.

The attributes that apply to the standard syntax model include:

syntax_direction Indicates the direction in which the parsed string is loaded into components of the CosNaming::Name. (Default value: kLeftToRight)

syntax_absolute_prefix The string(s) that define absolute prefixes. Absolute prefixes are used to denote an absolute name that is applied to a local root context. (Default value: "/", "\")

syntax_reserved_names The string(s) that define reserved names. Reserved names are not parsed, even if they contain separator characters. (Default value: ".:", "...")

syntax_delimiter The string(s) that are used to separate name components. If more than one character is specified then either can be used interchangeably. (Default value: "/", "\")

syntax_separator The string(s) that are used to separate the id and kind fields of a name component. If more than one character is specified then either can be used interchangeably. (Default value: ".")

syntax_escape The character that is used to escape the parsing rules. Only one character can be specified. (Default value: "\")

syntax_begin_quote The string(s) that define the beginning of a quoted string. If more than one character is specified then either can be used interchangeably, but they must be matched with a corresponding syntax_end_quote character (as determined by their index position within the character set). (Default value: """ (double quote), "'" (single quote))

syntax_end_quote The string(s) that define the end of a quoted string. The number of characters specified must match the number of characters specified in syntax_begin_quote. If more than one character is specified then either can be used interchangeably, but must match the corresponding syntax_begin_quote character used. (Default value: """ (double quote), "'" (single quote))

syntax_code_set Defines the code set used for parsing the string. (Default value: kISOLatin1)

syntax_locale_info Defines the locale used for parsing the string. (Default value: kUS_ENG)

The preceding syntax rules and attributes are represented by the following modified BNF:

```
<name_string>::= [ <absolute_prefix> ] <relative_name>;
<relative_name>::= { <name_component> <delimiter> }*
        <name_component>;
<name_component>::= <reserved_name>
        <name_id> [ <separator> [ <name_kind> ]];
<name_id>::= <component_string>;
<name_kind>::= <component_string>:
<component_string>::= <unquoted_string>
        | <begin_quote> <quoted_string> <end_quote>;
<unquoted_string>::= <opening_char> <unrestricted_char>*;
<quoted_string>::= <nonclosing_char>+;
<opening_char>::= any character, including
        <escape_sequence>, except
        <begin_quote>, <end_quote>, <delimiter>, or
        <separator>;
<unrestricted_char>::= <opening_char> | <begin_quote> | <end_quote>
        |<delimiter> ;
<nonclosing_char>::= any character, including
        <escape_sequence>, <begin_quote>,
        <delimiter>, or <separator>,
        except <end_quote> corresponding
        to <begin_quote> of
        <quoted_string>;
<escape_sequence>::= <escape> <delimiter>
        | <escape> <separator>
        | <escape> <begin_quote>
        | <escape> <end_quote>
        | <escape> <escape>;
<absolute_prefix>::= defined in syntax_absolute_prefix
        attribute;
<delimiter>::= defined in syntax_delimiter attribute;
<reserved_name>::= defined in syntax_reserved_names attribute;
<separator>::= defined in syntax_separator attribute;
<begin_quote>::= defined in syntax_begin_quote attribute;
<end_quote>::= defined in syntax_end_quote attribute;
<escape>::= defined in syntax_escape attribute;
```

Converting between a Name-String and a Name-Structure: This procedure is used to convert a name-string to a name-structure, or vice versa, using the string-syntax object. This is useful when you want to limit yourself to using only the standard CosNaming::NamingContext interface, but want to allow the user to specify names in the form of a string. The string-syntax object can be used to convert the user-specified string-name to a name-structure as required by the standard CosNaming::NamingContext() operations. The string-syntax object is a local-only object and can only be created on a CORBA C++ client or in a Component Broker server.

1. Create an instance of a string-syntax object: The string-syntax object is a local-only object and should be created using the normal Component Broker lifecycle model for local-only objects. That is, invoke the _create static member function on the NamingStringSyntax::StandardSyntaxModel class.
2. Convert the name-string to a name-structure: Given a name-string conforming to the standard syntax model grammar, you can convert it to a name-structure (a CosNaming::Name) using the string_to_name() operation.
3. Or, convert the name-structure to a name-string: Conversely, you can convert a name-structure to a name string that conforms to the standard syntax model grammar using the name_to_string() operation.

The following example demonstrates conversion of /.:/applications/LifeInsurance/Claims/myClaim, from a name-string into a name-structure:

```
// Declare a string-syntax object, and a name-structure
NamingStringSyntax::StandardSyntaxModel_var anSSO;
CosNaming::Name_var aNameStructure;

// Create a string-syntax object
anSSO = NamingStringSyntax::StandardSyntaxModel::_create();

// Set and convert the name-string to a name-structure
aNameStructure=anSSO->string_to_name(
        "/.:/applications/LifeInsurance/Claims/myClaim");
```

At this point, the name-structure is composed of the five elements. The ID-field of each field is set as follows:

1. “.:”
2. “applications”
3. “LifeInsurance”
4. “Claims”
5. “myClaim”

The corresponding kind-field in each case is a null-string.

The following example demonstrates conversion of a a name-structure into a name-string:

```
// Declare a string-syntax object, a name-string and a name-structure
NamingStringSyntax::StandardSyntaxModel_var anSSO;
string aNameString;
CosNaming::Name_var aNameStructure;

// Create the string syntax object and name structure
anSSO = NamingStringSyntax::StandardSyntaxModel::_create();
aNameStructure = new CosNaming::Name;

// Initialize the name-structure
aNameStructure->length=6;// The name-structure will have 6 elements
```

```
aNameStructure[0].id="*LOCAL";
aNameStructure[0].kind="cell";

aNameStructure[1].id="consumer insurance";
aNameStructure[1].kind="workgroup";

aNameStructure[2].id="*IGNORE";
aNameStructure[2].kind="host";

aNameStructure[3].id="whole life";
aNameStructure[3].kind="server";

aNameStructure[4].id="*ANY";
aNameStructure[4].kind="container";

aNameStructure[5].id="*ANY";
aNameStructure[5].kind="home";

// Convert the name-structure to a name-string
aNameString=anSSO->name_to_string(aNameStructure);
```

At this point, *aNameString* should be "*LOCAL.cell/consumer insurance.workgroup/*IGNORE.host/whole life.server/*ANY.container/*ANY.home".

Note that if the name-string is not formed in accordance to the standard syntax model, an IllegalStringSyntax or UnMatchedQuote exception is raised.

Chapter 8. Security Service

This section includes the following topics:

- Security in the Distributed Object System
- Principals, Credentials, and Secure Associations
- Authentication and End-Users
- Security and System Management
- DCE Security
- Logging in to DCE
- Destroying a Credential by Logging Out
- Security Service Objects

Security in the Distributed Object System

A fundamental concern in distributed systems in general is how to protect data and business assets available through the information system. This is no less true in distributed, object-oriented systems. Valuable information exists in business objects. This information can be manipulated and accessed remotely and therefore must be protected from unauthorized use.

Component Broker provides security services to help protect these assets. The security service is used primarily to prevent end users from accessing information and resources that they're not authorized to use. This predominantly covers distributed objects, but by extension includes any of the information and resources from other non-OO, or non-distributed sources that those business objects use.

In many cases Component Broker is used to wrapper legacy information system resources, such as business applications and enterprise data. Often, those resources have always been centralized resources, held in a physically secure environment or with restricted access over controlled access channels.

A key objective of object-oriented programming and business re-engineering is to provide for the abstraction of business resources that enables them to be used more readily in new applications. This has the effect of proliferating access to those legacy resources. Access may be increased to resources that have been traditionally (either intentionally or due to the limitations of technology) more restricted. Thus, the solution has the potential for undermining the protection that these resources require and have traditionally enjoyed.

The security service must compensate for any protections that may be otherwise lost due to the increased accessibility of business objects in a distributed object system. At the same time, any benefit an application programmer receives by using Component Broker should not be taken away by the security service, except to prevent unauthorized access to resources. By extension, this means that if security policies for a set of legacy resources have already been established and are in use in existing production systems, then it should be possible to use those same policies to protect resources in the object system; it shouldn't be necessary to re-specify existing security policies or to keep two sets of policies in sync.

Object systems tend to introduce many more independent objects than equivalent procedural systems. Procedural systems tend to wrap up individual objects into larger-grained artifacts, such as resources managers or database tables. The presence of so many objects introduces the potential for administrative scalability issues that present their own security exposures: when administration becomes overwhelming, administrators just stop administering and objects remain unprotected. The security service guards against this threat by factoring security policies across a server, thus forming an administrative boundary for controlling unauthorized access to the objects contained within that server, and to the resources that are used by that server.

Component Broker security provides support for authenticating users to prevent unauthenticated access to secure servers. It can certify to business objects the principal on whose behalf any given method request is being made. The security service also provides support for protecting message traffic between clients and server, and between servers and servers.

Principals, Credentials, and Secure Associations

Both users and servers can be authenticated to the system. Either users or servers can have identities, meaning either can be identified and access-controls exercised for any resources that are accessed on their behalf. Any entity, human or otherwise, that can be identified and authenticated in the system is referred to as a *principal*. A principal can be either a client-user or a server process. It can also be other software or abstract entities if those things can be associated with an identity and they have the means for authenticating themselves.

When a principal has been authenticated, the security service creates a credential for that principal. A credential is an object that represents the authenticity of a given principal. As such, it represents the principal, but only after the principal has been certified as being authentic.

In a secure server, all activities occur on behalf of a given principal. This is achieved in the following manner: When a principal is authenticated at a client (a client-principal), a credential is formed for that client. The credential is associated with the process. The credentials are communicated to the server along with any method requests that originate from that server, and the thread of execution in the server is tagged with the credentials of the client-principal that originated the request.

The security service is able to efficiently and safely communicate the credentials for the client-principal by establishing a secure association between the client and the server. Each client-server forms a unique association, even when the server acts as a client to another server. Client-principal identities are not delegated to down-stream servers. The secure-association is also used to protect any message traffic between the client and the server processes.

Manipulating Credentials

As discussed in “Principals, Credentials, and Secure Associations,” when a principal is authenticated, a credential is formed to represent that principal. At a client, the credential formed when you authenticate the principal becomes the default credential for the process. It is theoretically possible for each object to have its own-credentials, but in this release of Component Broker any object's own-credentials are synonymous with the default-credential for the process. In the absence of a thread-specific credential the default-credential is used for any activities performed in the client, or for any method requests invoked on a remote object.

If another principal is authenticated, the new credential replaces the previous as the process' default credential. However, unless the previous credential is destroyed, it remains a valid credential, at least until the credentials expire or are explicitly removed by a program. Once a credential is formed, it can be obtained by a local program.

Getting a Current Object

This procedure demonstrates how you can obtain a security Current object with which you can obtain or manipulate the credentials that you want to use in your program.

You can obtain a Current at either the client or in the server. However, you can only get a Current object if the security service run time has been installed and the ORB has been initialized. You cannot obtain a security Current in the Java client.

Obtain a Current object using the following steps:

1. Obtain a reference to the CORBA::ORB object. You can obtain a reference to the CORBA::ORB object by invoking the CORBA::ORB_init static function (the CORBA standard approach) or by obtaining it from the CBSeriesGlobal::orb static function (this static function is set by the CBSeriesGlobal::Initialize() method).
2. Get a CORBA::Current. Use the CORBA::ORB::get_current() method to get a Current object, passing in the name of the security current: "SecurityLevel2::Current".
3. Narrow to the Security Current interface. Narrow the Current to the security Current interface. In fact the security service introduces two derivatives of the Current interface: SecurityLevel1::Current, and SecurityLevel2::Current. You should narrow to the SecurityLevel2::Current interface as a matter of practice.

The following example demonstrates how to obtain a SecurityLevel2::Current object:

```
// Declare a reference to the CORBA::Current and the
// SecurityLevel2::Current objects.

CORBA::Current_var current;
SecurityLevel2::Current_var securityCurrent;

// Use the CBSeriesGlobal::orb to get a CORBA::Current

current = CBSeriesGlobal::orb()->get_current("SecurityLevel2::Current");

// Narrow to the SecurityLevel2::Current.

securityCurrent = SecurityLevel2::Current::_narrow(current);
```

Acquiring the Security Attributes of a Credential

This procedure demonstrates how you can acquire the security attributes of a credential. This is used to determine the security name and host identity of the principal that invoked the current method request, including the host where the principal is logged in.

This procedure is performed on a Credentials object. The security name and host name are security attributes that have been introduced by Component Broker. Therefore, they are identified by the IBM_BOSS_FAMILY_DEFINER, in attributes family 2. The security run time must be installed and the ORB must be initialized.

Acquire the security attributes of a credential using the following steps:

1. Get a credentials object. Use the procedure described in “Acquiring a Credential on a Thread” on page 145.
2. Get the desired attribute. Use the SecurityLevel2::Credentials::get_attributes() method to get the desired attributes from the credentials. Component Broker introduces two security attributes,

CredAttrSecName, and CredAttrHostName. These are defined in family 2 where IBM_BOSS_FAMILY_DEFINER is the definer of this family.

The following example demonstrates how to acquire the received-credentials, and then acquire the principals security name and host name:

```
#include <IExtendedSecurity.hh>
#include <CBSeriesGlobal.hh>
// Declare a reference to the CORBA::Current, SecurityLevel2::Current,
// Credentials and CredentialsList objects, and Atributes, AttributeList,
// and AttributeTypeLists.

CORBA::Current_var current;
SecurityLevel2::Current_var securityCurrent;
SecurityLevel2::CredentialsList_var receivedCredentialsList;
SecurityLevel2::Credentials_var receivedCredentials;
::CORBA::String securityName;
::CORBA::String hostName;
Security::AttributeList_var attributesList;
Security::AttributeTypeList attributesTypeList(2);

// Use the CBSeriesGlobal::orb to get a CORBA::Current

current = CBSeriesGlobal::orb()->get_current("SecurityLevel2::Current");

// Narrow to the SecurityLevel2::Current.

securityCurrent = SecurityLevel2::Current::_narrow(current);

// Get the received-credentials list

receivedCredentialsList = securityCurrent->received_credentials();

// Pull out the received-credentials from the first (0th) position

receivedCredentials = (*receivedCredentialsList)[0];"

// Get the principal's security name and host name.
// Set the length to 2

attributesTypeList.length(2);

// Create an entry for security name

attributesTypeList[0].attribute_family.family_definer=
    IExtendedSecurity::IBM_BOSS_FAMILY_DEFINER;
attributesTypeList[0].attribute_family.family=2;
attributesTypeList[0].attribute_type=
    IExtendedSecurity::CredAttrSecName;

// Create an entry for host name

attributesTypeList[1].attribute_family.family_definer=
    IExtendedSecurity::IBM_BOSS_FAMILY_DEFINER;
attributesTypeList[1].attribute_family.family=2;
attributesTypeList[1].attribute_type=
    IExtendedSecurity::CredAttrHostName;
```

```
// Get the attributes

attributesList = receivedCredentials->get_attributes(
        attributesTypeList);

// Extract the security name

securityName = CORBA::string_dup(
    (::CORBA::String) &(*attributesList)[0].value[0]);

// Extract the host name

hostName = CORBA::string_dup(
    (::CORBA::String) &(*attributesList)[1].value[0]);
```

The following is the proper way to create a valid Security::AttributeTypeList for get_attributes() of a Credentials object:

```
org.omg.Security.AttributeType[] attrTypeList =
   new org.omg.Security.AttributeType[2];

org.omg.Security.ExtensibleFamily attribute_family0 =
   new org.omg.Security.ExtensibleFamily((short)8, (short)2);

org.omg.Security.ExtensibleFamily attribute_family1 =
   new org.omg.Security.ExtensibleFamily((short)8, (short)2);

attributeTypeList[0] =
   new org.omg.Security.AttributeType( attribute_family0,
                           com.ibm.IExtendedSecurity.CredAttrSecName.value );
attributeTypeList[1] =
   new org.omg.Security.AttributeType( attribute_family1,
                           com.ibm.IExtendedSecurity.CredAttrHostName.value);
```

Acquiring a Credential on a Thread

This procedure demonstrates how you can acquire a credential on a thread of execution. This is used to determine the identity of the principal that issued the request, the identity of the server, or the identity used for any further method requests on downstream servers.

Any given thread of execution at either the client or the server may be associated with one of the following credentials:

Received-credential The received-credential identifies the principal for whom this request is being performed. In the server, the received-credential is the credential received with the currently executing method request. In the client, the received credential is the client's own-credential (since no up-stream method request drove the current thread of execution).

Invocation-credential The invocation-credential is the credential that accompanies any further down-stream method requests made from this thread of execution. In the server, when delegation is enabled, the invocation-credential is automatically set to the received-credential.

Own-credential The own-credential is also known as the process' default-credential. This credential identifies the principal associated with the process. In the server, this is the server-principal. In the client, this is the client-principal.

To perform this procedure you need to decide which credential you want, the security run time must be installed and the ORB must be initialized.

To acquire a credential on a thread of execution, use the following steps:

1. Obtain a security Current object: Get a security Current object.
2. Acquire the desired Credential: Use the SecurityLevel2::Current::received_credentials attribute, or the SecurityLevel2::Current::get_credentials() method to get the credentials. Use the former attribute if you want the received-credentials. Use the latter method if you want the invocation- or own-credentials.
3. If acquiring received-credentials, select the first credentials from the credentials list: The SecurityLevel2::Current::received_credentials attribute returns a CredentialsList. Component Broker only carries one received-credentials. The received-credentials is in the first position of the credentials list.

Acquire the **received-credentials** using the following steps:

```
#include <IExtendedSecurity.hh>
#include <CBSeriesGlobal.hh>
// Declare a reference to the CORBA::Current, SecurityLevel2::Current,
// and Credentials and CredentialsList objects.

CORBA::Current_var current;
SecurityLevel2::Current_var securityCurrent;
SecurityLevel2::CredentialsList_var receivedCredentialsList;
SecurityLevel2::Credentials_var receivedCredentials;

// Use the CBSeriesGlobal::orb to get a CORBA::Current

current = CBSeriesGlobal::orb()->get_current();

// Narrow to the SecurityLevel2::Current.

securityCurrent = SecurityLevel2::Current::_narrow(current);

// Get the received-credentials list

receivedCredentialsList = securityCurrent->received_credentials();

// Pull out the received-credentials from the first (0th) position
receivedCredentials = receivedCredentialsList[0];
```

Acquire the **invocation-credentials** using the following steps:

```
#include <IExtendedSecurity.hh>
#include <CBSeriesGlobal.hh>
// Declare a reference to the CORBA::Current, SecurityLevel2::Current,
// and Credentials objects.

CORBA::Current_var current;
SecurityLevel2::Current_var securityCurrent;
SecurityLevel2::Credentials_var invocationCredentials;

// Use the CBSeriesGlobal::orb to get a CORBA::Current

current = CBSeriesGlobal::orb()->get_current();

// Narrow to the SecurityLevel2::Current.

securityCurrent = SecurityLevel2::Current::_narrow(current);
// Get the invocation-credentials
```

```
invocationCredentials = securityCurrent->get_credentials(
        Security::InvocationCredentials);
```

Acquire the **own-credentials** using the following steps:

```
#include <IExtendedSecurity.hh>
#include <CBSeriesGlobal.hh>
// Declare a reference to the CORBA::Current, SecurityLevel2::Current,
// and Credentials objects.

CORBA::Current_var current;
SecurityLevel2::Current_var securityCurrent;
SecurityLevel2::Credentials_var ownCredentials;

// Use the CBSeriesGlobal::orb to get a CORBA::Current

current = CBSeriesGlobal::orb()->get_current();

// Narrow to the SecurityLevel2::Current.

securityCurrent = SecurityLevel2::Current::_narrow(current);

// Get the own-credentials

ownCredentials = securityCurrent->get_credentials(
        Security::SecOwnCredentials);
```

Access Control

Component Broker, in this release, supports a coarse-grained access control model. Access to business objects is controlled at the server level based strictly on whether the client principal has been authenticated. More specifically, the enterprise determines whether your business object must be secured or not. If so, an enterprise administrator should configure the server where your objects reside to be secure using the Component Broker system management facility.

Any objects created in a secure server are protected. The client principal must be authenticated prior to being allowed to invoke method requests against objects in the secure server. The same policy applies to all principals for any object in the server.

Finer grained control over who can access functions in your object can be obtained by acquiring the credentials of the principal on whose behalf the request is being made, and testing that against access policies that are relevant to your application. For instance, if you are developing a claims-inquiry function, you might want to test for whether the person requesting the inquiry is a beneficiary of the claim. If so, then you might allow the requestor to receive personal information about the claimant that you do not allow an adjuster to see.

Other Security Considerations for the Server

Component Broker can protect your business objects in a secure server by authenticating any access to them. However, this protection can be undermined if rogue or untrusted software is loaded in to the server. Since the implementations for business objects are captured in dynamic link libraries (DLLs), then an attacker can subvert the security of the system by changing or superceding the implementation of your business objects, perhaps handing out valuable information to other, unauthorized parties by replacing your DLLs.

To prevent this, you should protect the file system in which DLLs and EXEs (in general, any executable) are stored, and prevent the server from loading DLLs from anywhere but that protected file system. The LIBPATH for your server should be set to only those directories containing the DLLs that you want loaded in your server. This includes the Component Broker server EXE, the Component Broker system DLLs those that are needed to run the server process, and your business object DLLs.

WIN The default locations for Component Broker DLLs are the following directories:

- \Program Files\IBM\ComponentBroker\bin
- \OPT\Digital\dce\bin

AIX The default locations for Component Broker shared library files are the following directories:

- /usr/lpp/CBConnector/bin
- /usr/lpp/CBConnector/lib
- /usr/lpp/dce/bin

The system administrator may elect to install these files elsewhere. In any event, you should set the access controls on the directories containing the Component Broker DLL files so that only the servers can read files in those directories, and so that only selected administrators can put DLLs or other executable files in those directories.

Depending on how you have implemented your business objects, if you make use of other data files that affect the way your business objects perform their tasks, such as configuration files or policy rules files, then an attacker could modify these types of files as well to subvert your business objects. The above principle regarding the protection of the file system should be applied to any directories that contain data files that affect the behavior of your business objects.

Authentication and End-Users

Security systems are generally composed of several related concepts. This includes things like authorization, confidentiality, auditing and administration. While all security concepts are fundamentally built on the foundations of a cryptographic system, most security concepts are preconditioned by establishing who end users are, and certifying they are who they claim to be. Certifying that a person is authentic is known as authentication. Authenticated end users have identities. Those identities can be used to determine what resources the end-user is allowed to access, and how. Message traffic can be encrypted in a way that only an authenticated end-user can decipher. Identities of anyone challenging the integrity of the security system can be obtained.

Authentication of a person can be based on a variety of techniques that challenge what that person possesses, what they know, or who they are, or any combination of the three. For instance, you can assert who a person is by the fact that they possess a key to your house or employee-badge to your enterprise. This is typically a weak authentication scheme, as it can be easily defrauded by stealing the possession. The strongest technique is to base authentication on something that biometrically defines a person such as a finger-print, voice-print, DNA-print, or signature. Typically biometric-based authentication can be very reliable, but also somewhat intrusive. Biometric-based authentication schemes also typically require specialized hardware. The middle road is to base authentication on a secret that only that person should know, such as a password or your mother's maiden name. This is only as strong as it is difficult to guess the secret. However sufficiently obscure passwords can be reasonably difficult to guess making this technique quite strong. The first release of Component Broker supports password-based authentication relying on a secret that only that end-user should know.

When a User is not an End-User

Not all users are in fact people. More specifically, not all activity in the system is performed strictly on behalf of a specific person. Other entities in the system need to be authenticated too.

For instance, before using a particular server, you might like to be certain that the server is legitimate, that it is the server you expect to be working with. Component Broker provides support for authenticating servers certifying that the server is what it claims to be. To achieve this, server processes are given identities and are required to prove themselves to the system. Obviously, biometric or possession-based authentication schemes would not be very practical, and so servers are expected to authenticate themselves based on a password. Administration of a user's identity and password is discussed further in "Server Key-Tab File." For any method request between a client process and a server process (or between server processes) Component Broker attempts to authenticate both the the client to the server, and the server to the client. This is known as mutual-authentication.

User IDs and Passwords

Authentication is based on user-identities (user-ids) and passwords. The end-user is expected to enter a user-id and a password to log-in to the system. If the password is valid for the given user-id, then the user is deemed to be authentic. Component Broker offers a variety of ways of supplying the user ID and password (logging in), including the following:

- "Logging-In with dce_login" on page 164
- "Logging In with Environment Variables" on page 151
- "Key-tab File"
- "Logging in Programatically" on page 163
- "On-Demand Log-in Prompt" on page 163

Server Key-Tab File

A key-tab file can be used to store a user-id and password for a particular principal. While this can be used for client-principals (end-users), it is normally used to identify server-principals. A key-tab file is a convenient mechanism for storing log-in information; information that only a server should possess in order to authenticate itself to the security system.

When placed in a secure file system and protected with restrictive access policies, the key-tab file itself can be maintained safely. The policies governing access to the key-tab file should be set so that only the server's identity (the local identity under which the server runs) can access the key-tab file. If the server is activated automatically, then the local identity of the server is the same as the ORB daemon that starts it. If the server is started manually by an administrator, then the server's local identity is the identity of the administrator that starts it.

As the log-in information is kept in a well-known place, the server can be authenticated automatically. Also, the log-in information can be automatically updated thus helping to preserve the integrity of the log-in information and at the same time facilitating server automation. (See the *DCE Administration Reference*, particularly the subcommands of the **rgy-edit** security service commands for more information on key-tab file management.)

Key-tab File

Establishing a server's identity can most often be accomplished with the use of a key-tab file. The key-tab file is essentially used to retain the server's identity and password. By being isolated in this way, it can be administered more easily: for instance, the password can be automatically changed periodically to decrease the vulnerability of the server's identity.

However, since this vital information is stored in a file it must be protected to prevent other user's of the server host from accessing it and exploiting it for unauthorized purposes. This is achieved by putting the key-tab file in a protected file system, and setting the access controls on the file so that only the server can access it. This in turn requires that the server be started by an administrator or daemon process whose operating-system identity, inherited by the server, has the authority to access the file. The inherited operating system identity is used to provide access to the key-tab file from which the server's distributed system identity is established.

Each server on the same host can have its own entry in the key-tab file and establish its own distributed system identity. Nonetheless, any server started by the server activation daemon inherits the same operating system identity. The key-tab file should be set so that the daemon's operating system identity can access the file. This form of authentication is only exercised if this option has been enabled in the configuration, and the key-tab file has been created and can be accessed by the server process. This option can also be used by client processes and is subject to the same conditions and procedures as server processes. The server must be authenticated from a key-tab file.

Protecting the Key-Tab File

This procedure demonstrates how you can protect your server's key-tab file from unauthorized tampering. A key-tab file can be used for authenticating a server without requiring a local administrator to log-in for the server. Thus the key-tab contains sensitive security information, specifically the server's user-identity and password. It is essential for the integrity of the server that this file be protected.

The primary means of protecting the key-tab file resides with the file system where it is stored. The file permissions for the key-tab file should be set so that only the server can access it.

The server actually assumes the local operating-system identity of either the administrator that manually started the server, or more often, the identity of the ORB daemon that started the server automatically. In turn, the ORB daemon assumes the local operating system identity of either the administrator that manually started the ORB daemon (somorbd.exe), or more likely the Component Broker system management agent that started the ORB daemon. Finally, the system management agent assumes the local operating-system identity of the administrator that manually started the agent (bgmain.exe and bgsrvctl.exe), or the local operating-system identity of the administrator registered with Component Broker in the NT Registry, if the Component Broker is started automatically at system start-up.

Thus, the local-operating system identity of your server depends on your configuration and the process you use for starting the server. Most often, it assumes the identity of the administrator registered with Component Broker in the NT Registry. However, it could be the identity of another administrator if portions of the Host system are started manually. It is up to you to resolve which administrator's identity is used ultimately to start the server.

Knowing the local operating system identity under which your server runs is important because it is this identity that you must enable to access the key-tab file. Any other identity that you enable to this file has the ability to see and possibly change the DCE user ID and password for the server. Thus, the permissions for the key-tab should be as restrictive as possible.

Component Broker automatically creates a single default key-tab file per host. The server principal information for every server on that host is entered into that key-tab file. Thus, if different servers on the host are started under different local operating systems (OS) identities, then each of these identities needs to be enabled to access that key-tab file.

If this is unacceptable, that is if you have some servers that are started manually by different administrators and you do not want them to all have access to the default key-tab file, then you must use the DCE administration tools (rgy_edit) to create a unique key-tab file for that server and protect it separately. In doing so, you need to supply the name of the server for which an account should be created in the DCE user registry. Component Broker establishes the principal name for the server; you can obtain this from the Component Broker system management facility, but the corresponding account for the server in the DCE user registry should be created automatically. In addition, you need to modify the Component Broker system management configuration properties for that server to indicate the name of the key-tab file so that Component Broker can find it to log-in the server during server start up.

In Windows/NT, files can only be protected if they are installed in the NT file system (NTFS).

WIN Protect the server key-tab file using the following steps:

1. Log in to the host machine. Sign on to the host machine where your server resides, either as the administrator that normally starts the host machine, or the administrator that manually starts the part of the Component Broker whose local operating system identity is assumed by the server.
2. Create the key-tab file. If necessary, create a unique key-tab file for the server. Otherwise, assume the default key-tab file, v5srvtab.
3. Use explorer to navigate to the key-tab file and set the permissions:
   a. From the Windows NT Start menu, select **Programs** → **Windows NT Explorer**.
   b. In NT Explorer, choose: **C:** → **Opt** → **Digital**> **dcelocal** → **krb5**.
   c. Right mouse click on the key-tab file, **v5srvtab** or the key-tab file you created in step 2.
   d. Select **Properties**.
   e. Select the **Security** tab.
   f. Click on the **Permissions** button.
   g. Ensure only System and the group representing your administrator (that is, Administrators) has Full Control (All). Everyone should only have Execute (X).All other user groups and users should have No Access, or be removed from the ACL.
   h. Choose **OK** to accept the file permissions.
   i. Choose **OK** to close the Properties window.

AIX Protect the server key-tab file using the following steps:

1. Log in to the host machine. Sign on the host machine where your server resides as root.
2. Create the key-tab file. If necessary, create a unique key-tab file for the server. Otherwise, assume the default key-tab file, v5srvtab.
3. The key-tab file should already have the correct permissions. DCE on AIX sets the permissions automatically. If necessary, change directory (**cd**) to /krb5, and use **chown** to set the owner to your administrator's id or root, and use **chmod** to set the permissions so that only the owner can read or write the key-tab file.

Logging In with Environment Variables

You can specify the user ID, password, and cell in the environment variables *SCSPRINCIPAL, SCSPASSWORD* and *SCSCELLNAME,* respectively. The ID, password and cell values only have significance in the scope established for these variables. Depending on how these variables are created, the scope can be simply just the client process they are created in, or it can be any client process on the client machine, unless specifically modified in an individual process. These variables are then used by Component Broker to automatically log-in the specified user for any requests that are initialized from that client. This mode of log-in is only exercised if this option is enabled in the configuration, and the variables have been created and assigned a value in the client environment.

Note: This approach to logging in a user can be somewhat vulnerable to attack. A common practice is to use this option by setting the environment variables in a shell-script. If you hard-code the user-id and password variables in the shell-script, not only are you exposing the values to anyone else who has access to the file-system on which the script is stored, but if someone else is allowed to invoke the script they can use it to masquerade as the person identified in the shell script. Caution should be taken when using this log-in approach.

Using Environment Variables to Establish Authenticity

This procedure demonstrates how you can create a credential for a principal by supplying the principal's userid and password in environment variables. The values supplied in these variables are used to log-in the specified user when a credential is first required, when this option has been enabled in the configuration of the process.

The credentials produced for the principal specified in the environment variables are always local to the process where the log-in occurs. However, the same environment variables are used in all processes that fall within their scope. For instance, if you set these environment variables in the start-up script for the machine (for example, config.sys) then they are available to all processes started on the machine, unless explicitly nulled out in specified processes before they are used to log-in.

Note: This process is useful for certain circumstances such as when a shell-script is used outside of the application program to perform a log-in of the principal. However, this approach should be used with some care to avoid exposing the userid and password to potential attacks. For instance, it may be dangerous to set the environment variables from hardcoded values in a shell-script. Shell-scripts are stored in a file and therefore can be attacked if the shell-script file is not protected in a secure file system.

To log in to Component Broker, you need a user ID that has been registered with DCE. You should use the DCE administration tools to create an account for the corresponding user ID. DCE must be installed.

The following steps demonstrate how to create a credential for a principal by supplying the principal's userid and password in environment variables:

1. Set the SCSPRINCIPAL environment variable with the userid of the principal you want logged-in. The userid must have been registered with the DCE user registry.
2. Set the SCSPASSWORD environment variable with the password of the principal you want logged-in. The password must be valid for the principal identified in SCSPRINCIPAL.
3. Set the SCSCELLNAME environment variable with the cell in which you want to authenticate the principal specified in SCSPRINCIPAL. Component Broker supports a single cell, and so the SCSCELLNAME should be set with the cell used for the Component Broker installation.

The following example is an excerpt from an NT command file. This example specifies the user ID and password information for Jane Austin (user ID jaustin) in the Winchester cell.

```
set SCSPRINCIPAL=jaustin
set SCSPASSWORD=sensible
set SCSCELLNAME=winchester
```

The actual logging-in of the principal specified in the environment variables occurs well after the variables themselves are set. No error indication occurs when these variables are set, even if the principal name, password, or cell name are invalid. The first indication of this type of error generally occurs on the first method request initiated (or received) by the process and is reported back to the application with a

NO_PERMISSION exception on the request. Any errors that occur while logging-in the user are reported in the Component Broker error log. If you suspect an error has occurred during log-in, perhaps due to the principal or password supplied in the environment variables being incorrect, then you should check in the Component Broker error log.

Message Protection

Component Broker authentication services can provide you protection from unauthorized access to your server. However, you may also need to protect the method requests themselves as they flow over the network. This is particularly true in untrusted networks where the network flows over unguarded or publicly accessible wires. For instance, it is relatively easy to tap into a local area network (LAN) to monitor network traffic. An attacker can attach a monitor to see the content of every message. If your method requests pass monetary, personal, or business information that is sensitive, this can be viewed and even changed by the attacker. Component Broker provides different qualities of protection (QOP) for message traffic between client and server processes, including the following:

Integrity Protection The message is digitally signed. Component Broker verifies the signature of the message to ensure that no one has modified the content of the message en-route. This can prevent the message from being tampered with, but does not prevent an eavesdropper from viewing the message.

Confidentiality Protection The message is encrypted. Component Broker encrypts the message to ensure that no one can view the message en-route. This can prevent the message from being read, but it does not necessarily prevent the message from being modified, even if only to damage the message by setting it with an unencrypted value.

Confidentiality and Integrity Protection The message is encrypted and digitally signed. This can prevent the message from being read or modified.

None (Out-of-Sequence and Replay Protection) The message is neither encrypted nor digitally signed. This leaves the message vulnerable to being read and modified. However, as with all of the previous modes, the message is always out-of-sequence and replay protected. That is, Component Broker always assigns a secure-sequence number to all messages and detects when two messages are received out of order or if the same message is replayed. This prevents an attacker from reordering method requests so that, for instance, a withdrawal is processed before a deposit, when in fact the deposit was intended to be processed before the withdrawal. Likewise, this protection prevents an attacker from sending the same withdrawal method twice.

Out-of-Sequence and Replay protection is performed on all messages to a secure server.

Message protection is performed using a *session key*, which is exchanged as part of creating a secure association between a client-principal and a server. These session keys are always unique to every client-principal and server pair, and so different keys are used even if method requests are passed between two servers operating on behalf of different client-principals. All message confidentiality is performed with the Data Encryption Service (DES) using a 56-bit key (plus 8-bit parity). All message integrity is performed with **MD5**.

The desired quality of protection is set at the secure server as a configuration option in the server image. The selected quality of protection specified for the server is used for all method requests invoked on objects in that server, irrespective of where the requests originate.

Note: Both integrity and confidentiality qualities of protection make use of a cryptographic algorithm to sign or encrypt the message. If you select either of these qualities your system performance is affected and the rate at which you can invoke methods decreases. Encryption protection affects performance more than integrity. The extent to which your system is affected depends on the size and frequency of method requests that you perform in your application and the overall workload on your client or server machine. You should evaluate this effect in any risk/benefit analysis you perform.

Security and System Management

The following procedures are performed through the Component Broker system management facility.

Securing the Server

This procedure demonstrates how you can make a server secure. A secure server protects the objects within it, and prevents any request from being invoked on any object within that server unless the requesting principal has been authenticated. Requests from unauthenticated principals are rejected even before control is passed to the target object. This is useful as a coarse-grained object access-control policy. It also ensures that whenever you try to obtain the credentials for the requesting principal, you can be assured of obtaining an authentic principal.

This procedure that follows is performed through the Component Broker system management facility. The Component Broker run time and system management facility must be installed to use this procedure. In addition, a secure server must have its own principal identity registered with DCE, and can only be authenticated with a key-tab file.

Make a server secure using the following steps:

1. Define a new server model, or select an existing server model. For a new server, use the Component Broker system management facility to define the new server model. Or if you are enabling an existing server to be secure, locate the corresponding server model in the system management facility.
2. Open the properties notebook. Use the right mouse button to open the **properties** notebook.
3. Tab to the Security Service page. Select the **Security Service** page by clicking its notebook tab.
4. Enable Server Security. **Edit** the **Security Enabled** property. Set it to Yes.

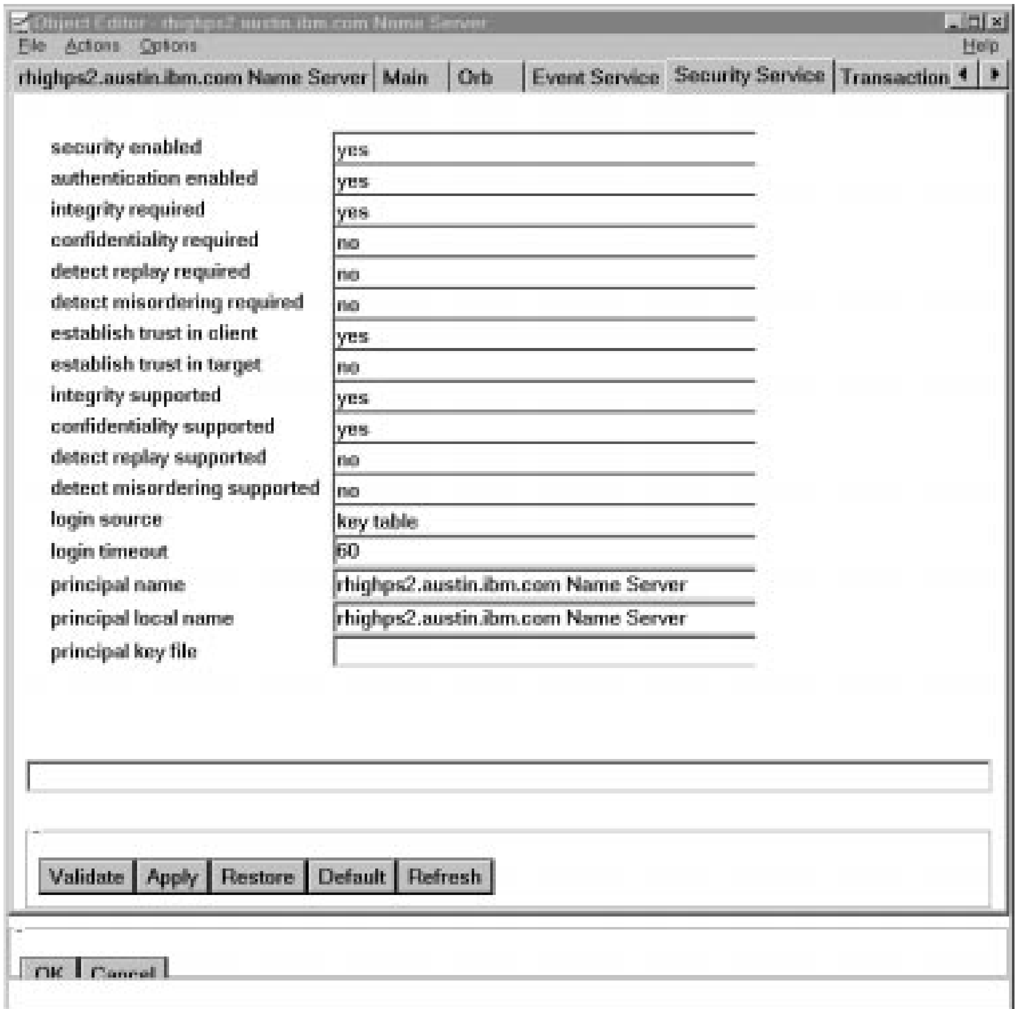


Figure 9. Server Notebook Page for Securing a Server

Establishing the Quality of Protection for a Server

This procedure demonstrates how you can establish the quality of protection that is enforced for all method requests that are sent to a server. The quality of protection for a server specifies how method requests are handled when transmitted to the server over the network. You can set the quality of protection for a server to any of the following values:

None The message is monitored to ensure it is not received by the server out of order or that the same message is not sent to the server more than once. This is the minimum protection that is used with any method requests sent to a secure server. The methods sent to the server can only be less protected if the server is configured to disable it as a secure server.

Integrity The message is digitally signed to ensure that it is not tampered with when transmitted over the network. If the server detects any attempt to tamper with the method request, the request is denied with the NO_PERMISSION system exception. This is raised with a minor code of SOM_SECURITY_NO_PERMISSION_PROTECTION_FAILURE.

Confidentiality The message is encrypted to ensure that it cannot be viewed when transmitted over the network.

Both The message is both digitally signed and encrypted to prevent tampering and viewing.

This procedure is performed through the Component Broker system management facility. The Component Broker run time and system management facility must be installed to use this procedure.

Note: In this release of Component Broker, no distinction is made between supported and required quality of protection. These values should be set the same using the system management facility.

Establish the QOP (Quality of Protection) for a server using the following steps:

1. Define a new server model, or select an existing server model. If it is a new server that you want to be secure, then use the Component Broker system management facility to define the new server model (or clone). If you are specifying the quality of protection for an existing server, then locate the corresponding server model (or clone) in the system management facility.
2. Open the properties notebook. Using the mouse, right-click on server name, then select edit to open the **properties** notebook.
3. Tab to the Security Service page. Select the **Security Service** page by clicking its notebook tab.
4. Specify the required quality of protection for the server. Edit the integrity required and confidentiality required properties and set them to the desired protection level. The detect replay required and detect misordering required properties are ignored and misordering detection are always performed.
5. Specify the supported quality of protection for the server. The supported quality of protection and the required quality of protection for the server should be the same values. Set the integrity supported, confidentiality supported, detect replay supported and detect misordering supported properties to the same values as their corresponding required properties in the previous step.

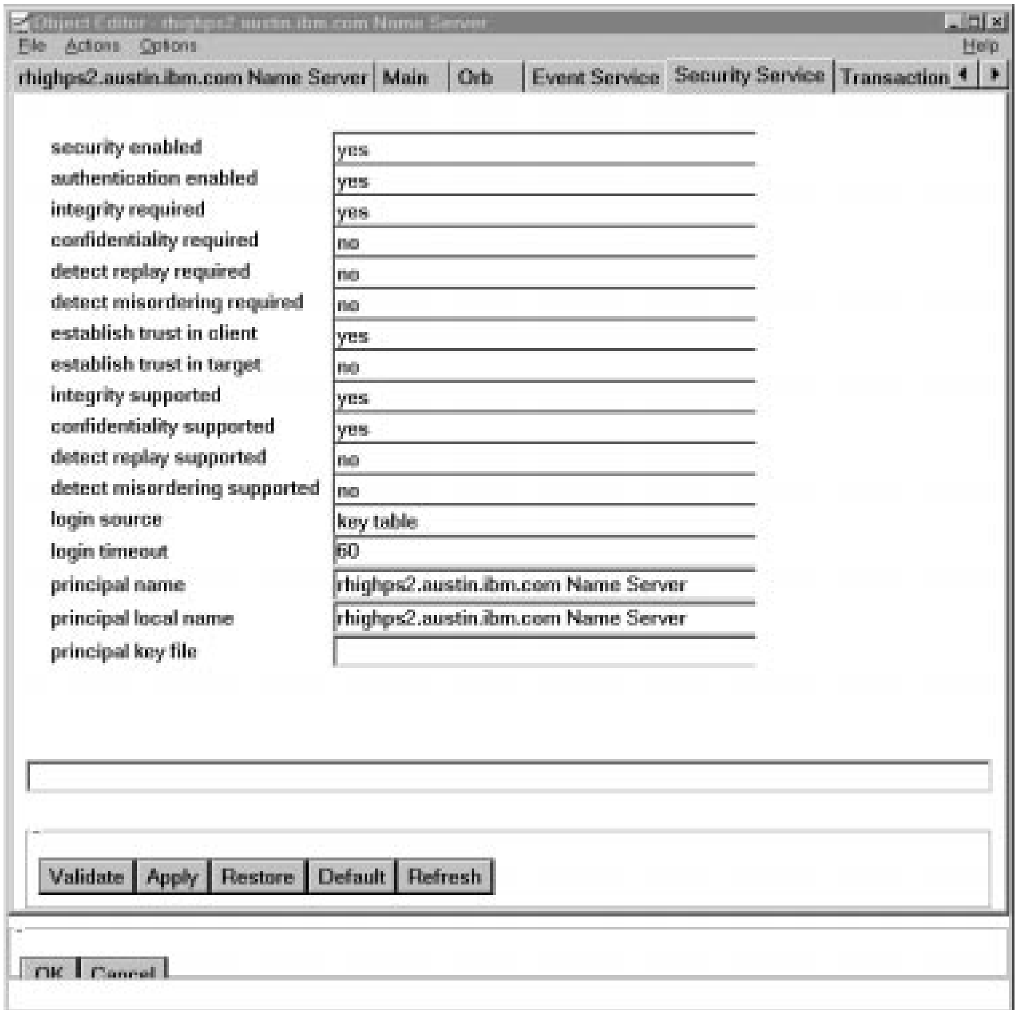


Figure 10. Server Notebook Page for Setting Required QOP

DCE Security

Component Broker security uses DCE for its underlying security functions. Component Broker principals are registered in the DCE user registry, and authenticated with the DCE security server. Also, messages are protected using DCE security functions. DCE must be installed both on the client and server sides to use Component Broker security services.

The general relationship between Component Broker and the DCE security service is depicted below. Note that the DCE Security Server forms a trusted third party. The client principal and the server principal are authenticated against the DCE security server. This is also referred to as three-party authentication.

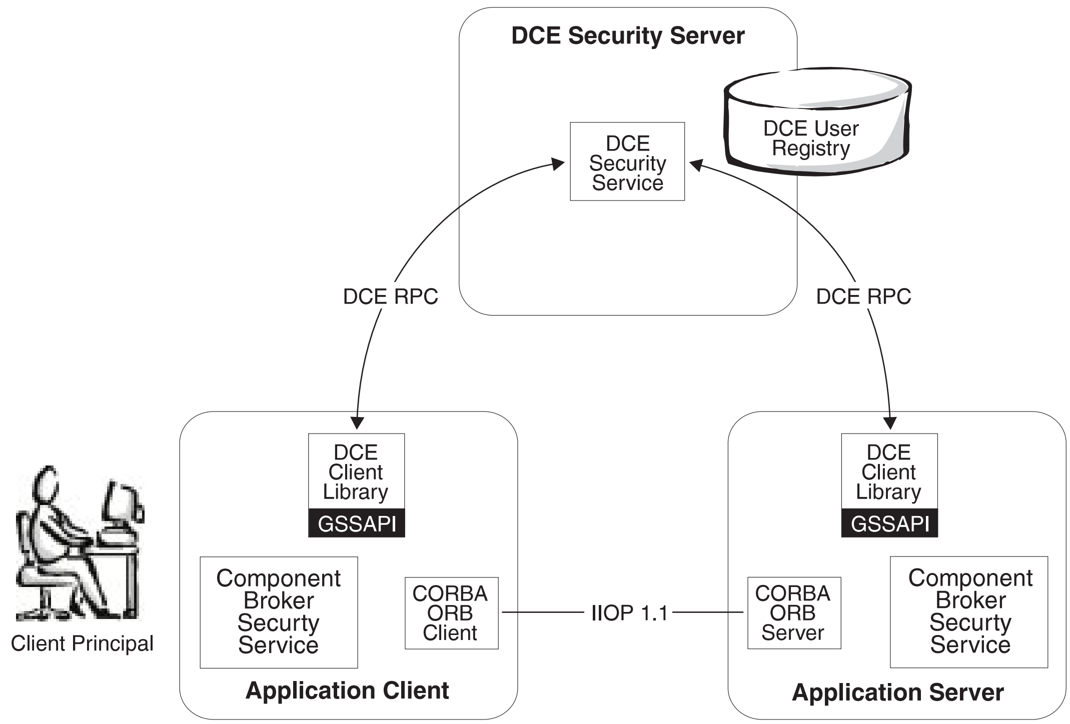


Figure 11. Relationship between Component Broker and the DCE security service

Note also that the Component Broker security service, which resides in both client and server processes, depends on the Generic Security Service API (GSSAPI) provided by the DCE Library. The DCE Library must be installed on all machines, both client machines and server hosts, that are protected by the Component Broker security service.

Principals and the User-Registry

All principals in Component Broker, including both client principals as well as server principals must be registered in the DCE user registry. Each principal is defined by an account in the DCE user registry. The DCE administration tools can be used to administer these accounts, including setting and resetting passwords, suspending their use, and establishing related security policies such as the composition and lifespan of passwords, and so forth.

Because the Component Broker Naming Service uses the DCE Cell Directory Service, access to individual naming contexts can be limited to individual principals by administering access controls and privileges to principal accounts defined in the DCE user registry.

Adding New Users to the User Registry

WIN This procedure demonstrates how you can add a new user to the user registry. This is useful for creating new accounts for client and server principals. Users are registered in the DCE security registry. You must have DCE installed. DCE Director administration tools to are used to perform this procedure.

Add new users to the user registry using DCE as follows:

1. From the Windows NT Start menu, select **Programs** → **DCE for Windows NT** → **DCE Director**. The Digital DCE Director window is opened.

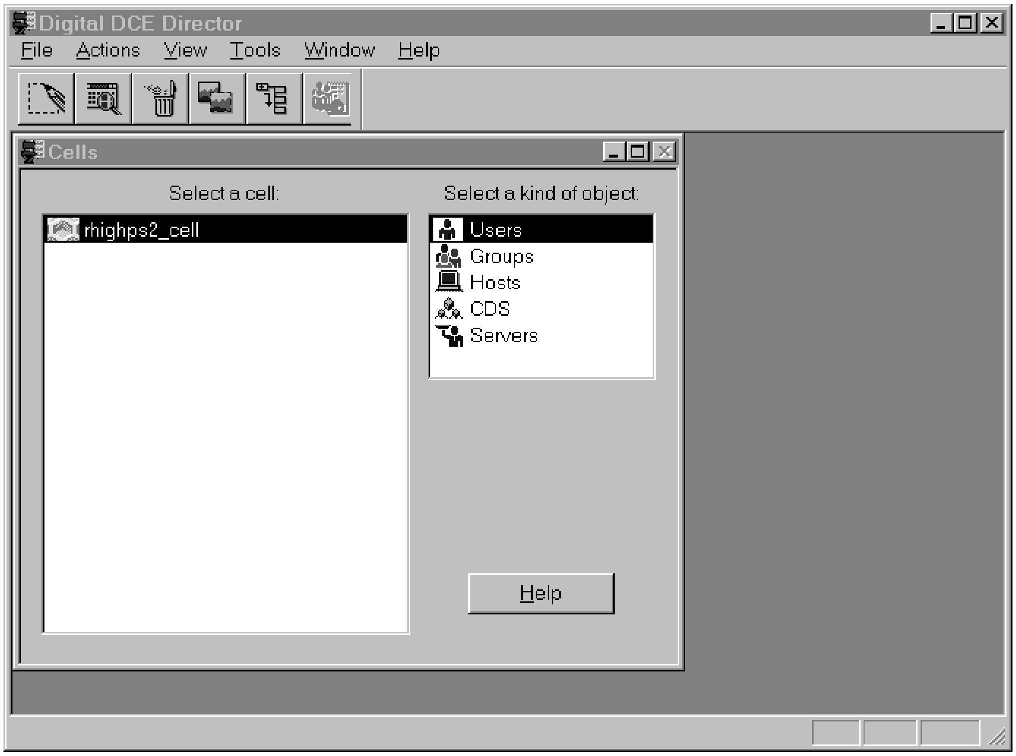


Figure 12. DCE Director for Administering Cells

2. Open the Users window. Double-click the **Users** object under Select a kind of object.

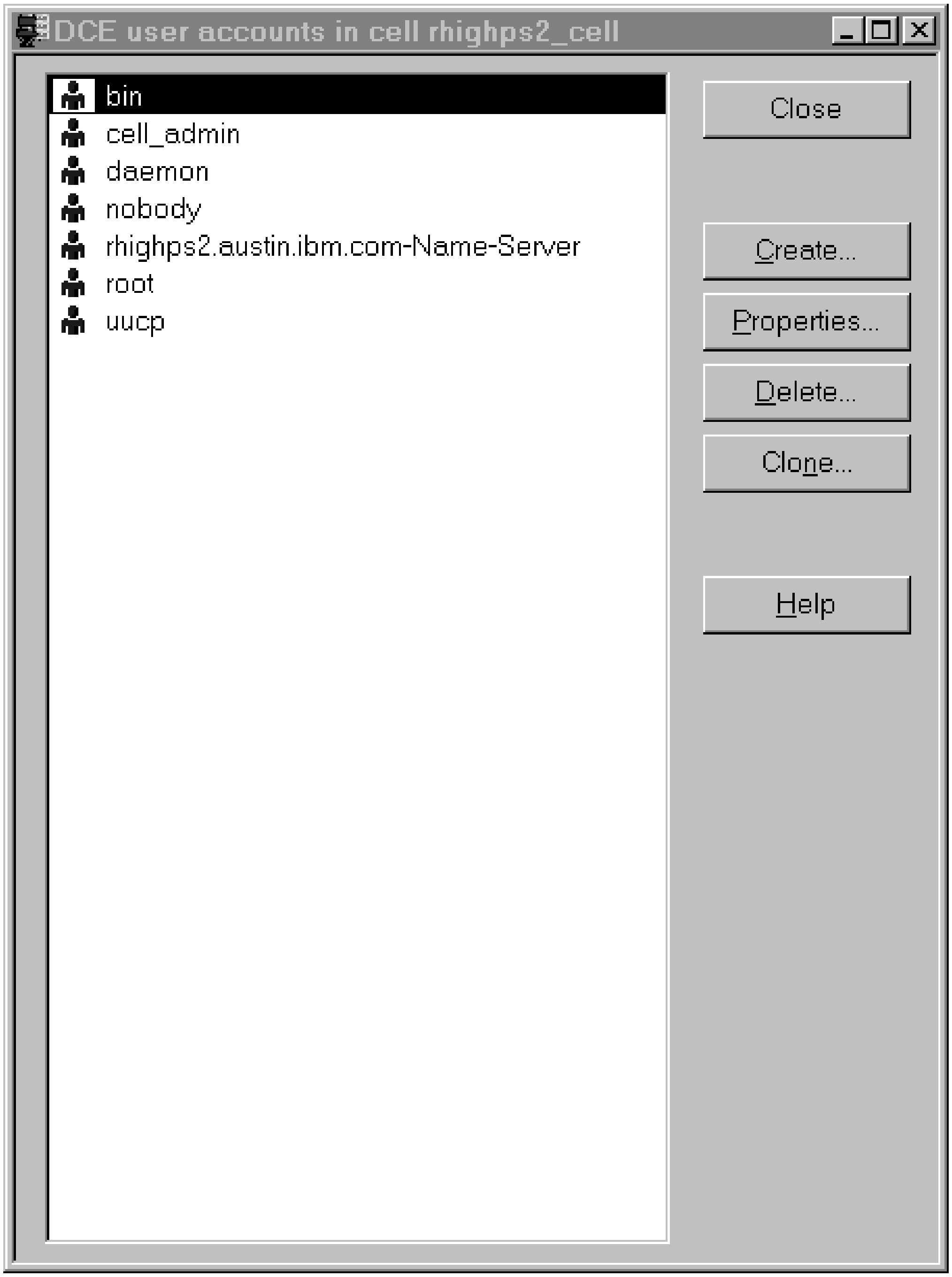


Figure 13. User Accounts Window

3. Open the User Creation window. Click **Create** to define a new account for the principal.

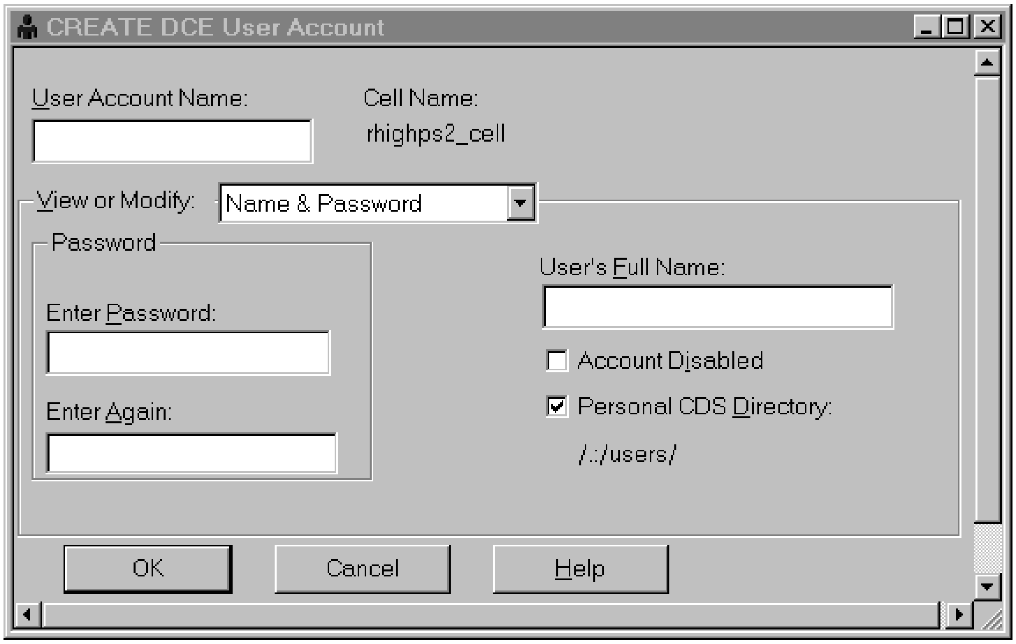


Figure 14. Account Creation Window

4. Supply the account information. Fill in the account information, including the user's account name (this is the user ID of your server), password (must be entered twice for verification) and user's full name fields for your server. Press **OK**.

Security in the DCE Java Client

The security service in this release of Component Broker uses the Distributed Computing Environment (DCE). The DCE client library is used to provide access to the DCE security server for authenticating and certifying principals. If you have Java clients and want to authenticate client-principals, you need to install the DCE client library at those stations. In addition, you must install the Component Broker Java security wrapper classes at the Java client station, even if the rest of the Component Broker run time and your application is operated as down-loadable applets.

The Current object is not supported in the Java client. Consequently, you cannot get access to the Credentials in use in the client. Nonetheless, you can still create new credentials with the IExtendedSecurity::LoginHelper object, and all other aspects of security that are relevant in a client continue to work.

Configuring a Secure Server Process

Through the Component Broker system management facility you can configure any given server process as a secure server. Doing so results in all of the managed objects in that server being protected: any request on a managed object in the server is rejected unless the principal of the request has been authenticated. Security enablement procedures are detailed in the *Component Broker for Windows NT and AIX Quick Beginnings* .

Running Applications with Security Enabled

To run applications in a Component Broker environment with Security enabled, please use the following checklist:

Note: This checklist assumes that the user has already successfully configured all required environments before running the application. If not, please read the *Component Broker for Windows NT and AIX Quick Beginnings* .

1. Check the DCE configuration and run-time status:

   For Windows NT:

   - Always open a DCEsetup window when you want to check the DCE configuration on NT. To open a DCEsetup window, click **Start→Programs→DCE for Windows NT→DCEsetup**. The DCEsetup window, when it opens, contains two panels.
   - Component Broker releases 1.0, 1.1, and 1.2 support only one DCE cell. Therefore, all your DCE clients and the DCE server must be configured into a single cell. To check the configuration, go to each Component Broker host and open a DCEsetup window. On the right panel, find the entry box labelled **Cell Name:**. Make sure the name in this field is the same on all DCE-configured host machines.
   - For a configured DCE server, the following services should be **Enabled** and in **Running** state:
     – Security Client
     – Security Server
     – CDS Advertiser
     – CDS Server
     – DTS
   - For a configured DCE client, the following services should be **Enabled** and in **Running** state:
     – Security Client
     – CDS Advertiser
     – DTS

   For IBM AIX:

   - Run the `lsdce` command to list all configured DCE services. All services should be in the COMPLETE state.
   - Do a `dce_login` to ensure DCE services are running.
   - Run the `getcellname` command to display the DCE cell name for each host. Verify that all hosts have the same cell name.

2. Check for Security enablement using the System Manager User Interface:
   - In the System Manager User Interface window, check all entries under **Client Style Images**. Right-click each entry to open the notebook and open the **Security** page. Verify that the value in the **Security enabled** field is `yes`.
   - In the System Manager User Interface window, check all entries under **Server Images**. Right-click each entry to open the notebook and open the **Security** page. Verify that the value in the **Security enabled** field is `yes`.

When Running the Java Client: Make sure you specify the system property that enables Security when running Java client applications. The name of the property is com.ibm.CORBA.EnableDCESecurity.

For example:

```
java -Dcom.ibm.CORBA.EnableDCESecurity=true MyJavaApp
```

Where *MyJavaApp* represents the name of your Java application. Check the readme file that comes with the Component Broker Java samples for more information.

If you have questions, you should contact an IBM representative.

Logging in to DCE

The following sections show the different ways of loggin in to DCE.

On-Demand Log-in Prompt

If a user is not logged-in using a command-line utility, environment variables, key-tab file, or programmatic Log-in, and if this option is enabled in the configuration, the user is prompted for a user ID and password at the first method request from the client to any given server. While this is an action of last-resort, it is also probably the most frequently exercised option for client processes. The prompt is not presented if the configuration has disabled this option. This allows you to prevent user prompts from occurring on unattended hosts.

Logging in Programatically

In some cases, an application acquires user-login information by prompting for it as part of its business logic or by some other means. This is not normally encouraged as it can easily be abused by rogue applications for gathering and covertly siphoning valuable log-in information. Also, special care must be taken to avoid creating exposures in the system when handling user-ids and passwords. Nonetheless, if the application does have log-in information that it has gathered, it can use this to log the user in directly. This can be accomplished with the IExtendedSecurity::LoginHelper::request_login() operation.

This procedure demonstrates how you can log in a user to DCE; producing a DCE credential on the client machine. This in turn, can be picked up by Component Broker programming interfaces. This is useful for when your application gathers log-in information for its own purposes and then you want to log in that user without requiring that user to enter their log-in information again at the Component Broker log-in prompt or the dce_login command-line utility.

To log-in to Component Broker, you need a user ID that has been registered with DCE. You should use the DCE administration tools for creating an account for the corresponding user ID. DCE must be installed.

The following steps demonstrate how to log in a user using the Component Broker programming interfaces:

1. Create a LoginHelper object. The LoginHelper object is a local-only object that can be created using the IExtendedSecurity::LoginHelper::_create() static method in C++, or com.ibm.IExtendedSecurity._LoginHelperHelper._create() static function in Java.
2. Solicit the user ID and password. If you are using this approach then you probably already have in mind that you will be soliciting the user ID and password for the principal in your application. Some care should be taken when doing this as to not inadvertently expose the password. Doing so allows an attacker to use the password to log in as the principal.

In addition, you need to supply a realm name for the principal. This is the realm, or more specifically the DCE cell, that you want the principal authenticated in. The principal must be registered as a valid user in that cell. Only a single cell is supported. Therefore, the realm should match the cell used for the Component Broker installation. If you leave this argument blank, the local cell is assumed automatically.

3. Request to log-in the specified principal. Use the request_login() operation to invoke the log-in request. If the log-in is successful, this returns a Credentials object representing the credentials of the user logged-in. This can be retained or explicitly set on a thread of execution. The Credentials produced in the request_login() request supercedes the default credential for the process.

   This operation returns some authentication-specific data. The data is provided for future use and is not intended to be interpretable by applications.

The following example demonstrates how to log-in Jane Austin (user ID jaustin) in the Winchester realm:

```
// Declare a LoginHelper and Credentials object, and an opaque structure
// for the authentication-specific data.

IExtendedSecurity::LoginHelper_var loginHelper;
IExtendedSecurity::Credentials_var new_creds, unused;
Security::Opaque_var authn_specific_data;

// Create an instance of a LoginHelper object

loginHelper = ISecurityLocalObjectDCEImpl::LoginHelper::_create();

// Log-in Jane Austin to the Winchester realm.

new_creds = loginHelper->request_login("jaustin", "Winchester",
        "sensible", unused, authn_specific_data);
```

Logging-In with dce_login

This procedure demonstrates how you can log in using the dce_login command. DCE supplies this command-line utility to let you log-in to DCE; producing a DCE credential on the client machine. This in turn, can be picked up by Component Broker to form a Component Broker credential for the principal that logged in.

If you invoke dce_login at a client, the resulting credentials are used as the invocation-credentials for any requests initiated by any process at the client. Even if the client is configured to use environment variables or a key-tab file, the credentials produced from dce_login are used instead if the dce_login is performed before the first method request initiated from the client. Only a programmatic log-in can be used to supercede the credentials produced by dce_login in this case. This credential continues to be used until the credentials expire. This rule does not hold true for any client processes that are started and that initiate a remote method request before the dce_login is issued. The credentials produced from dce_login do not have a bearing on the credentials used to identify a server.

Prior to logging in to Component Broker you need a user ID that has been registered with DCE. You should use the DCE administration tools for creating an account for the corresponding userid (see “Adding New Users to the User Registry” on page 158). This in turn requires that you have installed DCE.

Log in to Component Broker using DCE using the following steps:

1. Open a command-line window.Use the mouse to click **Start**, **Programs**, and **MS-DOS Command Prompt**. This opens a command prompt window.

2. Enter dce_login and your user ID. At the command prompt, enter **dce_login** and your user ID. Press the Enter key.
3. When prompted, enter your password. When prompted, enter your password. The password does not display. Press the Enter key. If the log-in fails you are notified with a message such as "Invalid Password."

There are a variety of reasons why logging-in a principal can fail, including that the userid does not exist or has been incorrectly specified, the password is incorrect or has expired, or the account has suspended or terminated. You should use the DCE administration tools to resolve any of these problems.

Destroying a Credential by Logging Out

This procedure demonstrates how you can destroy a credential, that is, how you can log-out a principal. To log-out of Component Broker you need the kdestroy command-line utility provided with DCE. This in turn requires that you have installed DCE and, of course, presumes that the user is already logged-in.

To destroy a credential, enter `kdestroy` from a command or shell prompt.

Security Service Objects

The Component Broker Security Service introduces the following object types:

Object Type	**Related Interface(s)**
"Principal Object"	CORBA::Principal
	IExtendedSecurity::Principal
"Credentials Object"	SecurityLevel2::Credentials
	IExtendedSecurity::Credentials
"Current Object" on page 166	SecurityLevel1::Current
	SecurityLevel2::Current
"LoginHelper Object" on page 166	IExtendedSecurity::LoginHelper

Principal Object

Important:: Please do not use the principlal object, it will be removed in a future release.

Credentials Object

A Credentials object represents a principal that has been authenticated to Component Broker. The SecurityLevel2::Credentials interface is introduced by the CORBA Security Service, and includes the following:

- Credentials copy()
- get_security_features(direction)
- get_attributes(attributes)
- is_valid(expiry_time)
- refresh()

Component Broker combines the CORBA::Principal and the SecurityLevel2::Credentials interfaces in the IExtendedSecurity::Credentials interface.

Current Object

The Current object provides your application access to the security service context associated with any given thread of execution. You can access any of the credentials associated with the thread of execution through a Current object. The CORBA Security service introduces SecurityLevel1::Current, and SecurityLevel2::Current, which inherits from the SecurityLevel1::Current interface.

The SecurityLevel2::Current interface adds the following methods:

- received_credentials()
- received_security_features()
- principal_authenticator()
- get_credentials(cred_type)

LoginHelper Object

The LoginHelper object can be used to log-in a user programmatically. The IExtendedSecurity::LoginHelper interface introduces the following method:

```
SecurityLevel2::Credentials:  request_login(security_name,
                                            realm_name,
                                            password,
                                            creds,
                                            auth_specific_data)
```

Chapter 9. Transaction Service

The Transaction Service enables programmers to implement transactions using standard object-oriented interfaces in a distributed environment.

The provision of a Transaction Service has always been an essential part of the software for mainframe systems because these systems run business critical applications. Now that such applications are also being written for a distributed environment, the software in this environment must also support a Transaction Service.

One of the features of business critical applications is that they often make a number of updates (changes) to the data to complete a task. At the same time, a number of different tasks are normally running that are also making updates to this data. The most difficult part of writing a business application is to keep the updates that belong to a single task together, while keeping them separate from the updates being made by other tasks. This is hard enough when the system is running properly; once you start considering all the different ways the system may completely or partially fail, the effort required to design and write the application becomes truly daunting.

This is where the Transaction Service is useful. The objects within an application group the updates required for a single task into a transaction and the Transaction Service ensures that either all of these updates occur or none of them do (this is called atomicity). Provided that the application has correctly grouped the updates in the transaction, then the data is always updated consistently. If the application uses the Transaction Service in conjunction with the Concurrency Service these updates are also not affected by updates being performed for other tasks. Finally, if persistent objects, or a database, are used to store the data, these updates will be permanent (durable) even if the system crashes.

An Example of a Transaction

Suppose you have two bank accounts, A and B, with balances of 300 and 100 dollars, and that you want to transfer 50 dollars from account A to account B. You might do this as follows:

1. A = A - 50
2. B = B + 50
3. Result: A = 250, B = 150

The result is correct. Suppose, though, that an error such as a system crash occurs just after account A is updated. If you are not using a transaction, the following would occur:

1. A = A - 50
2. System crash and restart
3. Result: A = 250, B = 100

Account A has been correctly debited but, because processing was interrupted by the system crash, the corresponding credit to account B has not been made. Apparently, 50 dollars have been lost. You can avoid this type of problem by using transactions.

You can implement the same bank transfer as a transaction:

1. Begin transaction
2. A = A - 50
3. B = B + 50
4. Commit transaction
5. Result: A = 250, B = 150

As expected, the result is correct. More importantly, if a system crash occurs after A is updated, the result is still correct:

1. Begin transaction
2. A = A - 50
3. System crash, system restart, transaction recovery
4. Result: A = 300, B = 100

This time, because the transaction was not committed, any changes made to the accounts before the system crash are discarded and both accounts return to their original state. The transaction can then be run again to get the correct results. Similarly if B is updated, but the transaction is not committed, the changes are discarded.

Top-Level and Flat Transactions

The most common type of transaction used by applications is the top-level transaction. For example, the first transaction created by an application is always a top-level transaction.

Top-level transactions are independent of one another; the updates that the application associates with one top-level transaction (see “Lifetime of a Transaction”) appear as an atomic update to other top-level transactions. They are also recoverable. This means that if some (or all) of the objects associated with the transaction terminate while the top-level transaction is still active (running) then the transaction waits until these objects have been recreated to allow them to participate in determining the outcome of the transaction.

An application can set a time limit for a top-level transaction. If it does not complete within this time limit, the transaction is said to have timed out and the Transaction Service causes it to rollback.

A top-level transaction is often referred to as a *flat transaction*.

The CORBA specification also describes another type of transaction, called a *subtransaction*, often referred to as a *nested transaction*. Component Broker does not currently support subtransactions.

Lifetime of a Transaction

Applications use transactions to group related updates to data such that all of the updates occur or none do.

Typically, an application:

1. Starts a transaction.
2. Makes the updates and associates them with the transaction.
3. Terminates the transaction

When an application terminates a transaction, it can request that the transaction is either rolled back or committed. If the application requests rollback, all of the updates it has made are undone. If the application requests that the transaction is committed, the Transaction Service checks that each object involved in the transaction is able to make its updates permanent. If all objects indicate that they can, the transaction is committed. Otherwise the updates are undone just as if the application requested rollback. The result of a transaction (that is, whether it committed or rolled back) is referred to as its outcome.

Transaction Scope and Context

The Transaction Service allows multiple objects to participate in a transaction. These objects can be distributed across multiple operating system processes and threads and each object can be working with more than one transaction at once. To control which transaction an object is working on at a particular point in the code, the Transaction Service provides a *transaction context*. This is a collection of Transaction Service objects that represents the transaction.

The *scope* of a transaction is made up of all the locations within your application where the transaction context is in use. In general, the scope of the transaction increases over the lifetime of the transaction as the transaction context is passed from object to object.

The Transaction Service provides two mechanisms for passing transaction context:

- The most common method is *implicit propagation*, where the transaction context is associated with a thread and is available to each method called within this thread that understands transactions. If a remote method is called, the Transaction Service automatically passes the transaction context to the thread in the remote server process where the method is run.
- An alternative method is for the application to pass the transaction context as a parameter on method calls. This is called *explicit propagation* and allows access to the transaction context without associating it with the remote object's thread. Explicit propagation is not used as widely as implicit propagation because it requires Transaction Service objects to be passed as parameters to application objects and prevents the Transaction Service from exploiting its own internal performance enhancements.

Recoverability

One of the main reasons for using the Transaction Service is that it removes the need for an application to manage the correction of its data if some, or all, of the operating system processes involved in a series of updates abnormally terminate. If the application associates the series of updates in a transaction, the Transaction Service is able to coordinate the objects responsible for these updates to ensure that either all or none of these updates occur, even in the event of system failures.

To do this, the Transaction Service requires that the objects that represent the updates made to the data are recoverable. This means they are capable of surviving, and of preserving their internal state, across a system or software failure. In the Component Broker programming model, these objects must be managed objects with persistent references and persistent state. These objects must also inherit from particular CORBA defined interfaces to allow the Transaction Service to call them when it is coordinating the updates. Refer to “The Transaction Service Objects and Interfaces” on page 178.

Recoverability is a quality of service that is provided by certain Component Broker Application Adaptors. The RDB Adapter is one such example.

Transaction Outcomes

When the Transaction Service is terminating a transaction, it uses the two-phase commit (“The Two-Phase Commit Process” on page 171) or one-phase commit (“The One-Phase Commit Process” on page 172) process to ensure the objects that have made updates to data during the transaction take the same action, committing (making permanent) the updates or rolling back (undoing them). The decision that is made, and the action the objects actually take, is referred to as the *transaction outcome*.

A top-level transaction (“Top-Level and Flat Transactions” on page 168) can have one of the following outcomes:

Commit All of the updates have been completed successfully and the changes are now permanently recorded in the data.

Rolled back
None of the updates requested for the transaction have been made. The data is left in the same state as if the transaction had not run.

Heuristic Mixed
Only some of the updates for the transaction have been permanently recorded in the data. The rest have been undone. In an ideal world, this outcome would never occur. However if:

- an application does not implement its resource objects (“The Transaction Service Objects and Interfaces” on page 178) correctly, or
- one of more objects are temporarily unable to contact the other objects involved in the transaction,

They may be forced to end the transaction by taking a heuristic decision (“Heuristic Decisions” on page 172) to release critical locks or resources. If this decision is inconsistent with the action chosen by the other objects then the outcome of the transaction is heuristic mixed.

In addition, if the top-level transaction is not able to contact all the objects, it can report *heuristic hazard*. This is a temporary result that changes to one of the outcomes described previously when all objects involved in the transaction are consulted.

The following table summarizes how the actions of the objects responsible for data updates within a transaction are aggregated into a transaction outcome.

Table 11 (Page 1 of 2). Transaction Outcomes

Action of Objects						**Transaction Outcome**
Commit	**Rollback**	**Heuristic Commit**	**Heuristic Rollback**	**Heuristic Hazard**	**Heuristic Mixed**	
yes						Commit
yes			yes			Heuristic Mixed
yes			yes	yes		Heuristic Mixed
yes			yes	yes	yes	Heuristic Mixed
yes			yes		yes	Heuristic Mixed
yes				yes		Heuristic Hazard
yes				yes	yes	Heuristic Mixed
yes					yes	Heuristic Mixed
	yes					Rollback
	yes	yes				Heuristic Mixed

Table 11 (Page 2 of 2). Transaction Outcomes						
Action of Objects						**Transaction Outcome**
Commit	**Rollback**	**Heuristic Commit**	**Heuristic Rollback**	**Heuristic Hazard**	**Heuristic Mixed**	
	yes	yes		yes		Heuristic Mixed
	yes	yes		yes	yes	Heuristic Mixed
	yes	yes			yes	Heuristic Mixed
	yes			yes		Heuristic Hazard
	yes			yes	yes	Heuristic Mixed
	yes				yes	Heuristic Mixed
		yes				Commit
		yes		yes		Heuristic Hazard
		yes		yes	yes	Heuristic Mixed
		yes			yes	Heuristic Mixed
			yes			Rollback
			yes	yes		Heuristic Hazard
			yes	yes	yes	Heuristic Mixed
			yes		yes	Heuristic Mixed
				yes		Heuristic Hazard
				yes	yes	Heuristic Mixed
					yes	Heuristic Mixed

The Two-Phase Commit Process

Two-Phase commit is a protocol used by the Transaction Service during transaction termination to enable all updates to data associated with the transaction to be made permanent (committed) or undone (rolled back).

In the first phase of the two-phase commit protocol, the Transaction Service sends a “prepare” message to each of the objects representing updates to the data made during the transaction. These objects respond by voting either to “Commit,” “Rollback” or “ReadOnly.”

A vote for “ReadOnly” means the object is not interested in the outcome of the transaction. It is therefore no longer involved in the two-phase commit.

A vote to “Rollback” causes the whole transaction to roll back. This object is not called again.

A vote to “Commit” means the object guarantees that it is in a state where it can either make its updates permanent or undo them, even if the system crashes before the Transaction Service can pass a message indicating which of these action to take. Because an object that has voted “Commit” is waiting for a decision from the Transaction Service, it is said to be “in doubt.”

If the Transaction Service receives a “Commit” or “ReadOnly” vote from all objects, it sends the “Commit” message to all objects that voted commit. These objects should make their updates permanent. They are not called again.

If the Transaction Service receives a “Rollback” vote from one or more objects it sends a “rollback” message to each object that voted “Commit.” These objects should undo their updates and they are not called again.

If all resources follow the protocol correctly (and none of the servers have a transaction retry limit set), the Transaction Service guarantees that all objects take the same action so that the updates for the transaction appear atomic. However, in exceptional circumstances, it might be necessary for some of the objects involved in the transaction to take a heuristic decision that might result in a loss of atomicity. This is referred to as *heuristic damage* or a *heuristic mixed outcome*.

If only one object is responsible for data updates in a transaction, the Transaction Service can use the one-phase commit optimization (refer to“The One-Phase Commit Process.”)

The One-Phase Commit Process

If all of the data updates for a transaction occur in a single object, the Transaction Service can optimize the termination of a transaction by using a one-phase commit protocol with this object rather than the two-phase commit (refer to “The Two-Phase Commit Process” on page 171.) With a one phase commit, a single message is sent to the object controlling the data updates and it reports whether it committed or rolled back. This result becomes the outcome of the transaction (refer to “Transaction Outcomes” on page 169.)

Heuristic Decisions

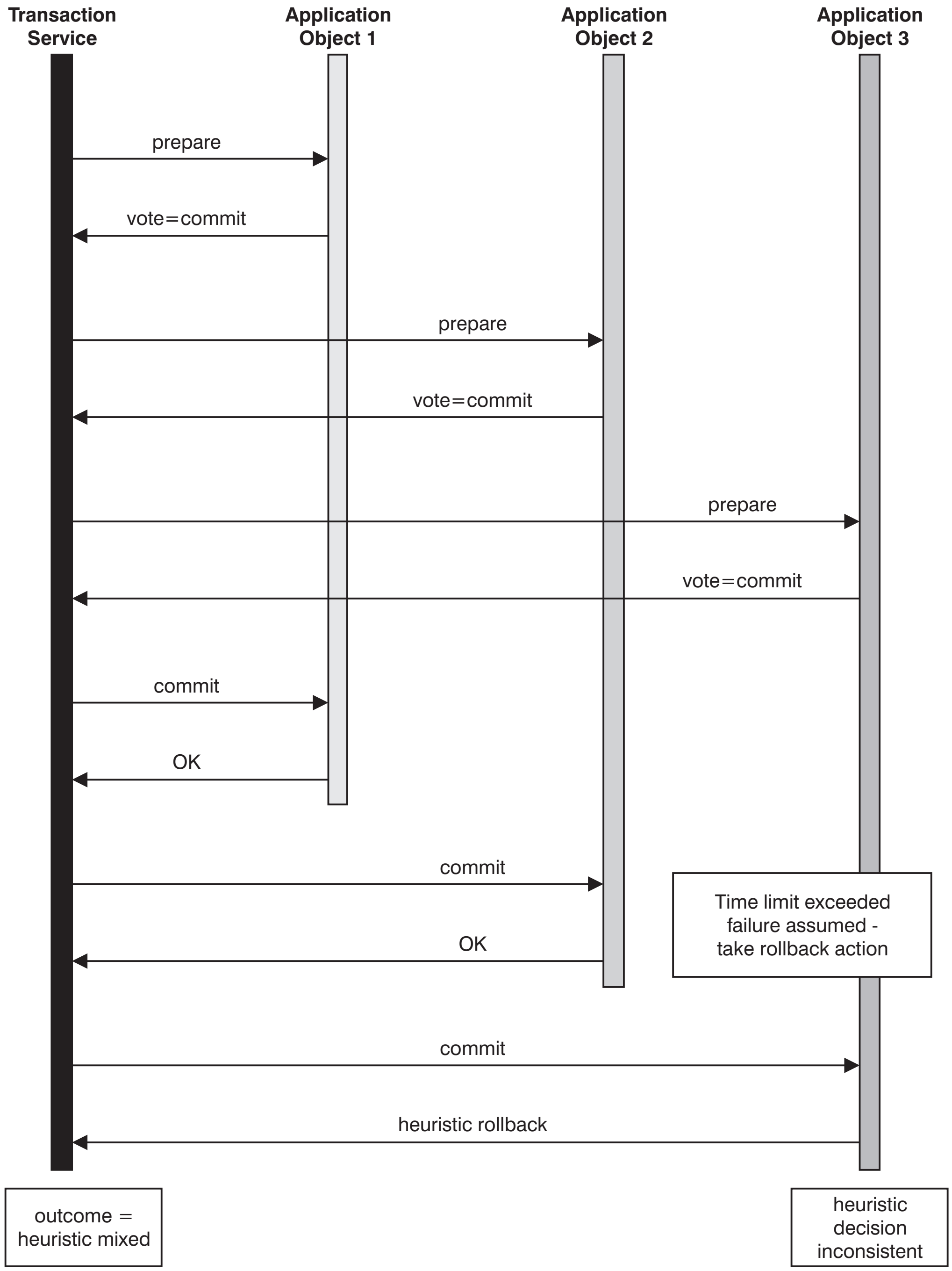
If all objects involved in making updates to data within a transaction correctly follow either the two-phase commit or one-phase commit protocol selected by the Transaction Service, and none of the servers have a transaction retry limit set, the Transaction Service guarantees that all objects take the same action during the completion of a transaction.

However, in exceptional circumstances, it might be necessary for some of the objects involved in the transaction to “guess” the outcome of the transaction in order to release critical locks or resources. This guess is called a *heuristic decision*.

If, at the end of the transaction, the heuristic decision matches the action taken by the other objects then the transaction is still atomic. However, if this guess is inconsistent with the action chosen by the other objects in the transaction, some of the updates will have been made permanent while others were undone. This is referred to as heuristic damage or a heuristic mixed outcome.

No heuristic decision is safe. Even if all objects are programmed to take the same heuristic decision on detection of a potential failure (for example a timeout), heuristic damage can still occur as it is possible that only some of the objects are affected by the failure and will take a heuristic decision.

Here is an example:



This example shows that object 3, which has voted to commit and takes a heuristic decision to roll back, can cause heuristic damage. The heuristic damage occurs because the other objects within the transaction do not detect a failure and so do not make the heuristic decision. Therefore atomicity can only be guaranteed by the Transaction Service if heuristic decisions are not used.

Transaction Retry Limits

If a server containing objects that are involved in a transaction terminates unexpectedly during the two-phase commit or one-phase commit process, the outcome of the transaction can not be resolved until the failing server is restarted. While the server is unavailable the rest of the objects involved in the transaction might be holding locks to critical resources. This could affect many users and even bring the entire system to a halt.

For some applications, an indefinite halt is a more serious problem than the possible loss of data integrity if the Transaction Service ignored the objects in the failing server. The Transaction Service can be configured to limit the number of times it attempts to contact a server during the two-phase commit or one-phase commit. If this limit is reached, the Transaction Service uses a pre-configured value as the "action" taken by the unavailable objects. This is factored into the transaction outcome as if the objects had reported it as normal.

The retry limit and the heuristic action assigned to an unavailable object are configured in each server using the "retry restricted," "commit retry limit" and "heuristic direction" attributes. These values must be used with care as any type of heuristic decision can result in a loss of data integrity.

Transaction Time Limits (Timeouts)

An application can set a time limit for its transactions. This time limit applies in all operating system processes and threads that are part of the transaction's scope. It is specified as the transaction is started and runs until the call is made to terminate (commit or rollback) the transaction.

When the time limit is reached, the transaction is said to have *timed out* and if the call to terminate the transaction has not been made, the Transaction Service rolls back the transaction.

As this rollback can occur while the application is still using the transaction, it might receive responses from the Transaction Service indicating that the transaction is no longer valid because it has rolled back.

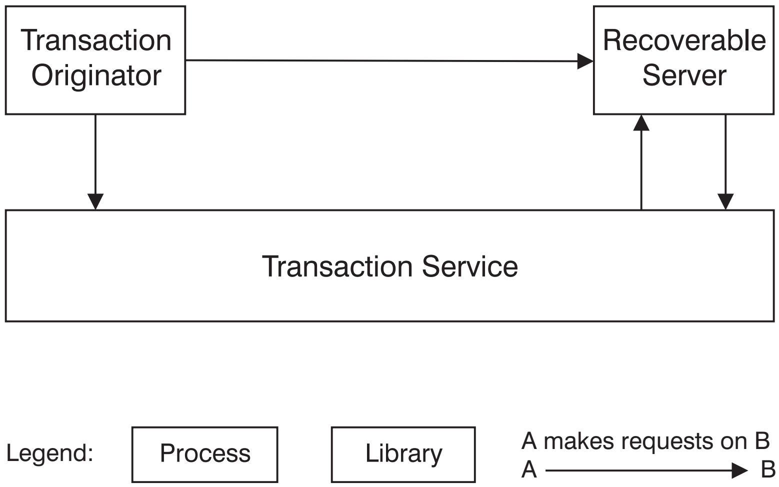
Time limits are useful mechanisms for recovering from deadlocks, or other failures that introduce delays into the transaction, especially if the transaction is holding critical locks. They are safe to use and do not result in heuristic decisions because the time limit is ignored once the two-phase or one-phase commit process starts.

Application Programming using the Transaction Service

Architecture and Design of a Transaction Service Application

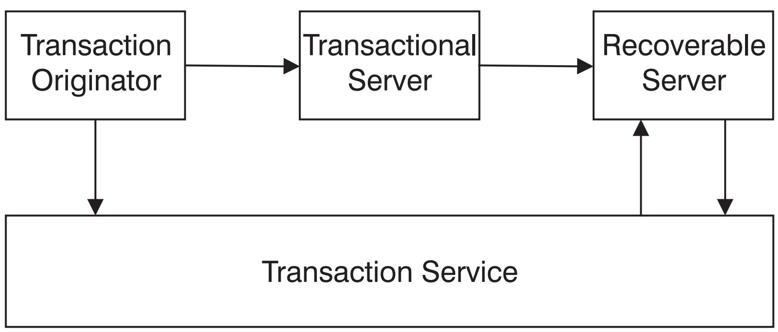
This section describes some suggested architectures for applications that use the Transaction Service. The Transaction Service itself places no restrictions on the architecture of applications (refer to Chapter 9, "Transaction Service" on page 167 for more information.)

The following diagram shows the basic elements that make up a Transaction Service application. These are the transaction originator and a recoverable server. The transaction originator is the process that starts the transaction. Usually it is a non-recoverable client but it can also be a server process. Once it has started the transaction, the transaction originator invokes methods on objects in the recoverable server. These objects manage the updates to data during the transaction.

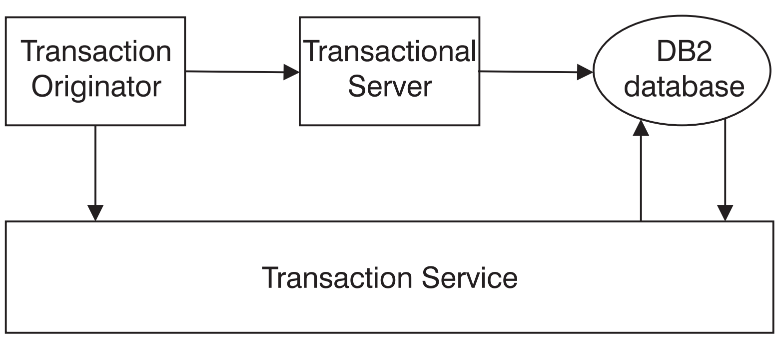


The objects containing the recoverable data need not all reside in the same recoverable server as indicated in the previous diagram. The transaction originator might invoke methods on recoverable objects residing in more than one recoverable server and these can all be involved in the same transaction.

Another alternative architecture, which is illustrated in the following diagram, involves an intermediate server that contains no recoverable data. This type of server is called a transactional server (refer to "Transactional Server" on page 176 for more information.) Typically, the transactional server would contain the business logic and the recoverable server would be responsible for data updates.



As an alternative, the recoverable server can be replaced with an XA database. The following diagram illustrates this.



The Transaction Service inter-operates with the DB2 XA Resource Manager to ensure that data contained in the database is involved appropriately in the application's transactions.

Non-Recoverable Client

The Transaction Service requires the Component Broker server environment to manage transactions. However, it also offers a client library that allows other processes to access the Transaction Service. This library is called “somosai,” for the IBM VisualAge C++ compiler, and “somosam” for the Microsoft Visual C++ compiler. Component Broker also provides a Java Client SDK zip file, somojor.zip, with Java client implementations of the Transaction Service interface. Processes that use the C++ libraries or Java zip file are called *non-recoverable clients*. Note that, in the case of a Java client that runs on a machine capable of also supporting a Component Broker server, the SOMOJOR.zip file must be at the start of the CLASSPATH otherwise the Business Object (server) java bindings will be loaded when a CORBA object service interface is called and a CORBA::NO_IMPLEMENT exception will be thrown.

A non-recoverable client can use the Transaction Service objects and interfaces in the normal way to start and end transactions. It can also propagate the transaction to objects located in servers. The Transaction Service ensures that the objects it needs to be located in a server are created in the server.

The restrictions for using the client library are:

- It cannot be executed within a Component Broker server process.
- It must be executed in conjunction with at least one available Component Broker server process. The Component Broker server process is required to maintain transactional information about transactions started in the client.
- Non-recoverable client processes can not receive transactional requests.

When the non-recoverable client originates a transaction, it needs to choose a Component Broker server on which to create the Transaction Service objects. The choice of this server can have a significant impact on performance. For example, if the client chooses a server that would not normally be involved with the transaction, performance will be adversely affected. To avoid this, the client will attempt to choose the same server as the first transactional object, by delaying the creation of the Transaction Service objects until needed by the transaction. In some circumstances, however, (for example, if the application asks for the name of a transaction), the client must create the Transaction Service objects before it can determine the location of the first transactional object.

When the client must determine the server before any transactional objects are used, the client uses the client style image stored in the CDS by system management. The factoryFinder attribute of the client style names the default factory finder that will be used by the client to find a transaction factory, and hence determine the server on which the transaction will be created. If no transaction factory can be found using this method, an arbitrary transaction factory will be chosen, typically the first server (alphabetically) in the name-space that has a transaction factory.

It is also worth noting that a Component Broker server can not detect when a client process terminates. Therefore it is recommended that all transactions that are controlled from a non-recoverable client process are created with a time limit. This means that if the client process terminates unexpectedly while it has incomplete transactions running in the server, these will be rolled back when the time limit expires. Without this safeguard, the incomplete transactions would hold any locks on your application's data until the server was shutdown.

Transactional Server

A transactional server is a Component Broker server that contains objects that inherit from the CosTransactions::TransactionalObject interface. Thus, if these objects are called within the scope of a transaction, the object's work is considered part of the transaction.

If a server has objects that update data as part of a transaction, it is called a recoverable server rather than a transactional server even if it also contains objects that inherit from the CosTransactions::TransactionalObject interface. The reason for this distinction is that a server that manages updates to data has additional responsibilities when it is using the Transaction Service.

Note that in the Component Broker programming model, all managed objects inherit from CosTransactions::TransactionalObject.

Recoverable Server

A Component Broker server may be recoverable or transactional. If the server is configured with a persistent data store such as DB2, and contains objects that manage updates to data during a transaction, then it is recoverable. If it is not configured with a persistent data store, then it is transactional.

Design a Transaction Service Application

There are two parts of an application design that are affected by the use of the Transaction Service

1. The objects that contain the business logic that understands how the updates to different pieces of data relate to the same user task.
2. The objects that actually perform the updates to the data.

Before carrying out this procedure, make sure you are familiar with:

- Chapter 9, “Transaction Service” on page 167
- “Lifetime of a Transaction” on page 168
- “Transaction Scope and Context” on page 169

The following steps explain how to identify which parts of your application need to call the Transaction Service.

1. Identify all of the updates for each of the user tasks that your application performs.

   Group these updates so that the data is consistent after each entire group have been performed. These form the basis of your application's transactions.

2. Locate the points in the code where the processing starts and ends for each group of updates.

   These are the places where the application should call the Transaction Service to start and end the transaction.

3. Identify all of the objects called between the start and end point of the transaction.

   If they cause data to be updated for the transaction, or call other objects that update data for the transaction, they need to execute within the scope of the transaction. Methods that are called in the same thread as the transaction was started in, or in a thread with which the transaction has been associated, are automatically included within the scope of the transaction. However, objects located in remote servers need to inherit from CosTransactions::TransactionalObject to inform the Transaction Service that the transaction needs to be implicitly propagated and automatically associated with the thread in the remote server where the method runs.

4. Identify the objects that actually make some or all of the updates for the transaction. Design resource objects for these objects.

See “Manage Transactions in Your Application” on page 179 for further information.

The Transaction Service Objects and Interfaces

The following table shows the interfaces defined by CORBA for managing transactions. These interfaces represent the various roles and responsibilities required to make updates that are distributed across a number of servers appear atomic. Some of these roles are fulfilled by the Transaction Service and the others by the application itself, as shown in the following table. Thus the Transaction Service and the application cooperate when transactions are in use.

Table 12. Interfaces defined by CORBA for managing transactions.

CORBA Interface	Implemented by
CosTransactions::Current	Transaction Service
CosTransactions::Control	Transaction Service
CosTransactions::TransactionalObject	Application Adaptor
CosTransactions::Coordinator	Transaction Service
CosTransactions::Terminator	Transaction Service
CosTransactions::Resource	Application Adaptor
CosTransactions::RecoveryCoordinator	Transaction Service
CosTransactions::Synchronization	Application Adaptor
CosTransactions::TransactionFactory	Transaction Service

There is a CosTransactions::Current object in every process. It is used by the application to start and end transactions.

When a transaction is started, the CosTransactions::Current object returns a CosTransactions::Control object. This is used by the application to represent the transaction context. The CosTransactions::Current object also associates the CosTransactions::Control object with the thread that created the transaction. This association is used to implicitly propagate the transaction context to any object that is called in this thread if the object inherits from CosTransactions::TransactionalObject. (Note that in the Component Broker programming model, all managed objects inherit from CosTransactions::TransactionalObject.)

The CosTransactions::Control object also provides access to the CosTransactions::Coordinator object and CosTransactions::Terminator object created by the Transaction Service for the transaction. The CosTransactions::Coordinator object is responsible for keeping a record of application objects that implement the CosTransactions::Resource interface. These resource objects represent updates to data that the application has performed that belong to the transaction. Under the instructions of a CosTransactions::Coordinator object, they are able to make these updates permanent or they can undo them.

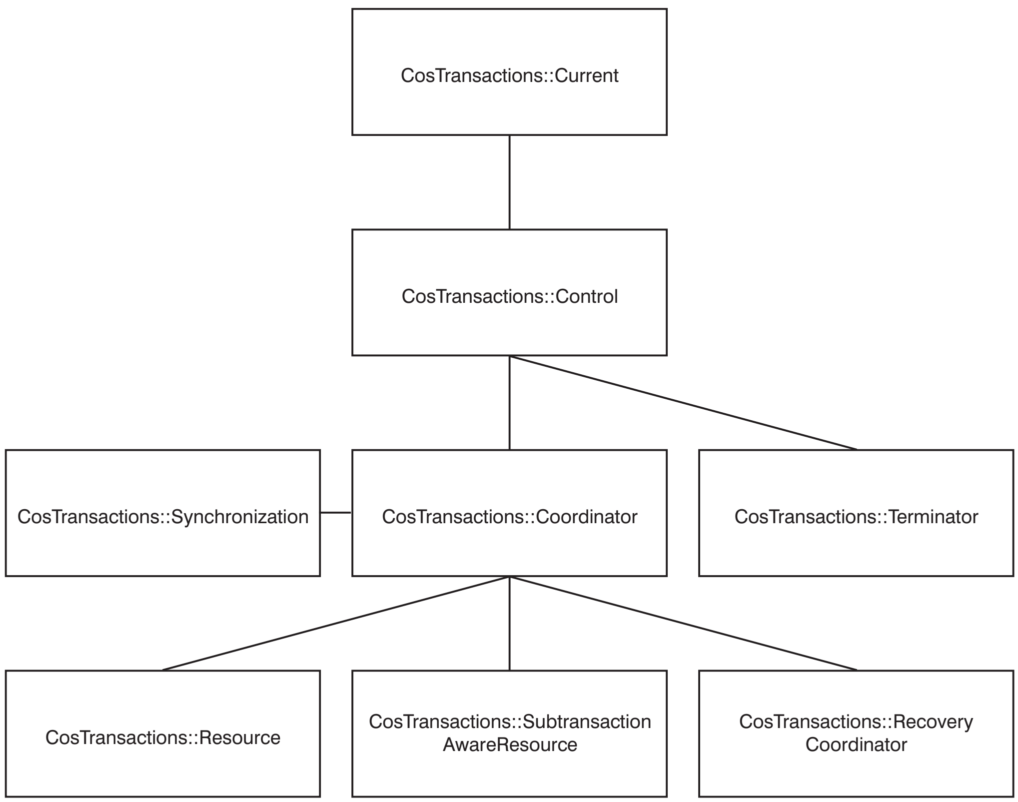
While the application is making the updates, it explicitly registers its resource objects with the CosTransactions::Coordinator object. This returns a CosTransactions::RecoveryCoordinator object for use by the resource object if the server process fails.

When the application has registered all its resource objects and has completed all the updates required for the transaction, it ends the transaction either by calling the CosTransactions::Current object, or by calling the CosTransactions::Terminator object extracted from the CosTransactions::Control object. It can request either that the transaction commits or that it rolls back (see “Lifetime of a Transaction” on page 168). This results in the CosTransactions::Coordinator object making calls to the application's resource objects. Using either the two-phase commit or one-phase commit process, the CosTransactions::Coordinator object ensures that the application's resource objects are either all told to make their updates permanent, or all told to undo their updates even if some or all of the servers abnormally terminate during this operation.

If an application wishes to be called just before the resource objects are called during a commit operation and just after all of the resource objects are either committed or rolled back, it can create an object that implements the CosTransactions::Synchronization interface and register it with the transaction's CosTransactions::Coordinator object. Such CosTransactions::Synchronization objects are normally only required when using a database such as DB2

When all of the application's resource and CosTransactions::Synchronization objects have been called, the transaction is complete. The transaction's CosTransactions::Control, CosTransactions::Coordinator, CosTransactions::Terminator objects and all the application's resource and synchronization objects are destroyed. The application can then use the CosTransactions::Current object to start another transaction.

The CosTransactions::TransactionFactory object provides an alternative operation for creating a transaction. It creates a transaction and returns a CosTransactions::Control object to an application without associating it with a thread. This might be required for some specialized applications that do not wish the transactions it is using to be associated with a thread.



Manage Transactions in Your Application

Applications manage transactions primarily by using the CosTransactions::Current interface. The *Component Broker Programming Reference* describes all the Transaction Service interfaces and describes which ones are appropriate for use within the Component Broker Programming Model. Some of the later sections in this chapter go beyond the Programming Model and are appropriate only for Application Adapter writers. This material is provided for background information.

There is one CosTransactions::Current object in each operating system process, and it provides the operations to access the main facilities of the Transaction Service. More information on the use of these operations is given in the following steps.

Before carrying out this procedure, make sure you are familiar with:

- “An Example of a Transaction” on page 167
- “Lifetime of a Transaction” on page 168
- “The Transaction Service Objects and Interfaces” on page 178
- “Design a Transaction Service Application” on page 177

To manage transactions in your application, follow these steps:

1. Access the CosTransactions::Current object. (See “Access the CosTransactions::Current Object.”)
2. Set a time limit for all new transactions. (See “Set a Time Limit for All New Transactions” on page 181.)
3. Start a transaction using the CosTransactions::Current interface. (See “Start a Transaction Using the CosTransactions::Current Interface” on page 181.)
4. Pass the transaction to a remote object. (See “Implicitly Propagate a Transaction Context to a Remote Object” on page 185.)
5. Update data.
6. End a transaction using the CosTransactions::Current interface. (See “End a Transaction Using the CosTransactions::Current Interface” on page 186.)

Access the CosTransactions::Current Object

The CosTransactions::Current object is available in every process where the Transaction Service is located. It provides access to most of the operations you require to control the transactions used by your application.

The following information describes how to extract a reference to the CosTransactions::Current object.

Before carrying out this procedure, make sure you are familiar with “The Transaction Service Objects and Interfaces” on page 178.

To access the CosTransactions::Current Object, follow these steps:

1. Get access to the ORB.
2. Retrieve the CORBA::Current object.
3. Narrow the CORBA::Current object to a CosTransactions::Current object.

Here is an example:

```
#include <CBSeriesGlobal.hh>
#include <CosTransactions.hh>
// Function to return the CosTransactions::Current object for this process
CosTransactions::Current *get_CosTransactions_Current()
{
  CORBA::Current_var theCurrent;
  // Get access to the orb and retrieve the transactions current object
  theCurrent = CBSeriesGlobal::orb()->get_current("CosTransactions::Current");
  // Narrow the transactions CORBA::Current object to a
  // CosTransactions::Current object
  return CosTransactions::Current::_narrow(theCurrent);
}
```

Set a Time Limit for All New Transactions

The CosTransactions::Current interface has a set_timeout operation that enables your application to set a time limit for all transactions that are subsequently started.

The default time limit value is set to 300 seconds. If the application specifies a time limit value of "0," transactions subsequently started using the CosTransactions::Current interface does not have a time limit set.

Before carrying out this procedure, make sure you are familiar with:

- "Transaction Time Limits (Timeouts)" on page 174
- "Access the CosTransactions::Current Object" on page 180

To set a time limit for all new transactions, follow these steps:

1. Obtain a reference to the CosTransactions::Current object in this process.
2. Invoke the set_timeout operation on the CosTransactions::Current object, passing the time limit required as a parameter in seconds.

```
#include <CosTransactions.hh> // CosTransactions module
...
// Access the CosTransactions::Current object.
CosTransactions::Current *current =get_CosTransactions_Current();
// Invoke the set_timeout operation on the CosTransactions::Current object.
current->set_timeout(60 /* seconds */);
...
// Start a transaction
...
```

If a transaction exceeds the time limit set, the Transaction Service rolls back the transaction and removes the CosTransactions::Coordinator object. When the application subsequently calls a remote object or the CosTransactions::Control::get_coordinator() method, the CORBA::TRANSACTION_ROLLEDBACK exception is raised. If this occurs, the application should call CosTransactions::Current::rollback() to remove the CosTransactions::Control object and CosTransactions::Terminator object.

Start a Transaction Using the CosTransactions::Current Interface

To start a transaction, an application uses the begin operation of the CosTransactions::Current object. Invoking the begin operation causes a transaction to be created and to be associated with the current thread of execution. The thread is then said to be running within the scope of the newly created transaction. (See "Transaction Scope and Context" on page 169 for more information.)

If a transaction was not associated with the current thread when the begin operation was called, a top-level transaction is created. (See "Top-Level and Flat Transactions" on page 168 for more information.)

Before carrying out this procedure, make sure you are familiar with:

- "Lifetime of a Transaction" on page 168
- "Top-Level and Flat Transactions" on page 168
- "Access the CosTransactions::Current Object" on page 180

To start a transaction using the CosTransactions::Current Interface, follow these steps:

1. Access the CosTransactions::Current object by narrowing on the CORBA::Current object.
2. Invoke the begin operation on the CosTransactions::Current object.

Here is an example:

```
#include <CosTransactions.hh> // CosTransactions module...
//Access the CosTransactions::Current object.
CosTransactions::Current *current = get_CosTransactions_Current();
...
// Invoke the begin operation on the CosTransactions::Current object.
current->begin();
...
```

If the Transaction Service is unavailable, it will throw one of the following standard exceptions:

CORBA::INITIALIZE
This means that a problem in recovery was detected while the server was starting. For example, the server was unable to open its log file. Error messages describing the problem were logged in the activity log when the problem was detected.

CORBA::PERSIST_STORE
This means that while running transactions the server found it was unable to use its log file. For example, because of insufficient disk space. Once the problem with the log file is fixed, the server will need to be restarted before new transactions can be created.

CORBA::INVALID_TRANSACTION
This means the Transaction Service is unable to start a transaction.

All of these exceptions are written to the activity log with a minor error code. This minor error code gives more detail on the cause of the problem.

Suspend a Transaction from the Current Thread

When a thread is associated with a transaction, an application can use the suspend operation of the CosTransactions::Current object to remove the association between the thread and the transaction. Following transaction suspension, the transaction still exists but is no longer automatically propagated to other objects in the application - that is, the current thread is no longer running within the scope of the transaction. (See “Transaction Scope and Context” on page 169 for more information.

The CosTransactions::Current::suspend operation returns a CosTransactions::Control object reference that represents the transaction that has been suspended. This reference can be passed to another thread and used to resume the transaction later. See “Pass a Transaction Context to Another Thread” on page 184 and “Resume a Transaction on the Current Thread” on page 183 for more information.

Before carrying out this procedure, make sure you are familiar with:

- “Transaction Scope and Context” on page 169
- “The Transaction Service Objects and Interfaces” on page 178
- “Access the CosTransactions::Current Object” on page 180

To suspend a transaction from the current thread, follow these steps:

1. Obtain a reference to the CosTransactions::Current object in this process.
2. Invoke the suspend operation on the CosTransactions::Current object.

Here is an example:

```
#include <CosTransactions.hh> // CosTransactions module...
CosTransactions::Control_ptr control = NULL;
...
// Access the CosTransactions::Current object.
CosTransactions::Current *current = get_CosTransactions_Current();
```

```
...
// Invoke the begin operation on the CosTransactions::Current object.
current->begin();
...
// Suspend the association between the transaction and the thread.
control = current->suspend();
if (!control)
{
  // There was no transaction associated with this thread prior to the
  // suspend. Perform appropriate action.
  cout << "Error": No transaction prior to suspend" << endl;
}
```

Resume a Transaction on the Current Thread

If an application has a pointer to a CosTransactions::Control object that represents an active transaction, it can use the resume operation of the CosTransactions::Current object to associate the transaction with the current thread of execution (in place of any previous transaction). Following the resume, the current thread runs within the scope of the transaction.

An application can also pass a NULL pointer on the resume operation to clear the thread of any association with transactions.

Before carrying out this procedure, make sure you are familiar with:

- “Transaction Scope and Context” on page 169
- “The Transaction Service Objects and Interfaces” on page 178
- “Access the CosTransactions::Current Object” on page 180

To resume a transaction on the current thread, follow these steps:

1. Obtain a reference to the CosTransactions::Current object in this process.
2. Invoke the resume operation on the CosTransactions::Current object, passing the reference of the CosTransactions::Control object representing the transaction to be suspended.

Here is an example:

```
#include <CosTransactions.hh> // CosTransactions module...
CosTransactions::Control_ptr control = control_parameter;
...
//Access the CosTransactions::Current object.
CosTransactions::Current *current =
get_CosTransactions_Current();
...
// Resume the association between the transaction and the thread.
try
{
  current->resume(control);
}
catch(CosTransactions::InvalidControl)
{
  cout << "Error: control object passed to resume was invalid" << endl;
}
```

Pass a Transaction Context to Another Thread

The Transaction Service allows an application to pass a transaction between its threads. The application does this by extracting the CosTransactions::Control object using the CosTransactions::Current object and passing it to the other thread. The other thread can then use the resume operation of CosTransactions::Current to associate the transaction with the itself.

When extracting the CosTransactions::Control object from the CosTransactions::Current thread, the thread that is passing the transaction has two options:

- to use the CosTransactions::Current get_control operation to retrieve a reference to the CosTransactions::Control object while leaving the transaction still associated with the thread, or
- to use the CosTransactions::Current suspend operation to retrieve a reference to the CosTransactions::Control object. This removes the association between the current thread and the transaction.

Applications would use get_control when both threads are to continue using the transaction, and suspend if the aim was to completely transfer execution for the transaction to another thread.

Before carrying out this procedure, make sure you are familiar with:

- “Transaction Scope and Context” on page 169
- “The Transaction Service Objects and Interfaces” on page 178
- “Access the CosTransactions::Current Object” on page 180
- “Suspend a Transaction from the Current Thread” on page 182
- “Resume a Transaction on the Current Thread” on page 183

To pass a transaction context to another thread, follow these steps:

1. Obtain a reference to the CosTransactions::Current object in this process.
2. Invoke the suspend or get_control operation on the CosTransactions::Current object.
3. Put the pointer in a location where it can be accessed by another thread.
4. Start a new thread.
5. Within the new thread, retrieve the pointer to the Control object and use the CosTransactions::Current resume operation to associate the thread with the transaction.

Here is an example:

```
#include <CosTransactions.hh> // CosTransactions module
...
CosTransactions::Control_ptr control = NULL;
...
// Access the CosTransactions::Current object
CosTransactions::Current *current = get_CosTransactions_Current();
...
// Suspend the association between the transaction and the thread.
global_control = current->suspend();
// Start a new thread
...

void new_thread(void *parameter)
{
  // Associate the transaction with my thread.
  try
  {
```

```
      current->resume(_global_control);
    }
    catch(CosTransactions::InvalidControl)
    {
      cout << "Error: control object passed to resume was invalid" << endl;
    }
    ...
  }
```

Implicitly Propagate a Transaction Context to a Remote Object

Having started the transaction, your application is ready to perform work as part of that transaction. This typically involves invoking methods on other objects that can be either local and remote.

When an application has a transaction associated with a thread, the Transaction Service automatically propagates the transaction to all objects invoked in the same thread and all remote objects invoked from this thread that inherit from the CosTransactions::TransactionalObject interface. These objects are then able use the CosTransactions::Current operations to control the transaction.

The Transaction Service does however place one restriction on the use of the transaction in servers other than the one that started the transaction: they cannot end the transaction. Only threads in the operating system process where the transaction was started can call any of these operations.

- CosTransactions::Current::commit
- CosTransactions::Current::rollback
- CosTransactions::Terminator::commit
- CosTransactions::Terminator::rollback

Before carrying out this procedure, make sure you are familiar with:

- “Lifetime of a Transaction” on page 168
- “Transaction Scope and Context” on page 169

To pass a transaction context to a remote object, follow these steps:

1. Derive your remote object class from the CosTransactions::TransactionalObject interface. This will happen automatically if the remote object resides on a Component Broker server, as all managed objects inherit from CosTransactions::TransactionalObject.
2. If you invoke a method on the remote object from within the scope of a transaction, it propagates the transactional context.

Force a Transaction to Rollback

The CosTransactions::Current interface has a rollback_only operation, which enables your application to ensure that an active transaction rolls back even if the CosTransactions::Current commit operation is called. Applications use this operation if they detect an error that means all the updates could not be completed successfully.

Once the rollback_only operation has been called, the application is no longer able to invoke methods on some remote transactional objects or register resource objects with the transaction's CosTransactions::Coordinator object. See “Implicitly Propagate a Transaction Context to a Remote Object” for more information.

Before carrying out this procedure, make sure you are familiar with:

- “Lifetime of a Transaction” on page 168

- “Access the CosTransactions::Current Object” on page 180

To force a transaction to rollback, follow these steps:

1. Obtain a reference to the CosTransactions::Current object in this process.
2. Invoke the rollback_only operation on the CosTransactions::Current object.

Here is an example:

```
#include <CosTransactions.hh> // CosTransactions module
...
// Access the CosTransactions::Current object..
CosTransactions::Current *current = get_CosTransactions_Current();
// Invoke the rollback_only operation on the CosTransactions::Current object.
current->rollback_only();
...
```

End a Transaction Using the CosTransactions::Current Interface

If the work has been done correctly inside the transaction, the application ends the transaction by committing the changes to the resources. Typically, this is done by invoking the CosTransactions::Current commit operation on a thread that is running within the scope of the transaction. A boolean parameter passed to the commit operation indicates whether the application requires heuristic exceptions to be reported (a value of TRUE indicates that they should).

If the application cannot commit all the changes made to resources (for example, if an attempt to update a resource in the transaction resulted in an error code being returned), the application might choose to rollback the changes it made as part of the transaction. Typically, this is done by invoking the CosTransactions::Current rollback operation from a thread that is running within the scope of the transaction that is to be rolled back.

Before carrying out this procedure, make sure you are familiar with:

- “Lifetime of a Transaction” on page 168
- “Access the CosTransactions::Current Object” on page 180

To end a transaction using the CosTransactions::Current Interface, follow these steps:

1. Access the CosTransactions::Current instance by narrowing the CORBA::Current object.
2. Invoke the commit or rollback operation on the CosTransactions::Current instance.

Here is an example:

```
 #include <CosTransactions.hh>   // CosTransactions module
...
::CORBA::Boolean rollback_required = FALSE;
...
// Access the CosTransactions::Current object.
CosTransactions::Current *current = get_CosTransactions_Current();

// Invoke the begin operation on the CosTransactions::Current object.
current->begin();

// Perform work for the transaction and set rollback_required to TRUE if an
// error is detected.
...

// Invoke commit or rollback depending on whether rollback_required is set.
```

```
// This must be called within a try...catch structure as the transaction
// service may raise an exception if an error occurs.

try
{
  if (rollback_required == TRUE)
  {
    current->rollback();
  }
  else // commit required
  {
    current->commit(/* report_heuristics = */ TRUE);
  }
}
catch (CORBA::TRANSACTION_ROLLEDBACK  &exc)
{
  // The application called commit, but the transaction service rolled
  // the transaction back because an error was detected.
  ...
}
catch (CosTransactions::HeuristicMixed  &exc)
{
  // The transaction service has reported that some or all of the resource
  // objects have made a heuristic decision. This has resulted in
  // heuristic damage.
  ...
}
catch (CosTransactions::HeuristicHazard  &exc)
{
  // The transaction service has reported that not all of the resource
  // objects could participate properly in determining the outcome of the
  // transaction. There is a possibility of heuristic damage.
  ...
}
catch (CORBA::UserException  &exc)
{
  // Another type of user exception has occurred.
  ...
}
catch (CORBA::SystemException  &exc)
{
  // The application called commit, but the transaction service rolled
  // the transaction back because an error was detected.
  ...
}
catch (...)
{
  // A general exception has occurred.
  ...
}
...
```

If a transaction rolls back unexpectedly, then the problem may be:

- There are requests to remote objects still outstanding.
- The time limit for the transaction has been exceeded. See “Transaction Time Limits (Timeouts)” on page 174.

- An object in your application has set the transaction to rollback. See "Force a Transaction to Rollback" on page 185.
- A server that houses some of your application's objects has failed.
- A standard exception was raised and not caught during a remote method request. See "Handle Exceptions."

Handle Exceptions

As with other CORBA object services, the Transaction Service may return a CORBA exception from a call. There are two types of CORBA exception

- User exceptions
- System exceptions

User exceptions can only be returned from an interface if it is specified on the definition of the interface. For an example, see the CosTransactions::Current::begin interface in the Programming Reference.

The Transaction Service user exceptions are:

- CosTransactions::SubtransactionsUnavailable
- CosTransactions::Inactive
- CosTransactions::NotPrepared
- CosTransactions::NoTransaction
- CosTransactions::InvalidControl
- CosTransactions::Unavailable
- CosTransactions::SynchronizationsUnavailable
- CosTransactions::HeuristicCommit
- CosTransactions::HeuristicRollback
- CosTransactions::HeuristicHazard
- CosTransactions::HeuristicMixed

System exceptions may be returned from any call. They are defined as part of the CORBA module. The system exceptions that are specific to the use of the Transaction Service are:

CORBA::TRANSACTION_ROLLEDBACK

If this exception is returned by either of the following methods:

- CosTransactions::Current::commit
- CosTransactions::Terminator::commit

The transaction has rolled back. If it is returned by any other method then the transaction has either been marked rollback only ("Force a Transaction to Rollback" on page 185) or is about to rollback. The transaction initiator (normally the client process) should then call either:

- CosTransactions::Current::rollback
- CosTransactions::Terminator::rollback

To complete the rollback process. (See "End a Transaction Using the CosTransactions::Current Interface" on page 186.)

CORBA::INVALID_TRANSACTION

If this exception occurs, the state of the transaction does not allow the requested operation. If a transaction has been successfully started, the transaction initiator (normally the client process) should then call either:

- CosTransactions::Current::rollback
- CosTransactions::Terminator::rollback

To end the transaction. (See “End a Transaction Using the CosTransactions::Current Interface” on page 186.)

CORBA::TRANSACTION_REQUIRED

If this exception occurs, the requested operation requires a transaction and no transaction exists. The application should start a transaction and retry the operation. (See “Start a Transaction Using the CosTransactions::Current Interface” on page 181 for more information.)

Whenever a system exception is raised, it is associated with a minor error code. These give more detail as to the cause of the error and are documented in Exceptions Defined by Minor Error Code, in the reference section.

Prevent Memory Leaks in the Transaction Service

Memory leaks occur when objects are created and not deleted, or storage is acquired and not freed. If memory leaks occur continuously in a process, the size of the process increases, making it run slower and eventually fail. The list below describes how to avoid memory leaks of Transaction Service objects.

Make sure that a process that starts a transaction always ends the transaction. (See “Start a Transaction Using the CosTransactions::Current Interface” on page 181 and “End a Transaction Using the CosTransactions::Current Interface” on page 186 for more information.)

If your application uses an interface that returns a Transaction Service object such as:

- CosTransactions::Current::get_control
- CosTransactions::Control::get_terminator
- CosTransactions::Control::get_coordinator

then ensure it also calls CORBA::release() to release the object reference once it is no longer required.

Always specify a time limit) for transactions started from a client so that the transaction is rolled back if the client terminates before ending the transaction. (See “Transaction Time Limits (Timeouts)” on page 174 and “Non-Recoverable Client” on page 176 for more information.)

Controlling the Transaction Service in a Running System

The Transaction Service Log

The Transaction Service creates a log for every server. This records information about transactions running in the server and is used for recovery.

Important:

> The log here is not the same as a message log (such as the Component Broker activity log), audit trail or journal service. It is only used for transaction state information and is not in a readable format.

The name of a server's log is assigned by the Transaction Service the first time the server is started, and appears in one of the messages written to the Component Broker activity log as the server starts up. The name is of the form somtr*nnn*; for example, somtr0000. This name is used as a prefix to all files that belong to the log. The log itself is split into two parts. Files tha begin somtr*nnn*.p contain information about the databases and any other server that the local server is coordinating transactions on. Files that begin somtr*nnn*.t describe the transactions that are running in the server.

Each part of the log consists of three types of files, qualified by the file extension:

.ctl A control file (for example, somtr000.t.ctl).

.csh A cushion file (for example, somtr000.t.csh).

.nnn Any number of extent files (for example, somtr000.t.001, somtr000.t.002, and so on). The number of extent files used is dependent on the number and age of the running transactions in the server.

The amount of disk space required for the log depends on the number of transactions running in the server, the type of work involved in these transactions, and their duration. It is recommended that you initially allow about 1MB of disk space per server. This amount can be revised once the load on the server can be assessed. If the transaction log runs out of disk space, your server will stop processing transactions until you make more disk space available, and have then restarted the server.

The location of the log is defined in the “log directory” attribute found in the Transaction Service part of the server's server image. The directory specified must exist and be on a local file system. It is also advisable to use a file system where any other data on it is reasonably static. This will ensure there is always sufficient disk space for the log.

As transactions running within the server complete, their entry is removed from the log. There is no need to perform housekeeping functions on the log files. If a server fails because of insufficient space in the file system, make more space without deleting any of the log files. The only time it is safe to delete a log file is if the file is for a server that has been deleted.

A server stores the name of its log in the Component Broker CDS. If you recreate your CDS, the server will no longer have the name of the log file and will be allocated a new log name. Therefore, before recreating your CDS, start up each server and ensure the Transaction Service starts successfully. Then, without allowing any new transactions to be started, shut the servers down. There will then be no partially complete transactions in your servers and you can safely delete the log files and recreate the CDS.

Types of Server Start-Up

The first time a server is started, the Transaction Service creates a Transaction Service log (“The Transaction Service Log” on page 189) for recording information about running transactions. The name of this log appears in a message written to the Component Broker activity log:

```
Opening new transaction service log <logfilename> in server <serverName>
The transaction service started successfully in server <serverName>
```

It is then possible to view a server's log name using the System Manager User Interface. The name of the log file is also displayed in a message written to the Component Broker activity log at each subsequent start of the server.

```
Opening transaction service log <logfilename> in server <serverName>
The transaction service started successfully in server <serverName>
```

If the Transaction Service discovers that there were transactions running when the server was last terminated, messages appear in the Component Broker activity log indicating that the Transaction Service is recovering incomplete transactions:

```
Opening transaction service log <logfilename> in server <serverName>
Recovering incomplete transactions from the transaction service log for server <serverName>
< a delay may occur here if other servers are not available >
All recovered transactions are now complete in server <serverName>
The transaction service started successfully in server <serverName>
```

The process of completing recovered transactions is called resynchronization. The server can only work with new transactions when resynchronization is complete.

If the Transaction Service can not create or open its log, messages such as those shown below are logged in the Windows NT Application:

```
The transaction service in server <serverName> could not open its log.
Error was <errorCode>
The transaction service is unavailable in server <serverName>
```

Any attempt to start a transaction in the server once this message has been logged results in a CORBA::INITIALIZE exception.

A description of these messages, and the correct action to take when they occur, can be found in the "Understand Transaction Service Messages" topic in the "Problem Determination" section of the *Component Broker for Windows NT and AIX Problem Determination Guide* .

Configuring a Server to Use the Transaction Service

The default configuration for each application server is set so that the Transaction Service is enabled.

If you wish to change the default attribute settings, you should use the System Manager, as described in the following steps:

1. Edit the Server Model for the server.
2. In the Object Editor Notebook, select the Transaction Service tab. The following attributes relate to the Transaction Service:
   a. Retry restricted
   b. Commit retry limit
   c. Heuristic direction
   d. Log directory
3. To save the changes and exit the Object Editor Notebook, click the OK button.
4. To apply the changes to the server, activate the configuration containing the Server Model.

Note: The Transaction Service will not be available in an application server if the log directory attribute specifes a directory that does not exist. This is because the Transaction Service creates log files in this directory that are required to preserve transaction integrity in the even of server failuire. You must therefore check that the directory specified is valid. If the directoy does not exist the Transaction Service will fail to initialize and it will not be possible to begin a transaction.

Problem Determination

While it is running, the Transaction Service writes out a number of messages. For an explanation of the Transaction Service messages, please see the "Understand Transaction Service Messages" topic in the "Problem Determination" section of the *Component Broker for Windows NT and AIX Problem Determination Guide*.

While the Transaction Service is running, Component Broker may also issue messages relating to XA Resource Managers. For an explanation of the XA messages, please see the "Understand XA Messages" topic in the "Problem Determination" section of the *Component Broker for Windows NT and AIX Problem Determination Guide*.

Summary of the Transaction Services

- The Transaction Service enables programmers to implement transactions through standard CORBA interfaces.
- A transaction simplifies applications that need ACID (atomicity, consistency, isolation and durability) properties.
- The Transaction Service provides support for top-level transactions only, and only top-level transactions can be used when accessing databases.
- Applications that use the Transaction Service normally have a client/server design and use managed objects to implement recoverable objects.

Chapter 10. Session Service

The following chapter is platform-dependent and does NOT apply to OS/390 Component Broker.

The Session Service is provided as part of the Procedural Application Adapter (PAA) software. The following sections describe what the Session Service is, and how to use it.

What is the Session Service?

PAA introduces the notion of a session to help manage resources within the context of a unit-of-activity scope. A session context is similar to a transaction context. For example, a session defines a scope and associated consistency and visibility semantics under which a set of activities is performed.

A session is started and ended by a client program (or something on its behalf). Sessionable objects that are invoked within the session context can register a sessionable-resource with a session coordinator. Sessionable-resources are then notified to participate in the completion of that session. In addition, the client can initiate intermediate checkpoints and resets of the session. These operations are discussed later in this chapter.

The Scope of Sessions

The Session Service provides primitives for applications in a distributed object environment to control the scope of a session and the application profile and arbitrary session properties that are relevant within the scope of that session.

The scope of the session is defined to exist between the point when the session is started and the point when the session is ended (with the beginSession and endSession methods). Within the bounds of the session, the application can suspend a session, copy or move a session to a different thread of execution, and resume the session. In general, an application can only end a session that is active on their thread of execution. Also, generally, a session can only be ended by the client (or server) thread and process that started the session. However, a session can timeout any thread with access to the session context and force a reset (and termination of the session), and multiple threads in the top-level session can collaborate on the outcome of the session, superceding either of the previous two rules. For more information about timeouts, see “The Timeout Value Associated With a Session” on page 194.

A session scope can be used by the server run time for a variety of purposes:

- Loose atomicity
- Loose consistency
- Isolation
- Re-use of resources
- Resource cleanup

In terms of atomicity, the Session Service does not guarantee atomic updates. However, the session can be used to synchronize the checkpointing of state among multiple, non-collaborating resources. Since all registered resources are synchronized on the session checkpoint event, the Session Service can be used to achieve loose-consistency among these otherwise disparate resources. Again, the consistency is not guaranteed, and no consistency is attempted between transactional resources and non-transactional resources operated on in the same session, except at the termination of the session. The Session Service will only attempt to synchronize transactional and non-transactional resources at the end of the session, essentially by preventing the session from being terminated until all outstanding transactions have completed.

In terms of isolation, the session provides the ability, outside a transaction context, to isolate particular instances of objects from other sessions; each session can have its own view of object data.

In terms of re-use, resources may be allocated during a session and carried forward from one method request to another in the same session context. An example of this is to reuse a CICS terminal from one method request to another. This would allow a pseudo-conversational set of CICS transactions to occur with the passing of COMMAREA data from one CICS transaction to the other. With resource cleanup, any resources allocated on behalf of the session can be cleaned up at the completion of the session.

Although this appears very similar to what a transactional context would define, it is different in one significant way: there is no commit/rollback support at all.

Sessions cannot be nested. There is at most one session context associated with a current thread at any time.

The Relationship Between Transactions and Sessions

The relationships between sessions and transactions are outlined briefly below. Specifically, a transaction is either completely inside one session, or is outside all sessions.:

- Transactions can be started outside of the scope of a session. However, if that transaction is suspended it cannot be resumed in the context of an active session.
- A session cannot be started in the middle of an active transaction.
- Multiple transactions can be executed within a single session context. However, if a transaction is started within a session context and then suspended, it cannot be resumed within a different session.
- A session cannot be terminated while any transactions are active within it. The transaction must be terminated before the session can be terminated. However, ending a session with the Reset-Force end-mode will automatically roll back any pending transactions before terminating the session.
- If the session is suspended on a thread of execution, then the active transaction, if any, is suspended on that thread of execution as well. When the session is resumed, the suspended transaction is resumed on that thread of execution as well.
- Sessions cannot be nested; a transaction can be involved with one session at most.

Note: Client application writers must not use the TransactionFactory directly to create a transaction, or the transaction Terminator directly to end the transaction. The checking of the relationships is done by the transactions Current and sessions Current objects, so these must be used.

The Timeout Value Associated With a Session

A session carries with it a timeout value which is established when the session is initially begun. This value defines the maximum duration of the session in seconds. If the timeout value is exceeded, the session is automatically ended (timed out). Setting the timeout value to zero (0) means that the session will not timeout.

The timeout value is part of the session context and is propagated on remote method calls to other servers involved in the session. Any server involved in the session is capable of determining that the timeout value has elapsed and initiating the timeout of the session.

The action taken when a session timeout condition occurs is to cause the session to be ended with the 'EndModeResetForce' end mode.

Resource Priorities

When registering a Resource, a priority value is specified. The following table lists the priority values:

Range	Meaning	Recommended Use
0x0000 - 0x0FFF	Top priority	BO-supplied resources
0x1000 - 0x3FFF	High priority	
0x4000		MOs
0x4001 - 0xBFFF	Medium priority	
0xC000		Connections
0xC001		PAO cache
0xC002 - 0xFFFF	Low priority	

How the Session Service is Used

There are two perspectives on why a Session Service is useful:

- From the perspective of a client programmer, a session is useful for demarking the beginning and end of related activity.
- From the perspective of a managed object, a session is useful for controlling the lifecycle of their objects when their objects cannot adhere to the strict ACID properties required in a transaction context.

Client Use of the Session Service

A client programmer can use the Session Service to begin and end a session context. The session context:

- Has a beginning and an ending.
- Has state.
- Is associated with the thread of execution on which it was begun.
- Propagates implicitly with any method requests initiated within that session context.

The client program can associate an application profile with the session, and in doing so, indicates the way that it intends for resources to behave or be handled within that session context. This can include whether the application requires pessimistic or optimistic locking of data, whether it can tolerate deferred consistency, etc. In addition, the application can establish arbitrary name-value pairs (session properties), that act as global, distributed, environment variables. Session properties also propagate implicitly with any method requests initiated within that session context, and dissipate them at the end of the session context.

More importantly, the application can indicate when it is through with any resources that it was using within the session. The system can take this cue to clean up any transient or other resources that were allocated for the session that were not otherwise cleaned up as part of some other, more strict context-binding mechanism, such as a transaction context.

Finally, the application can use the session to control the checkpointing of persistent state for any resources it used within the session, in a loosely-consistent fashion. When the application issues a checkpoint request, a best-effort attempt will be made to transition object state into the persistent storage systems underlying those objects that are not controlled with a transaction context.

Client applications should begin a session when they want to perform a set of activities under a common application profile, and as a single logical activity. They should then perform their work, and then end the session when they have completed that activity and want to free up any system resources that were allocated for use within that activity. In between, the client application can issue a checkpoint request to push out any changes that have been made to those resources, to the back-end data systems that back up those resources. Having checkpointed the object-system, the application can also reset the state of the back-end data systems back into their object-system resources. In addition to controlling the session, the application can also control any number of transaction contexts, either completely within, or completely outside of, the session context.

When a client originates a session, it needs to choose a Component Broker server on which to create the session service objects. The choice of this server can have a significant impact on performance. For example, if the client chooses a server that would not normally be involved with the session, performance will be adversely affected. Unlike the transaction service client, the session service client creates a session as soon as the beginSession method is called. At that point in time the client has no knowledge of which servers any of the business objects will be created on. In order to determine which server a session is created on, the session service client uses the client style image stored in the CDS by system management. The factoryFinder attribute of the client style names the default factory-finder that will be used by the client to find a session factory, and hence determine the server on which the session will be created. If no session factory can be found using this method, an arbitrary session factory will be chosen, typically the first server (alphabetically) in the name-space that has a session factory.

The Session Service client library is part of the Object Services library, called “somosai,” for the IBM VisualAge C++ compiler, and “somosam” for the Microsoft Visual C++ compiler. Component Broker also provides a Java Client SDK zip file, somojor.zip, with Java client implementations of the Session Service interface. Note that, in the case of a Java client that runs on a machine capable of also supporting a Component Broker server, the SOMOJOR.zip file must be at the start of the CLASSPATH otherwise the Business Object (server) java bindings will be loaded when a CORBA object service

Managed Object Developer Use of the Session Service

From the perspective of a managed object developer, transactional resources are generally orthogonal to sessionable resources. That is, a resource is either a transactional resource, and subject to the strict ACID properties that characterize transactional semantics, or the resource is a sessionable resource. Sessions, however, do not guarantee atomicity, consistency, or durability of updates, although they can be used to ensure isolation or visibility. Sessions operate with best-effort semantics.

Consequently, each managed object implementation must decide whether it can support the stricter ACID properties associated with a transactional object. If it can, then it should be implemented, and register a transactional-resource object with the transaction service. However, for objects that are implemented over many legacy procedural systems, such as CICS or IMS transactions, the strict ACID properties of a transactional resource may be difficult, if not impossible, to achieve. These objects should be implemented as sessionable objects, and register a sessionable-resource object with the Session Service.

Managed object developers can choose to implement their objects with the more stringent ACID properties of a transactional resource, or with the loose-consistency properties of a sessionable object. Typically this will be driven by the capabilities of the data system over which the managed object is implemented, and as instituted by the qualities of service support provided by the corresponding application adapter. Depending on which is selected, the managed object will then be governed by either the session context and lifecycle, or the transaction context and lifecycle.

Visibility Rules

Sessions can be run concurrently from different applications. Some complexity is involved when some of these concurrently running applications are accessing the same data from the same data store. Visibility rules define how the data interactions between these concurrent sessions are defined.

The Session Service is provided as part of a solution to provide Component Broker applications access CICS or IMS based applications on the third tier of a three-tiered architecture. Component Broker uses different mechanisms to attach to CICS and IMS applications, and these mechanisms have a slightly different behavior. Unfortunately, this behavior can reflect back into the client application and provide slightly different results for concurrently running applications. The following sections describe the different behavior relative to the following categories:

- Attribute getters and setters - those methods that read or update the attributes of a business object.
- Create, retrieve, update and delete methods.
- Pushdown methods - some methods cause interactions with the data store. For example, a method may need the value of an attribute from the data store. This will cause a retrieve operation to be performed. These methods that can indirectly cause communication with the data store are referred to as *pushdown* methods. It is the responsibility of the application developer to document which attributes may be read or modified for each pushdown method.
- Checkpoint and end session methods.

It should be noted that although these methods may make changes visible to other sessions or other applications, these changes are not forced on these sessions or applications. These sessions or applications must take some action to refresh their state or read the changed data before the changes are evident in these other sessions or applications.. Visibility should be viewed as making the changes *available* to other sessions or applications.

Using HOD to Access to IMS Applications

Host on Demand (HOD) is the mechanism used to provide access to IMS applications. The categories behave in the following manner:

Attribute getters and setters
When these methods are executed, they only affect the session in which they are used. They are **not visible** to other sessions.

Create, retrieve, update and delete methods
When these methods are executed, the changes are **visible** to other sessions.

Pushdown methods
When these methods are executed the changes are **visible** to other sessions.

Checkpoint and end session methods
When these methods are executed the changes are **visible** to other sessions.

When using this mechanism, many of the methods that are executed result in changes that are **immediately visible** to other sessions or other applications.

Using ECI to Access to CICS Applications

ECI (External Call Interface) is the mechanism used to provide access to CICS applications. The categories behave in the following manner.

Attribute getters and setters
When these methods are executed they only affect the session in which they are used. They are **not visible** to other sessions.

Create, retrieve, update and delete methods
When these methods are executed the changes are **not visible** to other sessions.

Pushdown methods
When these methods are executed the changes are **not visible** to other sessions.

Checkpoint and end session methods
When these methods are executed the changes are **visible** to other sessions.

When using this mechanism, many of the methods that are executed will result in changes that are **not immediately visible** to other sessions or other applications.

Towards a More Common Client Programming Model

In some instances, it is important for the application developer to have a more common programming model that is more independent of the attachment mechanism being used. In these cases, the following technique could be implemented. It can be deduced from the previous information that *checkpoint* or *endSession* operations could be used to bring these two models closer together.

A simple approach would be to code more *checkpoint* operations throughout the client application. This would bring the visibility of these two mechanisms very close. However, this technique should only be used if a more common programming model is desired since it removes the capability of reversing a set of operations through the use of an *endSession(EndModeReset)* operation.

Session Service Tasks

The following sections outline the fundamental tasks that you can perform using the Session Service.

Set a Time Limit for All New Sessions

The ISessions::Current interface has a setSessionTimeout operation which enables your application to set a time limit for all sessions that are subsequently started.

The default time limit is set to zero. That is, sessions may run indefinitely.

Before performing this task, make sure you are familiar with:

- "The Scope of Sessions" on page 193
- "The Timeout Value Associated With a Session" on page 194

To set a time limit for all new sessions, follow these steps:

1. Access the ISessions::Current object by narrowing on the CORBA::Current object returned from the ORB.
2. Invoke the setSessionTimeout operation on the ISessions::Current object, passing the new timeout value.

Here is an example:

```
CORBA::Current_var current;
ISessions::Current_var sessionCurrent;
// Get the current for this thread of execution
// from the ORB and narrow to the session current.
current = CBSeriesGlobal::orb()->get_current("ISessions::Currents");
sessionCurrent = ISessions::Current::_narrow(current);
// Set the session timeout.
sessionCurrent->setSessionTimeout(100);
```

Begin and End a Session

Begin a Session

You begin a session by invoking the beginSession operation on the ISessions::Current object. You should supply a text string representing the name of your application, or the application profile under which you want the session to operate. If the specified profile cannot be found, or if you specify an empty string, then a default application profile is used.

Your application profile specifies certain expectations about how your session will behave. This information can be used in combination with the capabilities and policies of the running system to produce a set of execution decisions that optimize the total performance and throughput of the system.

Once the session has been started, you can perform any number of operations on business objects within the session. All operations invoked within the session are performed with the same session context.

Before performing this task, make sure you are familiar with:

- “The Scope of Sessions” on page 193
- “Client Use of the Session Service” on page 195

To start a session, follow these steps:

1. Decide on the application name or application profile name under which you want the session to operate.
2. Access the ISessions::Current object by narrowing on the CORBA::Current object.
3. Invoke the beginSession operation on the ISessions::Current object, passing the application profile name.

Here is an example:

```
CORBA::Current_var current;
ISessions::Current_var sessionCurrent;
// Get the current for this thread of execution
// from the ORB and narrow to the session current.
current = CBSeriesGlobal::orb()->get_current("ISessions::Current");
sessionCurrent = ISessions::Current::_narrow(current);
// Begin a session context.
sessionCurrent->beginSession("LifeInsuranceApplication");
```

If the Session Service is unavailable, it will throw the following standard exception:

CORBA::INITIALIZE
This means that the Session Service initialization failed. For example, because a factory could not be found to create the objects needed for the session context.

CORBA::UNKNOWN
This means that the Session Service encountered an unexpected error such that initialization could not continue.

These exceptions are written to the activity log with a minor error code. This minor error code gives more detail on the cause of the problem.

End a Session

You complete the session by invoking the endSession operation on the session Current. Normally, you specify the EndModeCheckpoint end-mode with this operation. This drives all the sessionable resources used within the session to save their state changes persistently, through embedded operations on the underlying data system.

To reset the session, end it without saving any of the changes that occurred since your last checkpoint (or since the beginning of the session if you did not perform any checkpoints). Specify the EndModeReset end-mode with the endSession request.

EndModeCheckpoint and EndModeReset have no bearing on any transactions issued within the session, other than to ensure that the session is terminated before the session can end. However, if you encounter severe errors in your processing, you can end the session with EndModeResetForce. This will force the session to be reset immediately, including rolling-back any outstanding transactions.

To end a session, follow these steps:

1. Access the ISessions::Current object by narrowing on the CORBA::Current object. You may also use an ISessions::Current object obtained from a previous operation.
2. Decide on the way in which the session should end: checkpoint, reset or reset-force.
3. Decide whether the endSession operation should return immediately in the case where other threads in the same process still have the session context active, or whether to wait until the session context has ended on all threads.
4. Invoke the endSession operation on the ISessions::Current object, passing the end mode value and the wait flag value.

Here is an example:

```
CORBA::Current_var current;
ISessions::Current_var sessionCurrent;
// Get the current for this thread of execution
// from the ORB and narrow to the session current.
current = CBSeriesGlobal::orb()->get_current("ISessions::Current");
sessionCurrent = ISessions::Current::_narrow(current);
// End the session context, returning immediately in the case
// that there are other threads with the session context active.
sessionCurrent->endSession(ISessions::EndModeCheckPoint,1);
```

Full Example

The following example demonstrates how a single-thread client can begin a session, perform some work, and then end the session, checkpointing any non-transactional work that occurred within the session.

```
CORBA::Current_var current;
ISessions::Current_var sessionCurrent;
// Get the current for this thread of execution
// from the ORB and narrow to the session current.
current = CBSeriesGlobal::orb()->get_current("ISessions::Current");
sessionCurrent = ISessions::Current::_narrow(current);
// Begin a session context.
sessionCurrent->beginSession("LifeInsuranceApplication");
    try {
            // ... do the methods that will be executed under the
            // session ...
    }

    catch (ISessions::SessionResetForced) {

            // The session was forced to reset mid-stream, probably the
            // session timeout tripped, or a session resource
            // encountered a significant error and had to force the session
            // reset.

    };

// End the session context, including checkpointing any activity that
// occurred during the session.

try {
      sessionCurrent->endSession(EndModeCheckpoint,1);
}
catch (ISessions::DifferentEndModeForced) {

      // The end-session was forced to reset instead of checkpointing.

}
catch (ISessions::IncompleteProcess) {

      // Something failed to checkpoint. Identify the resource that
      // failed. Try opening  a new session,
      // driving the set of changes to that resource again, and attempt to
      // checkpoint the session again.

}

catch (ISessions::SubThreadPending) {

      // Something in the work that was done must have spawned an
      // asynchronous thread which is operating within the session and
      // has not completed yet. Wait some more time to give the thread a
      // chance to complete, and try to end the session again. This can be
      // retried a number of times (although look out for the session
      // timeout tripping). Eventually, if the thread never ends, you will
      // have to force the session to reset.

}

catch (ISessions::TransactionPending) {

      // Something in the work that was done must have started a
      // transaction and has not ended it. This could be a programming
```

```
        // error, although it could happen in an asynchronous thread that
        // has not completed yet. Try taking the same action as with
        // SubThreadPending.

};
```

Suspend and Resume a Session

There may be occasions when you want to switch the session under which you are operating. You can do this by suspending the current session, and starting a new one. Later, you can resume the original session. Each session is represented by an ISessions::Control object. By maintaining separate references to each Control, you can multiplex multiple sessions. The sessions can be resumed and suspended each for the period under which you want to operate.

Before performing this task, make sure you are familiar with:

- "The Scope of Sessions" on page 193
- "Client Use of the Session Service" on page 195
- "The Relationship Between Transactions and Sessions" on page 194

You can suspend a session with the suspendSession operation on the session Current, using the following steps:

1. Access the ISessions::Current object by narrowing on the CORBA::Current object. You may also use an ISessions::Current object obtained from a previous operation.
2. Invoke the suspendSession operation on the ISessions::Current object.
3. Store the returned Control object to be used later to resume the session context.

Here is an example:

```
CORBA::Current_var current;
ISessions::Current_var sessionCurrent;
ISessions::Control_var sessionControl;
// Get the current for this thread of execution
// from the ORB and narrow to the session current.
current = CBSeriesGlobal::orb()->get_current("ISessions::Current");
sessionCurrent = ISessions::Current::_narrow(current);
// Suspend the session context.
sessionControl = sessionCurrent->suspendSession();
```

You can resume the session with the resumeSession operation on the session Current, using the following steps:

1. Access the ISessions::Current object by narrowing on the CORBA::Current object. You may also use an ISessions::Current object obtained from a previous operation.
2. Identify the ISessions::Control object which represents the session context to be resumed.
3. Invoke the resumeSession operation on the ISessions::Current object, passing the Control object.

Here is an example:

```
CORBA::Current_var current;
ISessions::Current_var sessionCurrent;
ISessions::Control_var sessionControl;    // obtained from elsewhere.
// Get the current for this thread of execution
// from the ORB and narrow to the session current.
current = CBSeriesGlobal::orb()->get_current("ISessions::Current");
```

```
sessionCurrent = ISessions::Current::_narrow(current);
// Resume the session context.
sessionCurrent->resumeSession(sessionControl);
```

Explicit and Implicit Propagation of Session Context

Before performing this task, make sure you are familiar with:

- “The Scope of Sessions” on page 193

If you begin a session, then the session will automatically be propagated with any method request you invoke on any other managed object, regardless of whether the targeted object is local or remote. This is referred to as **implicit session context propagation**.

There may be occasions when you want to propagate a session context between threads, outside of a method request. You can do this with explicit session propagation. You can get a session Control object, representing a particular session context, using the getSessionControl operation on a session Current. You can then pass a reference to this Control object to another thread of execution and use that as input to the resumeSession operation. This will register the other thread's participation in the session. This is referred to as **explicit session propagation** and can be performed inside or outside a method request.

Note that methods with the following names do **not** have session context propagated on them:

- _is_a
- _non_existent
- getSessionCoordinator
- getSessionName
- registerResource
- getSessionContext
- decrementUseCount
- incrementUseCount
- prepareToEndSession
- prepareToCheckpointSession
- prepareToResetSession

Managed object writers should avoid using any of these names for their methods.

Notice that the following is a perfectly legal scenario: Thread-1 has an active session and suspends this session using the suspendSession operation. This returns a Control object representing the suspended session. It then begins a new session and invokes a method on some object, passing the original session Control as an argument. The suspended session is explicitly propagated, while the currently active session is implicitly propagated.

The session remains active on that thread of execution, independent of the original thread, until that thread separately ends its involvement in the session, typically by suspending the session on that thread of execution.

Checkpoint and Reset a Session Context

Before performing this task, make sure you are familiar with:

- “The Scope of Sessions” on page 193
- “Client Use of the Session Service” on page 195

When appropriate, you can checkpoint your progress in a session. That is, you can issue the checkpointSession operation on the session Current. As a consequence, any session resources registered in the session will be prompted to checkpoint their state to their corresponding persistent data system. In effect, any changes that you have made so far to the in-memory state of business objects you have used will be transitioned to their persistent storage system.

After making some number of changes to the in-memory state of your business objects, you can reset the session to the last checkpointed state by invoking the resetSession operation on the session Current. Consequently, any session resources registered in the session will be prompted to reset their state from their corresponding persistent data system. In effect, the persistent state of your objects will be transitioned in to memory.

Note that certain operations that you perform on your business objects may result in implicit checkpointing, that is, forcing in-memory state to be transitioned to persistent storage. Typically, this occurs in push-down methods, that is, methods that are encoded directly or indirectly to make use of legacy procedures and require or result in a certain amount of state transition in the course of those procedures. Thus, if you reset a session, the in-memory state may or may not revert back to the state you had the last time you explicitly checkpointed the session.

Note also, that in many cases where you are adapting to legacy procedures, transitions from memory to persistent storage, or vice-versa, may result in additional side-effects that may be relevant to your business logic. This phenomena may require additional adjustments to your business object implementations to consider the impact of those side-effects fully.

You can checkpoint a session context using the following steps:

1. Access the ISessions::Current object by narrowing on the CORBA::Current object. You may also use an ISessions::Current object obtained from a previous operation.
2. Invoke the checkpointSession operation on the ISessions::Current object.

Here is an example:

```
CORBA::Current_var current;
ISessions::Current_var sessionCurrent;
// Get the current for this thread of execution
// from the ORB and narrow to the session current.
current = CBSeriesGlobal::orb()->get_current("ISessions::Current");
sessionCurrent = ISessions::Current::_narrow(current);
// Checkpoint the session context.
sessionCurrent->checkpointSession();
```

Full Example of Checkpointing and Resetting a Session

Checkpointing and resetting a session are simply a matter of issuing the checkpoint or reset methods as follows:

```
try {
      sessionCurrent->checkpointSession();
}

catch (ISessions::IncompleteProcess) {

      // Something failed to checkpoint. Identify the resource that
      // failed. Try opening a new session,
      // driving the set of changes to that resource again, and attempt to
      // checkpoint the session again.

}
```

```
catch (ISessions::SubThreadPending) {

      // Something in the work that was done must have spawned an
      // asynchronous thread which is operating within the session and
      // has not completed yet. Wait some more time to give the thread a
      // chance to complete, and try to end the session again. This can be
      // retried some number of times (although look out for the session
      // timeout tripping). Eventually, if the thread never ends, you will
      // have to force the session to reset.

};
```

Register Sessionable Resources

Normally, the Component Broker run time automatically registers relevant session resources in a session. However, any application can introduce and register their own session resources with the Session Service. A distinction is made between a SessionableObject and a session Resource. While these typically represent essentially the same entity, the interfaces are separated to help distinguish between publishing a desire to be used within a session, and actually registering as a session resource. If a resource wants to publish a desire to be used within a session, the SessionableObject only advertises that a session context should be created and flowed on any method request invoked on the object. The object itself may or may not be capable of responding to session-related events, but rather may depend on other objects that do. If a resource wants to actually register as a session resource, the session Resource is capable of responding to session-related events. The same object may inherit both interfaces, fulfilling both roles. Or the interfaces could be inherited separately by two different objects, usually two closely collaborating objects.

A SessionableObject should register its Resource with the session Coordinator as soon as it realizes that it has been invoked in a new session. Typically this is done by performing a test at the beginning of each method on the SessionableObject. If the request is issued within a session context, and the session is new to the SessionableObject (one that it has never recognized before), then it should register its corresponding Resource object with the session Coordinator.

A SessionableObject can determine whether it is being invoked within a session by invoking getSessionControl on an ISessions::Current. If the request raises the NoSession exception, then the request was not invoked in a session. Otherwise, the request should return a ISessions::Control. The sessionable object can then determine whether the session is the same as one they have seen before by getting the session Coordinator (by invoking the get_coordinator on the session Control), and then invoking isSameSession on the Coordinator.

The isSameSession operation takes a Coordinator as an argument. The sessionable object should retain a reference to all of the Coordinators for each of the unique sessions it is currently participating in. Note that the same sessionable object could be invoked by multiple clients each under their own session context. Thus, the sessionable object can repeat the isSameSession request, passing in each of the Coordinators of the sessions it is participating in. If the session (Coordinator) is not the same as any it already knows of, then the session is new to it. The sessionable object should then register its Resource object and then add the Coordinator to its list of sessions in which it is participating. Later, when the session completes, issuing the endResource operation on the Resource, the sessionable object (through a private collaboration with its Resource) should remove the Coordinator representing that terminated session from its list.

Before performing this task, make sure you are familiar with:

- “Resource Priorities” on page 195
- “Client Use of the Session Service” on page 195

- “Managed Object Developer Use of the Session Service” on page 196

You can register a Resource object for the session using the following steps:

1. Access the ISessions::Current object by narrowing on the CORBA::Current object. You may also use an ISessions::Current object obtained from a previous operation.
2. Obtain the ISessions::Control object which represents the session context using getSessionControl on the ISessions::Current object. If this operation throws the NoSession exception, then there is no session context with which to register the Resource object.
3. Obtain the ISessions::Coordinator object that represents the session context, using getSessionCoordinator on the ISessions::Control object.
4. Determine whether the Resource has already been registered with this session context, using isSameSession on the ISessions::Coordinator. If the Resource has already been registered, then there is no need to do so now.
5. Obtain a reference to the Resource object to be registered. This can be done by either creating a new instance, or by reusing an existing Resource.
6. Decide on the priority value for the registration.
7. Invoke the registerResource operation on the ISessions::Coordinator object, passing the Resource object and priority value.

Here is an example:

```
CORBA::Current_var current;
ISessions::Current_var sessionCurrent;
ISessions::Control_var sessionControl;
ISessions::Coordinator_var sessionCoordinator;
ISessions::Resource_var myResource;
int myPriority;
// Get the current for this thread of execution
// from the ORB and narrow to the session current.
current = CBSeriesGlobal::orb()->get_current("ISessions::Current");
sessionCurrent = ISessions::Current::_narrow(current);
// Obtain the session Control object.
// This will throw NoSession if there is no current session context.
   try {
          sessionControl = sessionCurrent->getSessionControl();
   }
   catch (ISessions::NoSession) {

      //skip over the remaining code

   }
// Obtain the session Coordinator object.
sessionCoordinator = sessionControl->getSessionCoordinator();
// Determine whether already registered.
// This will involve using ISessions::Coordinator::isSameSession.
 ...
// Register the Resource
sessionCoordinator->registerResource(myResource,myPriority);
```

Collaborate on Session Outcome Amongst Multiple Concurrent Threads

Before performing this task, make sure you are familiar with:

- "The Scope of Sessions" on page 193
- "Client Use of the Session Service" on page 195

In some cases, particularly in window-based client programs, it is necessary to manipulate resources (business objects) from multiple threads, all within the same session context. The Session Service makes it relatively easy to do this. As described in Explicit and Implicit Propagation of Session Context the same session context can be propagated between threads by passing the session Control representing the session context between threads, and then resuming it on the subordinate thread using the resumeSession request on an ISessions::Current.

At least one thread must issue an endSession request to establish the outcome of the session. All of the other threads can simply issue an endSession request or a suspendSession request on a Current to end their involvement in the session. The session will not actually terminate until the last thread has issued either an endSession or a suspendSession request. If more than one thread issues the endSession request, the final outcome of the session is determined by the total consensus of all of the threads issuing the endSession request. For the session to be checkpointed, all of the threads must request to end with EndModeCheckpoint. If any thread requests to end with EndModeReset or EndModeResetForce, the session will be reset.

Note that collaboration of this sort can only be performed amongst threads in the process of the top-level coordinator.

Chapter 11. Query Service

The Query Service enables you to query for a set of objects that satisfy a set of conditions that you specify. Performing a query using the Query Service is conceptually very similar to performing query on a relational database. It differs in that the Query Service query is performed on a collection of objects rather than a collection of records, and the predicate is formed on the set of attributes and method return values for the object rather than on columns in the tables.

You will often find that you are dealing with very large collections in your business application. The collections that you deal with may have hundreds of thousands, millions, or even billions of object instances. Iterating through the entire collection of objects, looking for the one or few that you want to work with, can be enormously expensive, in terms of system resources. You can use the Query Service to preselect the set of objects that you want to work with. The Query Service will produce a subset of the original collection that satisfies the conditions that you set. If you only want to work with insurance policies that have coverage of more than a million dollars, you can form a query to return only those Policy objects that satisfy that condition, and then iterate on just those few.

The Query Service introduces a new query language: Object-Oriented SQL (OO-SQL). OO-SQL is an extension to the SQL language with additional constructs for operating on objects instead of tuples. OO-SQL is described in detail in the Component Broker reference section.

Queries are actually performed by a query evaluator. The query evaluator understands the OO-SQL grammar and how to apply it to collections of objects to form the requested result. In some cases, the query evaluator is able to push queries all the way down into the underlying datastore for a collection of objects. In this case, the query can be performed in the datastore and can yield significant performance improvements.

There are constraints on where a query evaluator resides relative to the collections that it is evaluating. The query evaluator you use to initiate a query must reside in the same server as the collections on which the query will be performed. If your program is running in a client process, or if your business object is in one server process and you are querying collections that reside in another server process, you will have to obtain the query evaluator that resides in that process. To accomplish this you must be able to find the name of the server on which those collections reside. This process is described in Get the Server Name of a Query Evaluator.

Certain kinds of collections, termed queryable collections, are able to support query operations directly. If you are performing simple queries on only one collection, you can issue the query request directly on the collection. The collection, in turn, will locate an appropriate query evaluator and use that to form the results that it hands back to you.

Depending on the needs of your application, queries have two different kinds of results. If you perform a query on a single collection, or multiple collections of the same type of object, then you probably want to return a result set containing that same type of object. For instance, if you are performing a query on a collection of Policy objects, then you probably want a result set of Policy objects.

However, if you are performing a query over multiple collections of different types, or even if you are performing a query on a single collection but only want to return a subset of the state produced by those objects, also referred to as a projection, then you probably want to return an array of data records.

The Query Service locates collections referenced in the FROM clause of any query statement by looking up the referenced collection name in the system name space. Thus, collections must be named in the system name space before they can be used in a query statement.

The data returned is a collection of references to objects of one type. The objects in the returned collection can be the exact same objects that were queried in one of the input collections, or a subset of these objects. In this case, no new schema results when the data is returned. Alternatively, to support the notions of projection, join, union, and function, the objects in the returned collection can be of a new dynamic and transient type.

Object Oriented Structured Query Language

The language for the Component Broker Query Service is Object Oriented Structured Query Language (OO-SQL). OO-SQL is a Query Service over objects where the syntax of the query is expressed in standard or extended forms of the Structured Query Language (SQL). A small number of extensions of the SQL SELECT syntax are available to exploit the object model. The primary extension is that of path expression, that generalizes the notion of navigation through attributes and methods of a Component Broker CORBA Interface in IDL that are CORBA structures (for example, the struct construct in CORBA IDL), references to objects or collections of objects. In accordance with the object model, the database is perceived as a set of collections of objects, and relationships are represented by collection and reference attributes of the IDL. Results are retrieved by specifying a result collection that can be derived from one or more collections. The result returned is a collection of references to objects of some type. The objects in the returned collection can be the exact same objects that were queried in one of the collections, or a subset of these objects. Alternatively, to support projection, join, union, and function, the objects in the returned collection can be the instances of a new type.

Differences Between OO-SQL and SQL

This section contains a brief review of SQL showing how OO-SQL differs from SQL. For more information on SQL see the SQL Reference Manual and Application Programming Guide in the DB2 product information. To trace and display information about the SQL queries that are executed as a result of OO-SQL queries from an application server, see the “Trace SQL Queries” section in the *Component Broker for Windows NT and AIX System Administration Guide*.

SQL is a structured query language designed for use with relational databases. Use the following employee and department tables, you can perform queries to find specific data.

Table 13. Employee

empid	**name**	**deptno**
12	'Dave'	42
14	'Andrew'	42
16	'Liz'	44
18	'Amy'	44
20	'Don'	44

Table 14. Department

deptno	**name**	**mgrid**
42	'Sales'	16
44	'Dev'	20

You can find all employees in department 42:

```
select empid,name from employee where deptno=42
```

You can find all employees whose manager has the ID of 16. This query, however, requires a join of both tables.

```
select e.empid, e.name from employee e, dept d
where d.deptno=e.deptno and d.mgrid=16
```

You can find all employees that are not managers:

```
select empid, name from employee where empid not in
(select mgrid from dept)
```

You can find the number of employees in each department:

```
select deptno, count(*) from employee group by deptno
```

OO-SQL is an extension of SQL. Instead of tables used in SQL, data takes the form of collections of objects with attributes and methods.

empHome is a home collection of employee objects with the interface:

```
interface employee{
          attribute readonly long empid;
          attribute string name;
          attribute dept deptPtr;
          }
```

deptHome is a home collection of dept objects with the interface:

```
interface dept {
          attribute readonly long deptno;
          attribute string name;
          attribute employee mgr;
          IManagedCollection::IIterator emps();
          }
```

Unfortunately IDL does not tell you what kind of objects the method emps() returns. Assume that these are employee objects.

OO-SQL queries equivalent to the queries above would be:

```
select e.empid,e.name from empHome e where
e.deptPtr..deptno=42;
```

This query returns the values of empid and name for employee objects in department 42. It is called a data array query.

Some important points to remember:

- OO-SQL queries always end with a semicolon.
- The FROM clause names the collection. (Later you will see how to query an unnamed collection.) The name of the collection is the name that the home uses in the DCE namespace. Be aware that home collections have two names, a home name and a factory finder name. The FROM clause always uses the home name, never the factory finder name.
- Correlation identifiers (the “e” in the query above) are always required in OO-SQL. In SQL correlation ids are not always required.
- The 2 periods (..) is a dereference operator in OO-SQL. This is the same idea as the -> operator in C++. The dereference operator can be used with data types that are object references.

If you want to return object references instead of attribute values the query would be:

```
select ref e from empHome e where e.deptPtr..deptno=42;
```

This is called a reference query.

A correlation name preceded by the keyword REF returns pointers to objects in the collection associated with the correlation name. If the correlation name is not one of the members in the collection associated with the correlation name, the REF correlation name has the same semantics as correlation name. This feature was introduced to preserve compatibility with SQL in which column names can be unqualified. For example, to select pointers to employee objects with the name of 'Bob' from the empHome collection:

```
select ref e from empHome e where name='Bob';
```

If the collection empHome has no member attribute "e," then the above query is the same as the following query:

```
select e from empHome e where name='Bob';
```

You can return attribute values and object references:

```
select e.empid, e.name, ref e from empHome e
where e.deptPtr..deptno=42;
```

This is considered another type of data array query.

To find all the dept objects where the deptno is between 10 and 100 the query would be:

```
select ref x from deptHome x where x.deptno between 10 and 100;
```

The query to find all non-manager employee objects would be:

```
select ref e from empHome e where e.empid not in
(select d.mgr..empid from deptHome d );
```

A count of employees in each department would be performed as follows:

```
select e.deptPtr..deptno, count(*) from empHome e
group by e.deptPtr..deptno;
```

Another similar query is:

```
select d.deptno, count(d.emps) from deptHome d;
```

You can perform string searches using the SQL LIKE operator:

```
select ref e from empHome e where e.name like 'Bob%';
```

"%" is the wild card character in SQL. SQL strings are delimited by single quotes where strings in C++ are delimited by double quotes.

Note: String searches are case sensitive in SQL.

If the dept interface also includes methods, I can also include methods in my queries.

```
interface dept {
          attribute readonly long deptno;
          attribute string name;
          attribute employee mgr;
          double compute_overtime();
          long compute_vacation(in long year);
          };
```

Find all dept objects where the overtime is greater than 10 hours:

```
select ref d from deptHome d where d.compute_overtime() > 10;
```

Find the deptno, name and vacation days of dept objects where vacation in 1996 was less than 50 days.

```
select d.deptno, d.dname, d.compute_vacation(1996)
from deptHome d where d.compute_vacation(1996) < 50;
```

The key points of OO-SQL queries is that they:

- Are similar to SQL queries.
- Use collection names in the FROM clause (SQL queries use table names).
- Can return object references as well as attribute values (SQL queries can only return column values).
- Have a dereference operator (..) that can be used to follow object references.
- Can do joins, subselects, ordering and summarize data just like SQL.
- Can use object attributes and methods in the select and where clause. Only methods that return a value and have either no parameters or only input parameters can be use in a query statement.

Methods

OO-SQL supports invocation of CORBA IDL methods in queries. (Methods are also referred to as member functions.) In an OO-SQL query, a method name is followed by the method arguments within parentheses. For example, m(a_1,a_2,...a_n) is a method with name **m** and arguments a_1,a_2,...a_n. Following the C++ convention, methods with no arguments are followed by empty parentheses: m().

Component Broker implements a dynamic run-time environment for method selection and invocation.

If a method argument is a null value, then the value returned by the method is also null. A programming error in the implementation of the method can cause OO-SQL to fail.

Methods must be defined as having zero arguments or input only arguments and must not be defined with a return type of void.

The implementation of methods appearing in queries has limitations. Method arguments in OO-SQL statements are checked for type correctness. Where possible, when method execution results in exceptions, a method failure message is generated and the query is terminated. In some cases, a programming error in a user's method might cause the query engine to halt (infinite loop in method) or terminate abnormally.

The following table presents the conversion that is performed when an argument of a given type is passed to a method that is defined with a parameter of the same or different type.

The table shows for example, if you have the idl interface

```
myInterface {
   attribute short s1;
   attribute string s2;
   long methoda(in long input);
   }
```

the query statement

```
select e.methoda(e.s1) from myHome e;
```

is valid and the Query Service will convert *s1* from short to long when calling the method. However the query statement

```
select e.methoda(e.s2) from myHome e;
```

is not valid because the string type attribute *s2* can not be passed to methoda.

argument/ parameter type	pointer	short	long	float	double	string	vargraphic	other
pointer	NC	E	E	E	E	E	E	E
short	E	NC	C	C	C	E	E	E
long	E	C*	NC	C	C	E	E	E
float	E	C*	C*	NC	C	E	E	E
ICBCdecimal	E	C*	C*	C*	C*	E	E	E
double	E	C*	C*	C*	NC	E	E	E
string	E	E	E	E	E	NC	C	E
vargraphic	E	E	E	E	E	E	NC	E
other	E	E	E	E	E	E	E	E

C Conversion. The argument type is converted to the parameter type.

C* Conversion with the possibility of an overflow, an underflow, or a loss of precision due to a type conversion.

E Error. The argument type used in a method in a query is not applicable to the parameter type of the method.

NC No Conversion. The argument type and the parameter type are the same.

Note: There is no pass by value capability for method arguments in queries, as indicated by the *other* type. Arguments that are of complex type must be passed by pointer to be used in methods in queries. Character string pointers are considered string types by query, not as pointer types.

Inheritance

OO-SQL supports interface inheritance as in the following example. Suppose the manager interface inherits from employee.

```
interface manager : employee {
          attribute dept manages_deptPtr;
          attribute long executiveLevel;
          }
```

A query statement over manager can select inherited attributes just like noninherited attributes. (No special syntax is required.)

```
select m.no, m.name, m.executiveLevel from managerHome m;
```

Navigation

A navigation is specified by path expressions. Path expressions allow traversal through references, embedded structures, and collections to reach embedded members. The ".." characters are used to express traversal through embedded members. Path expressions can appear anywhere a member can. A path expression is q.m1..m2..mn where q is a correlation name defined for collection C, and m1 is a member of the element type of C, and m2 is a member of the type of m1 and so on. A member of mi can be a member or a method. A path expression evaluates to the value of the leaf of the expression.

Through Embedded Structures

Embedded Structures Members can be defined in terms of structures. Navigation allows traversing into the embedded members of structure definitions.

Example:

```
struct addressStruct {
       string street;
       string city;
       string state;
       string country;
       string zip;
       }

interface employee {
          attribute long empid;
          attribute addressStruct address;
          }
```

You can write the query statement

```
select e.address, e.empid, e.address..city from empHome e
where e.address..zip='95120' order by e.address..city;
```

returns the address struct, employee ID and city for employees in postal code 95120 sorted by city.

Through References

Reference members can also participate in navigational expressions. A reference that has a zero value is treated as a null reference. Only references to objects, structures, and collections can be traversed (that is, appear as other than leaf nodes in path expressions). However, a member of any type can appear as a leaf node of a path expression. Its interpretation is dependent upon its type. If a reference member points to a character string, then OO-SQL will dereference the reference to return the character string value. In all other cases (for example, integer, double precision), OO-SQL cannot dereference the reference to obtain the value and if such a data item appears in a SELECT statement, the reference to the value is returned. The application can then dereference the reference to retrieve the value. Uninitialized or invalid references can cause OO-SQL to terminate abnormally if these are part of a path expression that is traversed.

Through Collections

Navigation or traversal through collection members creates implicit correlation names over each embedded collection in the path expression.

Example: The query selects the numbers and names of employees in department one. The set of employees in each department is modeled with the member *emps* defined as a collection. The traversal through *emps* given by *d.emps..empid* defines an implicit correlation q over *d.emps*, and the semantics of *empid* is *q.empid*.

```
select d.emps..empid, d.emps..name from deptHome d where d.deptno=1;
```

Collections

Collections are used in place of tables in the OO-SQL SELECT syntax. Collections are made up of objects of some type. Objects are used in place of rows and the members of objects are used in place of columns. The term members is used to mean both attributes and methods of a Component Broker CORBA interface. There is no inherent order of objects within a collection. Every object must have one or more members, but the collection can be empty or the number of objects in the collection can be zero. Some types of collections include:

queryable collection
: A collection that may appear in the FROM clause of the OO-SQL queries. The creation of these collections is system dependent.

result collection
: A set of objects that OO-SQL selects or generates from one or more queryable collections.

Query Optimizations

In general, the semantics of any query requires that the Query Service invoke the methods or attributes specified in the query expression, perform any mathematical operations on the resulting values as specified in the query expression, and determine whether the final result satisfies the specified predicate for each object in the collection. Due to the inherent encapsulation semantics of object-oriented programming, this requires that the Query Service activate each object instance in the collection and perform the evaluation one object at a time.

However, if the collection(s) you are querying is collected by a Home, and that Home is configured to store the state of its objects in a relational database, specifically DB2, then the Query Service can optimize its search. The query evaluator is smart enough to detect that the collection(s) it is operating on may be adapted to a DB2 data store. When this is the case, and when there is a straightforward mapping between the attributes specified in the query, and the underlying columns of the tuple in which the managed objects collected by the Home are stored, then the query evaluator will transform the OO-SQL expression into a standard SQL expression and “push down” the query to examine the underlying datastore.

Even if only part of the OO-SQL expression can be mapped in this way, the resulting push down will often yield an intermediate result set that is a fraction of the original collection size. Thus, the remaining query can iterate over the intermediate subset and significantly reduce the overhead that would be incurred if the evaluation had to iterate over every object in the collection.

DBMS Pushdown Rules

The query pushdown determines what parts of the OO-SQL query are passed down to the underlying relational database management systems (DBMS) where the data resides. The parts of the OO-SQL query that are not pushed down are evaluated in the memory. This section lists which of the OO-SQL query constructs are pushed down and which are not for the DB2/390, DB2 Universal Database (UDB) and Oracle database management systems.

Simple Expressions: All DBMS types: The expressions containing numeric, date, time, and timestamp functions, arithmetic operators and comparison operators appearing in predicates are pushed down to the DBMS. Comparison operators among {<,≤, >, ≥} are not pushed down for varchar and vargraphic types.

Joins: All DBMS types: Multiple tables from the same database can be pushed down in a single query if the table are related by an equi-join predicate.

Aggregates, Group by Clause, Having Clause: DB2/390,UDB: Aggregates, group by and having can be pushed down provided that all other clauses in the query can be pushed down.

Oracle: Aggregates, group by and having can be pushed down provided that all other clauses in the query can be pushed down and that only columns appear in the projection list.

Distinct: All DBMS types: Pushdown is disabled.

Order By: All DBMS types: Pushdown is disabled.

Union: All DBMS types: Pushdown is disabled.

Subqueries: All DBMS types: If the tables participating in a subquery are from the same database as the tables participating in the outer query and the body of the subquery can be pushed down, the following rules apply: Exists (existential) subqueries are pushed down. Subqueries that are basic predicates, and ANY (existential) and ALL (universal) subqueries are pushed down if the comparison operator is between {=, ≠} or if the comparison operator is among {<, ≤, >, ≥} and the operands of the operator are numeric, date, time, timestamp (that is, arguments of type varchar, vargraphic disable pushdown).

Projection (Query without Aggregates, Group by and Having): All DBMS types: Projection clauses in subqueries can be pushed down. The projection clause of the outer query is computed in the memory.

Projection (Query with Aggregates, Group by and Having): DB2/390.UBD: The projection list can be pushed down (see aggregate function list below for details on when pushdown occurs).

Oracle: Pushdown is disabled if anything other than columns appear in the projection list.

Scalar Functions

char

UDB: The CHAR function can be pushed down for arguments of type varchar, smallint, integer, decimal, date, time, timestamp. Pushdown is not applied for arguments of type 4 byte float, double, duration due to formatting differences.

DB2/390: Same as UDB except that varchar arguments cannot be pushed down.

Oracle: The CHAR function is pushed down using the Oracle to_char function for arguments of type smallint, integer, and decimal. Note that these numeric types map to the Oracle number type with a certain precision and scale.s

integer

UDB: The INTEGER function can be pushed down for varchar and numeric arguments.

DB2/390: Same as UDB except that varchar arguments cannot be pushed down.

Oracle: Pushdown disabled.

digits, float, decimal, year, month, day, hour, minute, second, date, time, timestamp, microsecond

DB2/390, UDB: Pushdown enabled.

Oracle: Pushdown disabled.

smallint, double

UDB: Pushdown enabled.

DB2/390, Oracle: Pushdown disabled.

Aggregate Functions

count, sum, avg

DB2/390, UDB: Pushdown enabled.

Oracle: Pushdown is enabled if aggregates aren't in the projection list (e.g., in a having clause or in a subquery).

min, max

All DBMS types: Pushdown is enabled for numeric, date, time, timestamp arguments, and disabled for varchar, vargraphic arguments.

Miscellaneous Rules

Methods in queries

All DBMS types: Query terms that are methods are not pushed down.

Queries with reference collections

All DBMS types: Query terms that are reference collection attributes are not pushed down.

Queries with in-memory object building

All DBMS types: Query terms that are reference collection attributes are not pushed down.

Path expressions over home collections

All DBMS types: Path expression over home collections can be pushed down as join expressions.

The Cast Operator

The cast operator sets the type of a member or method in the body of a query. Thus casting provides type information to OO-SQL when it is not available from the schema. However, the casting can be used to override the type information in the schema.

The cast operator follows the member to be altered and specifies the type name between(% and %).

Casting is a fragile operation, since casting a member to the wrong type may result in producing incorrect answer to the query or can cause OO-SQL to fail. See Query Over Reference Collections for an example of casting.

Query Over Reference Collections

The syntax of a query over a reference collection is the same as query over a home collection.

There is one important difference when querying an object whose IDL definition contains an IReferenceCollection or IIterator type as an attribute or return type of a method. The IDL definition does not indicate what kind of object the ReferenceCollection or Iterator references. The Query Service must know this information in order to process the query and so it necessary to indicate this information using a cast function in the query statement itself.

For example, using the dept interface from the previous section, the query over a home collection to find all departments that contain an employee whose name starts with 'D' would be:

```
select d from deptHome d where d.emps..name like 'D%';
```

To do this same query over a reference collection (whose name is deptRC) of department objects would be:

```
select d from deptRC d where d.emps(%Collection<::employee*>%)
..name like 'D%';
```

The notation (`%Collection<::interfaceName*>%`) is the OO-SQL cast function that specifies the object type of *emps*.

The internal processing for a query over a reference collection is different from a home collection. A query over a reference collection is processed by iterating over the reference collection and activating each object (if it is not already activated) and evaluating the query.

When creating the reference collection, make sure you use the createCollectionFor() method and pass in the string equal to the IR name of the objects the collection will contain. For example:

```
createCollectionFor("IDL:policy:1.0");
```

You can find out what this IR name is by loading the IR and then doing an irdump with a parameter of your interface name.

If you don't use createCollectionFor(), when you query the reference collection, the Query Service won't know what kinds of objects are contained in the collection and cannot execute the query. An exception is thrown.

DB2 tables have the capability of using indexes and DB2 has a search engine. Having DB2 do the search is preferable to doing searches over large reference collections where there is no indexing capability.

Design your application to make use of home collections. Avoid the use of query over reference collections when query performance is important.

Data Type Mapping Between DB2 and CORBA

Many of the DB2 data types have obvious counterparts in CORBA such as DB2 integer mapping to CORBA::long and DB2 char(n) and varchar mapping to CORBA::string.

Be aware that char(n) and varchar will map to null terminated strings in CORBA. Binary string data can be handled by used either VARCHAR FOR BIT DATA or CHAR FOR BIT DATA in the table definition mapped to ByteString datatype in idl.

There are four data types in DB2 that do not have obvious counterparts in CORBA. They are DB2 Date, Time, Timestamp and Decimal. Date, Time and Timestamp should be mapping to CORBA::String. There are helper classes (ICBCDate, ICBCTime and ICBCTimestamp) provided in Component Broker if you need to do date and time manipulations of these strings. Decimal can be mapped to CORBA::double or CORBA::String. Use string when you need exact precision. Double byte strings can be stored using GRAPHIC or VARGRAPHIC datatype in the table definition and Wstring in the idl.

Query Evaluators

A query evaluator is the engine behind the Query Service. The query evaluator parses the query expression you supply, locates the inferred collections, and evaluates the collections for the set of objects that satisfy the query predicate. The query evaluator supports the QueryEvaluator interface as defined in the standard CORBA services Query Service specification.

The evaluate operation, as specified by OMG in the CosQuery::QueryEvaluator interface returns an any. CORBA leaves it to query implementers to specify the structure of this any for the various types of results that can be produced from a query. Depending on the conditions you specify in the query expression you could potentially need to get back either an iterator (a collection of objects whose type matches the objects in the collection you are evaluating), or a data array. However, the Component Broker implementation of the CosQuery::QueryEvaluator::evaluate() operation returns only an

IManagedCollections::Iterator. You need to test the results returned to ensure they match your expectations.

Component Broker has extended the CosQuery::QueryEvaluator interface to introduce variations of the evaluate method that return more specific result set types. If you want to be more specific about the type of result set you get, you can use the evaluate_to_iterator() operation which passes back an IManagedCollections::Iterator, or you can use the evaluate_to_data_array() operation which passes back an IExtendedQuery::DataArrayIterator.

In general, a query evaluator could support any number of query languages. You would be expected to specify the language that you intend to use, and accept that the query evaluator you choose may or may not be implemented to support that language. The Component Broker query evaluator only supports one language--Object-Oriented Structured Query Language (OO-SQL). OO-SQL is a rich language, following in the tradition of SQL, with extensions that are specific to object-oriented programming.

Default Query Evaluator

Component Broker automatically creates an instance of a query evaluator in every Component Broker server, and binds this in the system name space at the following location:

```
/host/resources/servers/<server-name>/query-evaluators/default
```

Plug your server name in for <server-name>. If your program is executing on a server, you can get the name of your local server from the CBSeriesGlobal::serverName static member function. This member function can only be invoked within a server process. In a client process, you must know the name of the server containing the query evaluator you want to use.

Obtain a Query Evaluator

The following procedure demonstrates how to obtain the default query evaluator from the system name space for a well-known server. This procedure can only be completed if you know the name of the server on which the query evaluator exists. The query evaluator you obtain should be on the same server as the collections that you will be querying.

1. Determine which server you want to use.

   You need to know the name of the server that contains the query evaluator that you want to use. This could be the server on which you're already executing, or it could be a remote server. In the former case, you can simply get the local server name from the CBSeriesGlobal::serverName static member function.

2. Resolve the default query evaluator from the system name space.

   Use the naming service operations to resolve the default query evaluator in the named server from the system name space.

The following example obtains the default query evaluator from the local server. This example can only be used in a server process—for instance, in a business object implementation.

```
// Declare an intermediate object ref, intermediate naming contexts
// and the targeted query evaluator

CORBA::Object_var intermediateObject;
IExtendedNaming::NamingContext_var serversNC;
IExtendedNaming::NamingContext_var localServerNC;
IExtendedQuery::QueryEvaluator_var defaultQE;

// Resolve to the server's naming context in the Host name space
```

```
serversNC = CBSeriesGlobal::nameService()->resolve_with_string("/host/resources/servers");

// Resolve to the local server

localServerNC = serversNC->resolve_with_string(CBSeriesGlobal::serverName());

// Resolve and narrow to the default query evaluator

intermediateObject = localServerNC->resolve_with_string("query-evaluators/default");
defaultQE = IExtendedQuery::QueryEvaluator::_narrow(intermediateObject);
```

Get the Server Name of a Query Evaluator

The query evaluator you use to initiate a query must reside in the same server as the collections on which the query will be performed. If your program is running in a client process, or if your business object is in one server process and the query that it wants to perform is on collections that reside in another server process, then you will have to obtain the query evaluator that resides in that process. To accomplish this you must be able to find the name of the server on which those collections reside.

Unfortunately, Component Broker does not provide any automated mechanisms for determining the name of a remote server. However, there are a number of techniques you can employ.

First, if the collections you need to query are on the same server as your business object, then you can get the name of the local server from the CBSeriesGlobal::serverName static member function. Even if the collections are not in the same server, it is good to note that the CBSeriesGlobal::serverName static function will always return the name of its local server.

There are at least five strategies for finding the server name for a query evaluator. These include:

- Ask the User
- Ask an Administrator
- Know your Collections and you'll know their Server
- Create an Anchor
- Specialize your Collections

You may be able to derive your own approach, perhaps as a variation of one of these.

Ask the User

In some cases, the query statement will actually be formed by an end user and provided to you through a user interface. In this case, you may be able to depend on the user knowing the layout of their distributed system topology, and can supply the appropriate server name along with the query statement.

Ask an Administrator

Even if the topology of the system is foreign to your business end users, the system administrator who configured the system should know something about where different resources are located. As part of your application design, you may be able to require that the administrator identify on which servers specific collections exist, and to supply that information to your application through a configuration file. Your application can then read this file during its initial load and use that during its runtime.

If your application uses a number of different collections, this configuration file may need to contain a table of collection to server assignments. By indexing on the collection name, you can look up the corresponding server and use that to find the appropriate query evaluator for the collection you are querying.

Know your Collections and you will know their Server

If your application uses a number of different collections, this configuration file may need to contain a table of collection to server assignments. By indexing on the collection name, you can look up the corresponding server and use that to find the appropriate query evaluator for the collection you are querying.

```
/host/resources/servers/<server-name>/collections
```

where <server-name> is the name of the server on which they exist. Likewise, the corresponding query evaluator that can operate on those collections is named in,

```
/host/resources/servers/<server-name>/query-evaluators/default
```

If you know the fully-qualified name of your collections, then you can deduce from their path the server in which they reside. From that, you can form a path to the corresponding query evaluator.

Note that if the collections reside on a server in a remote host, you may have to use a fully qualified path to navigate to that host. For instance,

```
/.:/hosts/<host-name>/resources/servers/<server-name>/collections
```

or

```
/workgroup/hosts/<host-name>/resources/servers/<server-name>/collections
```

depending on whether the host is in your local workgroup or elsewhere in the cell. Notice that in both cases you need to know the name of the target host.

If you only know the host name or that it is on the local host, you can do a brute-force search through all of the servers within the

```
/host/resources/servers
```

naming context. In the worst case, you can do a brute-force search through all of the servers in all of the hosts in the

```
/.:/hosts
```

naming context.

Create an Anchor

For each of the collections that you want to query, you can introduce your own Application Object (an anchor) with instructions to the application assembler to install an instance of each these in the same server as the collections that you're interested in. These anchor application objects can have a simple interface supporting a single operation that returns its own server name. The implementation simply uses the CBSeriesGlobal::serverName static function to deduce its own server name and return that from the operation. However, you would want each anchor to have a distinct primary interface name, perhaps all derived from the same base interface containing the single operation.

You could then build or hard code a mapping table that correlates collections with the primary interface name of the anchor that corresponds to that collection. Before initiating a query, you can look up the anchorÆs primary interface name corresponding to the intended collection, and use that with a factory finder to find the Home for the anchor. From the anchor itself, invoke the simple operation that returns its server name, and then use that to form a name path to its query evaluator.

A variation of this is to create an individual instance of the same type of anchor in each relevant server, and as part of the creation process, bind these by their collection name in a naming context that you define. You could then look up the anchor by its corresponding collection name and then use the anchor to return its local server name as before. In this case, each anchor would not have to have its own unique primary interface, and you could avoid using the factory finder for locating it.

Specialize your Collections

Many of the queries you perform will be on queryable Homes. Homes are collections and normally are automatically bound in the collections naming context under the server where they belong. However, as Homes, they're also registered in the factory repository and can be found using a factory finder.

If you specialize your Home, you can introduce the same method that we suggested in the “Create an Anchor” strategy that returns its own local server name. In this way, the Home collection can act as its own anchor. You can find the Home using a factory finder, get its local server name, and use that to find a query evaluator that operate on that Home as a collection.

This strategy probably only works well for Home collections.

Topology of Query Evaluators and Collections

The FROM clause of the query statement contains the name of one or more collections. The evaluate_to_iterator() and evaluate_to_data_array() operations operate only on collections that have been named in the system name space or named in a parameter list. Specifically, collections should be named under the following location in the Host name tree and server, as specified in <server-name>, where the collection actually exists:

```
/home/resources/servers/<server-name>/collections
```

The query evaluator looks up the collection specified in the FROM clause either in the parameter list or on the local Host name tree under the query evaluator's own server if the collection is not supplied in the parameter list. If the referenced collection is not supplied in the parameter list or has not been bound in this naming context, then the query cannot be performed. This has the following implications:

- If you do not supply the collection in the parameter list, collections must be uniquely named in the system name space, specifically within the collections naming context for any given server.
- Queries can only operate on collections that exist in the same server as the query evaluator that is operating on them.

Homes are normally automatically bound in the collection's name context in the server on which the Home exists when the Home is created. You can specify whether a Home is to be bound, and its collection name in the Application DDL for that Home using Object Builder. If you create your own collections, other than Homes, it is up to you to bind that collection in the system name space before you can perform any queries on it.

As previously mentioned, you can supply the collection in the parameter list, provided you give it the same name in the parameter list as you specified in the FROM clause in the query statement, as shown in the following example:

Parameter List	**Query Statement**
“myCollection,” IManagedCollections::IReferenceCollection_var myCollection	“select p from myCollection p where p.number > 10”

Form a Query

This procedure demonstrates how you can form a query on a collection. This procedure assumes you already know the name of the server containing the collection you will query (myServer in this example).

1. Determine the name of the server where your collections exist. You need to determine the name of the server on which your collections exist. The query evaluator you use must reside in the same server as the collection(s) you are querying. If you are using a local collection, then you can get the local server name using the CBSeriesGlobal::serverName static member function. Otherwise, get a remote server name as outlined under “Get the Server Name of a Query Evaluator” on page 221.
2. Obtain a corresponding query evaluator. Get the query evaluator that corresponds to the collections you will be querying. Otherwise, you will have to form a name path using the server name that you produced in step 1.
3. Determine the type of result you want to receive. The evaluate_to_iterator() operation returns an iterator over a collection of object references. The evaluate_to_data_array() operation returns an iterator over a collection of data array rows.
4. Decide if you want any initial values back from the iterator. Both evaluation methods that you may use will return an iterator: either an iterator over a reference collection, or an iterator over a collection of data array rows. Normally you will iterate over these collections either one or several elements at a time. You have the opportunity at the time you initiate the query to ask that an initial set of elements be returned in a sequence outside of the iterator. This is a convenience mechanism that is equivalent to invoking the query, getting back the iterator, and requesting the first n elements in a separate request.
5. Issue the query request. Depending on the decision you made in step 3, invoke either the evaluate_to_iterator or evaluate_to_data_array() operation on the query evaluator. In doing so, pass in the query statement, any accompanying parameter list, and an indication of how many initial elements to return from the resulting iterator.

Queries on Queryable Collections

Certain collections supplied by Component Broker, specifically Homes, can be queried directly. You can query a Home by narrowing to its IManagedAdvancedClient::IQueryableIterableHome interface, and invoking the evaluate method. This method has been implemented to locate an appropriate query evaluator, and reissue the request on it. If you use this approach, the queryable collection will form its own SELECT and FROM clause, and append the predicate that you supply in the query statement argument of the evaluate method. If you use this approach, the queryable collection will form its own SELECT and FROM clause in the form `SELECT REF x FROM thisCollection x WHERE` and append the predicate that you supply in the query statement argument of the evaluate method.

Note: The correlation ID will always be the letter `x`.

Queries that Result in an Object Collection

When you specify your query expression, you indicate in the SELECT clause the type of the results you expect to get back. The result can be an object type as defined by a managed object in IDL, or some combination of one or more data types.

```
select ref e from empHome e;
```

In the preceding statement, the result is the type of object that is collected by the empHome collection, presumably Employee. This example returns a collection of objects. This has the benefit of allowing you to perform other operations supported by Employee objects on any of the objects returned from these queries. You can direct the query evaluator to return a collection of objects (literally, an iterator to a collection of objects) using the evaluate_to_iterator() operation.

The evaluate_to_iterator() operation returns an IManagedCollections::IIterator object, and a sequence of zero or more initial entries from the iterator. The IIterator is an object that represents a collection of references to objects, and can return one or more object references, that is, entries in the reference collection. If you use the next operation on the IIterator, it will return the next object reference in the collection. If you use the nextS operation, you can specify how many entries you want returned, and these will be returned as a sequence of references. You can request the evaluate_to_iterator() operation to return an initial set of entries from the IIterator. This is equivalent to returning the iterator, and then requesting nextS to get that same initial set.

Queries that Result in a Data Array

There are times when you want a query to result in an array of data values instead of a set of objects that would normally encapsulate that data. This could be the case, for example, when you want to present the resulting data in a scrolling list on the end user interface.

The following statement returns an array of data values:

```
select empid, name from empHome e where e.deptPtr..deptno=11;
```

In the preceding example, the returned array of data values contains the employee number (empid and the name for each employee contained in the empHome collection that is assigned to department 11.

In the preceding example, the returned array of data values contains the employee number (empid) and the name for each employee contained in the empHome collection that is assigned to department 11. You can direct the query evaluator to return an array of data values using the evaluate_to_data_array() operation.

```
select ref e from empHome e where e.deptPtr..deptno=11;
```

You can also use this operation with any query statement that would normally return a collection of objects. In this case a reference to each resulting object is stored as a data field in the data array. You can then iterate through the data array, pick up the first field (and presumably the only field unless your SELECT clause specifies other data fields to return as well) of each row in the array, and use that as a reference to the object. At that point, once you narrow to the appropriate interface, you can perform any operation on the referenced object that it supports.

The evaluate_to_data_array() operation returns an IExtendedQuery::DataArrayIterator object, and a sequence of zero or more initial entries from the iterator. The DataArrayIterator is an object that represents the data array collection and can return one or more data array rows, that is, entries in the data array collection. If you use the next_one() operation on the DataArrayIterator, it returns the next DataArray row (a sequence of any types) in the collection. If you use the nextS operation, you can specify how many entries you want returned, and these are returned as a sequence of N rows.

Using the evaluate_to_data array() operation, you can request that it return an initial set of entries from the DataArrayIIterator. This is equivalent to returning the iterator, and then requesting nextS to get that same initial set.

Queries Over Unnamed Collections

In the queries we have seen so far, the from clause is the name of a collection. This name must be registered with the name service. A home collection usually registers itself with the name service with a name such as:

```
host/resources/servers/MyServer/collections/empHome
```

Only the string empHome is specified in the query statement. Most home collections are registered, but they don't have to be. Reference collections or view collection many times are not registered. To run a query over a collection that is not registered with the name service, use a parameter list. A parameter list is a Name/Value pair list that consists of strings and references to collection objects (homes, views or reference collection). In the from clause of the query you use the name from the Name/Value pair, and on the evaluate_to_data_array or evaluate_to_iterator call, you pass the Name/Value pair list.

An Example Using the Query Evaluator Interface

This section contains an example that shows:

- Why you would use the query evaluator object.
- How to get an object reference to the query evaluator.
- How to deal with data arrays returned from query evaluator.
- An example using the evaluate_to_iterator method.
- An example using the evaluate_to_data_array method.

The query evaluator is a system object on the application server that is a direct interface to the Query Service. The details of the query evaluator are described in IExtendededQuery.idl. ActiveX, Java and C++ clients all have bindings to the query evaluator. The query evaluator is used when you want to:

1. Run queries over reference collections (reference collections don't have an evaluate method).
2. Run complex queries where you want to join several home collections together.
3. Run a data array query that returns object attribute values. This might be more efficient than first finding object references and then using the references to get the values.
4. Run a data array query that does data summarization.

If RC is a reference collection of employee objects and you want to find employees with names starting with the letter D:

```
select ref e from RC e where e.name like 'D%';
```

You have to use the query evaluator interface because of reason 1 in the previous list. If you want to find the employees whose name is the same as any department name:

```
select ref e from empHome e, deptHome d where e.name = d.name ;
```

You use the query evaluator because of reason 2 in the previous list.

Find the deptname and object reference of all departments with deptid greater than 100:

```
select d.name, d from deptHome d where d.deptno > 100;
```

You use the query evaluator because of reason 3 in the previous list.

Find the number of departments whose dept number is greater than 100:

```
select count(*) from deptHome d where d.deptno > 100;
```

You use a query evaluator because of reason 4 in the previous list.

The query evaluator has these important methods:

evaluate_to_iterator() This method is similar to evaluate() on the home collection and is used to return object reference queries such as `select ref e from empHome e;`

evaluate_to_data_array() This interface takes a data array query and the output is an iterator over a collection of data arrays. A data array is a sequence of CORBA::Any. Each any contains an attribute value.

The following query contains 3 elements in the data array. The first element is empid and is of type long second element is name and is type string, and the last element is an object reference to an employee object.

```
select e.empid, e.name, ref e from empHome e;
```

Sometimes the data type of the attribute that comes back in a data array is different from the data type defined in the idl definition of the interface.

Corba Attribute Datatype in IDL	Datatype Returned in Data Array
long (signed or unsigned)	long
short (signed or unsigned)	short or long
double	double
string	string
object reference	object reference
float	float or double
octet	long
enum	long
boolean	short
char	string (length 1)

Complex types such as struct, union, sequence, array and CORBA::Any can be used in query statements.

The query evaluator interface is very powerful but slightly more complex because you have to know how to deal with the idl SEQUENCE and the CORBA ANY data types. A data array is a CORBA sequence <any> structure and a memberList is a sequence of data arrays. You can think of a sequence as an array of elements.

To find the length of sequence X:

```
X.length()
```

To get the third element of X:

```
X[2]
```

An Any is a CORBA structure that is a self describing value. The Any stores both a typecode and a value.

To put something into an Any you use the operator <<=:

```
 CORBA::Any y;
    y <<= "a string value";
    y <<= 52;
```

To get something from an Any you use the >>= operator. The >>= operator will first do a typecode check to make sure the receiving variable is of the correct type:

```
CORBA::string_var s;
  if (y >>= s)
    cout << "If TRUE, then s contains a copy of
            the string value" << endl;
    else
      cout << "if FALSE, the extract failed because
              the any did not contain a string" << endl;
```

When dealing with data arrays for the first time, be careful. Do not just extract from an any and not check the return code. You extract operator might fail and no exception will be thrown.

Look at the parameters to the method evaluate_to_iterator and evaluate_to_data_array. The input parameters are:

- The query statement itself as a string. Make sure you include the ending semicolon;
- The second parameter can be coded as NULL. This indicates the query language, but the default Query Service supports only OO-SQL.
- The third parameter is a name/value pair list (see the next topic).
- The fourth parameter is NULL for now. This is reserved for future use.
- The fifth parameter is called HOW_MANY. It is the number of result elements to return in the memberList. This should be a value of zero or a positive number.

There output parameters are:

- MemberList. The first n result elements are returned as a CORBA sequence. The value of n is determined by HOW_MANY.
- Iterator. The iterator gives access to the remainder of the result collection.

Suppose that the result collection was 20 elements and HOW_MANY was set to 10. The first 10 elements would be returned in the memberList, and the remaining 10 could be retrieved using the iterator. There are two types of iterators. IMananagedCollection::IIterator is returned from evaluate_to_iterator. This is the same iterator interface as used by Reference Collections. Evaluate_to_data_array returns a data array iterator. Its interface is defined in IExtendedQuery.idl. It is similar to IIterator with the major difference is the IIterator returns managed object references and the Data Array Iterator returns Data Arrays which are CORBA sequences of values from the query result.

Look at the IDL definition of DataArrayIterator. At run time the following methods can be used to determine the number of columns in the data array in addition to the type and attribute name for each column:

- get_number_of_fields
- get_field_name
- get_field_type
- get_field_class_name

By setting how_many to the expected size of the result set, you can reduce the number of trips across the orb to fetch the query result collection.

Do not forget to make use of the nextS() interface on the iterator to retrieve the remainder of the result collection in groups of N. By using n=10 and retrieving 100 objects, you can do it with 10 trips across the ORB instead of 100.

The query evaluator methods can throw 3 different exceptions when things go wrong. The exception types are IExQueryInvalid, IExQueryProcessingError, IExQueryTypeInvalid. All of these types contain an error number (errorNo), message text (why) and extended details (argList).

Additional details on the cause of the error are found in the activity log of the application server. Following is a complete example of using the evaluate_to_iterator method:

```
// step 1 have the following include files in your C++ client
//        program
#include <IManagedAdvancedClient.hh>
#include <IManagedCollections.hh>
#include <CBSeriesGlobal.hh>
#include <IExtendedLifeCycle.hh>
#include <CosTransactions.hh>
#include <IExtendedQuery.hh>
#include <IQueryManagedClient.hh>
#include <IQueryLocalObjectImpl.hh>
#include "Policy.hh"
CORBA::Current_ptr                    orbCurrentPtr;
CosTransactions::Current_ptr          currentTransaction;

// step 2 start a transaction and get the query evaluator object
CBSeriesGlobal::Initialize();
orbCurrentPtr =  CBSeriesGlobal::orb()->get_current();
currentTransaction =
  CosTransactions::Current::_narrow( orbCurrentPtr );

// set transactions time out to 600 seconds.
// Default value of 30 seconds may not be long enough
// when doing some queries.

currentTransaction->set_timeout( 600 );
ICollectionsBase::IIterator_var _queryIt;
try {
 currentTransaction->begin();
 CORBA::Object_var o = CBSeriesGlobal::nameService() ->
   resolve_with_string("host/resources/servers/MyServer
   /query-evaluators/default");
 IExtendedQuery::QueryEvaluator_var _qe =
     IExtendedQuery::QueryEvaluator::_narrow(o);

// step 3 issue the query

 IExtendedQuery::MemberList* x;
 _qe->evaluate_to_iterator(
      "select e from policyDefaultTransDB2Home e
         where e.amount > 0; ",
      0,
      0,
      0,
      0,    // in this example how_many is set to zero
      x,    // how_many is zero, x will be an empty sequence
      _queryIt);

// step 4 iterator over the result
IManagedClient::IManageable_var tup;
while( (_queryIt->nextOne(tup)) != NULL )
  {
  Policy_var p =Policy::_narrow(tup);
  cout << "Policy no= " << p->policyNo() << " amount " <<
           p->amount() << " premium " << p->premium()<< endl;
  }
```

```
  // step 5 normal cleanup
  _queryIt->remove();
  currentTransaction->commit(0);
   }

// step 6 exception processing
  catch (IExtendedQuery::IExQueryInvalid &ex)
    {
      cout << "query error number=" << ex.errorNo << endl
           << "query error message=" << ex.why << endl;
      currentTransaction->rollback();
    }
  catch (IExtendedQuery::IExQueryProcessingError &ex)
    {
      cout << "query error number=" << ex.errorNo << endl
           << "query error message=" << ex.why << endl;
      currentTransaction->rollback();
    }
  catch (IExtendedQuery::IExQueryTypeInvalid &ex)
    {
      cout << "query error number=" << ex.errorNo << endl
           << "query error message=" << ex.why << endl;
      currentTransaction->rollback();
    }
  catch (...)
    {
      if (_queryIt!=0) _queryIt->remove();
      currentTransaction->rollback();
    }
```

Following is the same query except using a data array query to retrieve attributes amount and premium:

```
  // step 1 and 2 same as above
  // step 3 becomes
  IExtendedQuery::DataArrayList* members;
    _qe->evaluate_to_data_array(
  "select p.policyNo, p.premium, p.amount, p
            from policyHome p where p.policyNo in(10,11,12); ",
              NULL,
              NULL,
              NULL,
              3,
              members,
              _queryDataIt);
     long policyNo;
     double amount, premium;
     if ((*members)[0][0] >>= policyNo) {}
           else cout << "error extracting policyNo" << endl;
     if ((*members)[0][1] >>= amount) {}
              else cout << "error exactlying amount" << endl;
     if ((*members)[0][2] >>= premium) {}
             else cout << "error extracting premium" << endl;
     cout << policyNo << amount << premium << endl;
     if ((*members)[1][0] >>= policyNo) {}
            else cout << "error extracting policyNo" << endl;
     if ((*members)[1][1] >>= amount) {}
               else cout << "error exactlying amount" << endl;
     if ((*members)[1][2] >>= premium) {}
```

```
          else cout << "error extracting premium" << endl;
    cout << policyNo << amount << premium << endl;
    if ((*members)[2][0] >>= policyNo) {}
          else cout << "error extracting policyNo" << endl;
    if ((*members)[2][1] >>= amount) {}
            else cout << "error exactlying amount" << endl;
    if ((*members)[2][2] >>= premium) {}
            else cout << "error extracting premium" << endl;
    cout << policyNo << amount << premium << endl;
 IQueryManagedClient::DataArrayIterator_var itptr =
 IQueryManagedClient::DataArrayIterator::_narrow(_queryDataIt);
 itptr->remove();

 //  exception processing not shown here.
```

Following is an example of a query using a parameter list:

```
 IExtendedQuery::ParameterList* collection_names;
 IExtendedQuery::ParameterListBuilder *pb =
      IQueryLocalObjectImpl::ParameterListBuilder::_create();
 // add a name value pair for "RC"
 // rcptr is a pointer to the collection.
 pb->add_object_parm("RC", rcptr);
 collection_names =  pb->get_parm_list() ;
 // the following line of code is needed in release 1.0, it is
 //  not needed in release 1.1 and above
 collection_names->length(1);   // set the length to 1
 _qe->evaluate_to_iterator(
    "select a from RC a  where a.policyNo > 3000 ; ",
    0,
    *collection_names,
    0,
    0,
    x,
    _queryIt);
```

Java Clients and Java BO Example

The following example is a program that uses the query evaluator and is written in Java. The program comments indicate the important points. One important difference is that C++ allows some of the query evaluator input parameters to be zero or null but in Java all parameters must have a value.

```
 import java.net.*;
 import java.io.FileInputStream;
 import java.io.InputStream;

 import org.omg.CORBA.ORB;
 import com.ibm.IExtendedTransactions.*;
 import com.ibm.IExtendedNaming.*;
 import com.ibm.IExtendedLifeCycle.*;
 import com.ibm.IExtendedQuery.*;
 import com.ibm.IManagedCollections.*;
 import com.ibm.IManagedClient.*;
 import com.ibm.CBCUtil.CBSeriesGlobal;
 class QuerySample {
   public static void main (String args[]) {

  org.omg.CORBA.Current orbCurrent;
```

```
 org.omg.CosTransactions.Current currentTransaction ;
 org.omg.CORBA.Object obj;

 try {
// initialize using hostname and default port number and
// get currentTransaction

  CBSeriesGlobal.Initialize("wisneski.stl.ibm.com","900");
  orbCurrent = CBSeriesGlobal.orb().get_current("CosTransactions::Current");
  currentTransaction = org.omg.CosTransactions.CurrentHelper.narrow(orbCurrent);

// locate query evaluator object for server "testsrv"

  obj=CBSeriesGlobal.nameService().resolve_with_string(
    "host/resources/servers/testsrv/query-evaluators/default");
  com.ibm.IExtendedQuery.QueryEvaluator qe;
  qe = com.ibm.IExtendedQuery.QueryEvaluatorHelper.narrow(obj);

// start a transaction scope

  currentTransaction.begin();

// allocate parameters for query evaluator call

  com.ibm.ICollectionsBase.IIteratorHolder it =
      new com.ibm.ICollectionsBase.IIteratorHolder();

  com.ibm.IExtendedQuery.MemberListHolder members =
      new com.ibm.IExtendedQuery.MemberListHolder();

  org.omg.CORBA.InterfaceDef ql_type=null;

  org.omg.CosQueryCollection.NVPair[] collection_names;

// build a parameter list and convert to sequence of Name,Value pairs

   com.ibm.IExtendedQuery.ParameterListBuilder pb =
   com.ibm.IQueryLocalObjectImpl.ParameterListBuilderHelper._create();
   org.omg.CosQueryCollection.NVPair[] params =
               new org.omg.CosQueryCollection.NVPair[0];

   com.ibm.IManagedClient.IHome aHome = null;

// code goes here to find pointer to a Home Collection object.

   pb.add_object_parm("aHome", aHome);
   collection_names = pb.get_parm_list();

// invoke the query service returning set of object references
   qe.evaluate_to_iterator(
    "select x from mcarMOHome x;", // the query statement
    ql_type,
    collection_names,      // parameter list of collection names
    params,                // empty parameter list
    3,                     // return first 3 results in members
    members,
    it);                   // iterator for remainder of result set
```

```
      com.ibm.IManagedClient.IManageableHolder mo = new
        com.ibm.IManagedClient.IManageableHolder();

    // retrieve the list of managed objects from the members

      int n;
      int max = members.value.length;
      for (n=0; n<max; n++)

    {
     mo.value = members.value[n];
     System.out.println(" object reference from sequence " + n );
    }
  // retrieve the remainder of the query result set
    boolean more;
    for (more = it.value.nextOne(mo);
         more;
         more = it.value.nextOne(mo))
    {
      System.out.println(" object ref from iterator" + n );
      n++;
    }
    // you must remember to cleanup the query iterator
      it.remove();
    // invoke query service and return a data array
      com.ibm.IExtendedQuery.DataArrayIteratorHolder da_it =
          new com.ibm.IExtendedQuery.DataArrayIteratorHolder();

      com.ibm.IExtendedQuery.DataArrayListHolder da_members =
          new com.ibm.IExtendedQuery.DataArrayListHolder();

      collection_names = new org.omg.CosQueryCollection.NVPair[0];

      qe.evaluate_to_data_array(
       "select x.id, x.model  from mcarMOHome x ;",
       ql_type,
       collection_names,
       params,
       10,              // first 10 results returned in da_members
       da_members,
     da_it);            // remainder of results set returned in da_it

    // retrieve the list of tuples from the da_members sequence

      com.ibm.IExtendedQuery.DataArrayHolder da =
         new com.ibm.IExtendedQuery.DataArrayHolder();
    // number of columns in the data array
      int n_elements = da_it.value.get_number_of_fields();
      {
       max = da_members.value.length; // number of rows in
                                      // the da_members array
       for (n=0; n<max; n++)
       {
       // for each row print out the column value
       da.value = da_members.value[n];
       int i;
       for (i=0; i < n_elements; i++)
```

```
    {
    // for each column print out the value of the
    // CORBA::Any based on its typecode
    // the following code shows how to retrieve values
    // from a CORBA::Any variable in Java.
     org.omg.CORBA.TCKind tc = da.value[i].type().kind();
     if (tc == org.omg.CORBA.TCKind.tk_long)
                 System.out.println(da.value[i].extract_long());
     else if (tc == org.omg.CORBA.TCKind.tk_short)
                 System.out.println(da.value[i].extract_short());
     else if (tc == org.omg.CORBA.TCKind.tk_double)
                 System.out.println(da.value[i].extract_double());
     else if (tc == org.omg.CORBA.TCKind.tk_string)
                 System.out.println(da.value[i].extract_string());
     else if (tc == org.omg.CORBA.TCKind.tk_null)
                 System.out.println(" null ");
     else if (tc == org.omg.CORBA.TCKind.tk_objref)
                 System.out.println(" obj ref returned " );
     else
                 System.out.println("  unknown type returned " );
     }
    }
  }

// retrieve the list of tuples from the iterator

for (more = da_it.value.next_one(da);
    more;
    more = da_it.value.next_one(da))
 {
  int i;
  for (i=0; i < n_elements; i++)
   {
   // for each column print out the value of the
      CORBA::Any based on its typecode

org.omg.CORBA.TCKind tc = da.value[i].type().kind();
   if (tc == org.omg.CORBA.TCKind.tk_long)
                 System.out.println(da.value[i].extract_long());
   else if (tc == org.omg.CORBA.TCKind.tk_short)
                 System.out.println(da.value[i].extract_short());
   else if (tc == org.omg.CORBA.TCKind.tk_double)
                 System.out.println(da.value[i].extract_double());
   else if (tc == org.omg.CORBA.TCKind.tk_string)
                 System.out.println(da.value[i].extract_string());
   else if (tc == org.omg.CORBA.TCKind.tk_null)
                 System.out.println(" null ");
   else if (tc == org.omg.CORBA.TCKind.tk_objref)
                 System.out.println(" obj ref returned " );
   else
                 System.out.println("  unknown type returned " );
  }
 }

// you must remember to clean up the iterator

// first narrow the iterator to a managed client iterator
  com.ibm.IQueryManagedClient.DataArrayIterator damc_it ;
```

```
    damc_it =
      com.ibm.IQueryManagedClient.DataArrayIteratorHelper.narrow
      (da_it.value);
    damc_it.remove();
  currentTransaction.commit(true);
   }
   catch (org.omg.CosTransactions.SubtransactionsUnavailable e)
    {
      System.out.println("transcations not available excpetion " + e );
    }
   catch (Exception e)
    {
      System.out.println(" system exception " + e);
    }
   }
  }
```

Memory Management

When you run a query using the evaluate(), evaluate_to_iterator() or evaluate_to_data_array() method, query builds a result collection in the application server. An iterator over this result collection is returned to the client. The memory used by this result collection is released only when the remove() method is run on the iterator. Remember to run the remove() method on an iterator in both your mainline and your exception code paths. If you do not do this, your server will run short of memory after you run many queries.

Usage of Name Service by Query

Collection names appearing in the FROM clause of queries are resolved using the naming service. To save the cost of repeated calls to the naming service, the Query Service internally caches collection names. If the binding of a name in the name service changes, the change will not be seen by the Query Service until the Component Broker server is restarted.

A parameter list can be passed as an argument to a query evaluator to be used in conjunction with a query. When resolving collection names appearing in the FROM clause of a query, the system first looks in the parameter list before going to the name space. This can result in a significant performance optimization and it is most commonly used for collections that are not identified in the name space. Collection names taken from the parameter list are considered volatile; in contrast with names taken from the name space that are considered stable. The system still caches metadata associated with volatile names, but performs a minimal verification upon the usage of a name in every query to determine if the collection references objects of the same type. If so, the metadata is kept in the internal catalog, otherwise, the metadata is discarded and reacquired. The verification is performed if a name space collection name appears as a parameter list name in another query. Similarly, the verification is also performed if a parameter list name appears as a name space collection name in another query.

Limit on Number of Query Iterators per Transaction

The Query Service can not have more than 64 open SQL cursors per transaction. SQL cursors are also used by the cache service. Therefore you may be limited to 64 or less active query iterators in a single transactions.

Query Service Tips

The following tips will help you in using the Query Service. Some tips cite specific locations where further information can be found.

- Conditions required for queries on page 236
- Deferred updates and query statement processing on page 236
- DB2 LOBs and DB2 data types are not supported on page 236
- Reset the timeout to be greater than the default or to zero on page 237
- A query over persistent objects must be executed within the scope of a transaction on page 237
- Use parameter lists instead of Named collections on page 237
- Support for object relationships is limited to 1 to 1 and 1 to Many relationships on page 237
- Use the query evaluator of a Component Broker server to query collections local to that server on page 237
- Use the foreign key pattern in object builder for better performance on page 237

Conditions required for queries You can query Home Collections, Views and Reference Collections provided you meet the following conditions:

1. The interface of objects to be stored in collections is defined as “queryable” in object builder.
2. The home inherits from IBOIMIQueryableHome.
3. For view collections, the underlying home collection is queryable.
4. The elements of the Reference Collection are defined as queryable. If the object interface is not queryable, you can still create Reference Collections containing these objects but you can not query the collection.
5. The Reference Collection should be created with the createCollectionFor() operation.

If you do not use the createCollectionFor() then you must supply the interface name in the query statement FROM clause as in the example:

```
select r from MyReferenceCollection.acct r where r.Name ='Bob';
```

In this example *acct* is the interface name of the objects in the collection.

Deferred updates and query statement processing When there are deferred updates, the query may not take the deferred updates into account when processing the query statement. For example:

```
aMO->name("NewName");
it = aHome->evaluate(" name='NewName');
// the object aMO will likely not be returned in the iterator result set
// because the search "name='NewName'" was performed against
// values in the database.
```

To make sure that the query search sees the current values, issue a commit() if possible before doing the query.

```
aMO->name("NewName");
currentTransaction->commit(1 );
it = aHome->evaluate(" name='NewName');
// the object aMO will now be returned by the query search.
```

DB2 LOBs and DB2 data types are not supported. Extended data types such as DB2 LOBs and user-defined DB2 data types are not supported.

Reset the timeout to be greater than the default or to zero. The default ORB request timeout value of 30 seconds may be insufficient when executing queries from a client. Reset the timeout to either a higher value or to zero to wait indefinitely.

A query over persistent objects must be executed within the scope of a transaction. The iterator returned from query must be used to retrieve the result set before ending the transaction. The iterator becomes invalid at end of the transaction. Refer to the following example.

```
currentTransaction->begin();
IManagedIterator_var it = myHome->evaluate (" amount > 10");
currentTransaction->commit();
currentTransaction->begin();
while (aMO= it->next())
{ . . . // do something with aMO }
// unpredictable behavior because you are using
// an iterator outside the transaction scope in which
// it was created.
```

This may effect the design ManagedObjects whose methods return query iterators if the ManagedObject is configured into an atomic container. The iterator will become invalid because of the implicit commit done by the atomic container at request termination. See the “More on Iterators” section in the *Component Broker Programming Guide*.

Use parameter lists instead of Named collections. The use of parameter lists to pass object references to collections to query may perform better than having the Query Service retrieve the reference from the name service. See “An Example Using the Query Evaluator Interface” on page 226 for an example of how to use a parameter list.

Support for object relationships is limited to 1 to 1 and 1 to Many relationships. Relationships with outer join are not supported.

Use the query evaluator of a Component Broker server to query collections local to that server. Each Component Broker server has a query evaluator and only that query evalutor can be used to query collections that are local to the server. A query evaluator in server A can not be used to query collections that reside in server B. Nevertheless, queries can span multiple back end datastores provided that the Component Broker server has connections to each datastore. So a single query statement can join collections C1 and C2 provide that C1 and C2 are defined in same server as the query evaluator even if C1 is mapped to database D1 and C2 is mapped to database D2.

Use the foreign key pattern in object builder for better performance of object relationships. Use Object Builder object relationship foreign key pattern for better performance of object relationships. When defining object relationships and object attributes that are object references, use the foreign key pattern in object builder. Queries expressions that use the object references can be pushed down to the datastore resulting in better query performance.

```
interface person {
          attribute read only long id;
          attribute string name;
          }

interface account {
          attribute read only long acct_id;
          attribute person  acct_owner;
          }
```

If acct_owner is stored as a stringified object reference or handle, then the query

```
select a from accountHome a where a.acct_owner..name like 'Bob%';
```

will not be pushed down to the datastore resulting in the more data being read from the database and the query performed in object space. If acct_owner is stored as a relational foreign key in the account table then this query can be pushed down and performed as a relational join between the account and person tables. Only the qualifying rows will be read by the Component Broker application server.

Chapter 12. Cache Service

The following chapter is platform-dependent and does NOT apply to OS/390 Component Broker.

The objective of the Cache Service is to provide better performance and concurrency for applications. The Cache Service does this by following these heuristics:

- Keeping read only data (or mostly read only data) resident in memory. If data does not change very often it should not be necessary to have to reread the data from the database on every transaction. The **refresh interval** cache option can be used to control how often data is reread from the database.
- Data whose application must have the most current value must be read from the database for every transaction and the data must be locked in the database to guarantee that the data does not change.
- The administrator can control the isolation level of locking used by the database manager through use of the **lock confidence** and **access** cache options.
- The user can specify whether to defer updates until commit. If a transaction updates two attributes on an object instance, using deferred updates will result in only one SQL update. If the updates are done immediately when the attribute value changes, then two SQL updates will be done. The advantage of deferring update is reduced SQL calls and better performance. The advantage of not deferring updates is that the application gets immediate feedback (with an exception) if the update violates some database constraint. If you defer updates until commit and a database constraint is violated, the only feedback that the client application receives is that the transaction commit failed and the transaction is rolled back. The client application will have to repeat the entire transaction. Even so, it is usually recommended to defer updates.

There are four configuration attributes for the cache service. Each managed object type (interface name) can have its own configuration. The attributes are:

- Lock confidence (pessimistic or optimistic)
- Refresh interval (specified in number of seconds to retain data in memory)
- Defer update (yes or no)
- Access (read, write, upgrade; applicable to DB2 only)

Pessimistic caching holds a lock on the database record and data is read for every transaction. Optimistic caching does not hold a lock on the database record after reading the record. When using pessimistic locking, if access is “read” or “upgrade,” a share lock is maintained on the database record to prevent concurrent updates. If access is “write,” an exclusive lock is maintained on the database record to serialize all access. “Access=write” is useful when reading and updating a sequential counter to serialize concurrent transactions that attempt to read and the update the counter. “Refresh interval” does not apply when the pessimistic cache option is used.

If data that is being cached optimistically is updated, there is a possibility that the record in the database may have been updated by another transaction or may have been deleted. When optimistically cached data is written back to the database, a read and compare is done to make sure that the data record still exists in the database and the data values have not changed. This prevents any “lost updates” from occurring. Only the attributes that are actually updated are compared. The read-and-compare operation does not apply to long varchar columns in a table. When updating a long varchar column you should also update some other column (such as date of last update) to guarantee data integrity.

When using optimistic caching, there is potential for a large amount of virtual memory to be used in caching data. A limit on the size of the cache can be specified. The cache uses an LRU algorithm to manage the cache to this specified size. Access does not apply for optmistic caching.

Table 15 and Table 16 on page 241 contain summaries of the valid cache options. You set these options using the System Manager User Interface. For more information see *Component Broker for Windows NT and AIX System Administration Guide*.

Table 15. Optimistic Cache Options

Defer Updates	Refresh Interval	Access	Comments
yes	=0	not used	Database locks are released after reading the data. This minimizes database lock resource usage. Updates are deferred. Because the refresh interval is zero, data is purged from memory at the end of the transaction. Every transaction rereads data from the database so data is current. **This is the recommended option for long running transactions. It prevents the long running transactions from causing concurrency problems at the database server.**
yes	>0	not used	Same as above except data stays in memory at the end of the transaction The refresh interval specifies how many seconds data stays in memory until a refresh. **This is the recommended option for read only data like TAX tables, ZIP CODE tables and product descriptions.**
no	=0	not used	Similar to above except updates are not deferred. An SQL update is executed whenever an attribute changes value. **If the transaction needs immediate feedback on any database integrity violations, use this option.**
no	>0	not used	Similar to above except data stays in memory and can be reused by other transactions. Updates are not deferred. The refresh interval specifies the number of seconds for data to stay in memory.

Table 16. Pessimistic Cache Options			
Defer Updates	**Refresh Interval**	**Access**	**Comments**
yes	not used	read or upgrade	Data is locked (share locks) in the database during the transaction. Data is purged from cache at commit. Updates are deferred until commit. **This is the recommended option for data that changes often or if the application must have current data. Examples might be inventory quantities or bank balances.**
no	not used	read or upgrade	Same as previous except updates are not deferred. An sql update is performed whenever as object attribute changes value.
yes	not used	write	Data is locked exclusively in the database during the transaction. Data is purged from cache at commit. Updates are deferred until commit. This is the recommended option for data that must be serialized for both reading and writing and there is a high probability of contention among multiple transactions such as reading and updating a sequential number generator.
no	not used	write	Same as previous except updates are not deferred. An sql update is performed whenever an object attribute changes value.

For information on how to use Object Builder using the Cache Service, see *Component Broker Application Development Tools*.

For information on how to configure the Component Broker application server to use the Cache Service or how to configure your database to use the Cache Service see *Component Broker for Windows NT and AIX System Administration Guide*.

Cache Service and DB2 Locking Considerations

When reading records from a DB2 database, the cache service uses CS database locks when optimistic locking is specified and RS locks for pessimistic locking.

Cache Service and DB2 Limits

The Cache Service can have a maximum of 64 SQL cursors per transaction. One cursor is used for each table accessed by the cache service and one cursor is used for each active query iterator. During a transaction, accessing tables and query iterators whose combined number exceeds 64 will cause an exception.

Cache Service and Oracle Locking

When reading records from an Oracle database, the cache service obtains an exclusive lock when “lock confidence=pessimistic.” When “lock confidence=optimistic” no lock is obtained on the data record. For data retrieved using an OO-SQL query, the record in the database is never locked. The setting of the “access” configuration attribute has no effect on the type of locking used for an Oracle database.

Chapter 13. Object Request Broker

The Object Request Broker (ORB) enables objects to transparently make requests (invoke methods) and receive responses from local or remote objects. The ORB supports remote method calls for distributed C++ and Java applications.

The following topics describe the Object Request Broker:

Remote Method Invocation

This section includes the following topics:

Conversion of Objects to String Form

Both proxy objects and pointers to local objects are kinds of “object reference.” An object reference contains information that is used to identify a target object. For example, a pointer to a local object contains the physical address of the object; a proxy object contains information to locate the target server and the target object within that server.

Sometimes, it is useful to convert object references to a string form (for example, to save references in a file system or to exchange object references with other application processes). This technique can be used, for example, to allow a client process to obtain a proxy to an object residing in a server process, for one client process to "give" a proxy object to another client process, or for a server process to record an object reference in a form that is meaningful beyond the lifetime of the process. Object references to and from string form are used when object references are passed between clients and servers using remote method invocations.

The ORB class defines a method for converting object references (both local object pointers and proxy objects) to an external form. This external form is a string that can be used by any process to identify the target object. The ORB class also supports the translation of these strings back into the original local objects or equivalent proxies. The ORB methods for converting between object references and their string representations are specified by the following IDL:

```
string object_to_string (in Object obj);
Object string_to_object (in string str);
```

- When a string refers to a remote object (an object not residing in the same address space as the calling process), the string_to_object method always returns a new proxy object for that string. The returned proxy is not the same as the proxy passed to object_to_string, and repeated invocations of string_to_object each return different proxy objects. These duplicate proxies can be destroyed using the CORBA::release function.
- When a string refers to a local object (an object residing in the same address space as the caller), the string_to_object method returns a pointer to the local object. This is true even if the string was originally created by another process calling object_to_string, passing in a proxy to the object. If the local object to which the string refers no longer exists, and is not a persistent object that can be reactivated by the instance manager, an exception is raised.

- When object_to_string is invoked on a local object within a client-only process (a process that has not called impl_is_ready on the BOA object), the resulting string has validity only as long as the object exists within that process, and only within that process.
- When object_to_string is invoked on a local object within a server process (one that has called impl_is_ready on the BOA object), the resulting string can be distributed to other processes, which can then call string_to_object with the string to generate a proxy to the original object.

As with other forms of object references, the lifetime of a string reference to an object in a server depends on the implementation of the server. If the server's instance manager supports persistent objects, and the object is persistent, then the reference is valid even after the server process terminates. (The next time the reference is used by a client, the location-service daemon will restart it, and the server can reactivate the referenced object.)

The string form of an object reference (the result of calling object_to_string) should be considered opaque to application programmers. The only assumption that can be made about such a string is that it can be passed to string_to_object to locate the original object.

Two different strings can refer to the same object. Generally, it is not safe for an application to use the strings as unique object identifiers.

Code-Set Conversion for Remote Method Invocations

Configuration settings are available that allow applications to request that the ORB perform code-set conversion for all character and string data transmitted over the network in remote method invocations. This applies to method parameters and return results that have been declared as IDL type char, string, or constructed types composed of char or string types. The ORB performs code-set conversion using the XPG4 libraries and locales, which must be available and properly configured on both communicating systems. The code-set conversion is performed according to the OMG “IDL Type Extensions” specification. Because the OMG specification is based on OSF code set numbers, rather than XPG4 code set names, the configuration settings to enable code-set conversion must be set using OSF code set numbers, rather than XPG4 code set names.

The following configuration settings support code-set conversion. These settings can be updated in the appropriate client or server image using the systems management tools.

In client and server images:

translation enabled
: When set to 1 (or any non-zero, non-NULL value), code-set conversion is enabled. This setting has no effect unless set to 1 for both the client and the server. Because the code-set conversion support requires the client and server to exchange IIOP 1.1 messages, the server should not be configured to generate IIOP 1.0 messages, otherwise this setting has no effect. (The default is for servers to generate IIOP 1.1 messages.) The default for this setting is zero.

use ISO-Latin1
: When set to 1 (or any non-zero, non-NULL value), indicates that the process should transmit all character and string data in the ISO-Latin1 codeset. This setting provides a more limited form of code-set conversion than the above, and is provided to aid interoperability with other vendors' ORBs. This setting is meaningful when the above setting is zero or when communicating with a remote process that communicates using IIOP 1.0 messages. Both client and server should use the same setting. The default setting is zero.

native char code set
: This setting is the OSF number of the native codeset used by the process for single-byte char and string data. This setting is optional (if unset or zero, it is calculated automatically using the

XPG4 nl_langinfo() function.) If present, either this setting or the "native wchar code set" setting must match the process's actual native code set, as determined by the XPG4 nl_langinfo() function.

native wchar code set
The OSF number of the native codeset used by the application for wchar and wstring data. This setting is needed only if both the application and the ORB support the IDL types wchar and wstring. If present, either this setting or the "native code set" setting must match the process's actual native code set, as determined by the XPG4 nl_langinfo() function.

In server images only:

char code sets
These are the codesets that a server can translate to/from its native code set, for single-byte char and string data, specified as a space-delimited list of OSF codeset numbers. (The list can be empty.) This list of code sets gets advertised in the object references that the server exports; clients then choose either the server's native code set or one of the code sets in this list as the transmission code set.

wchar code sets
These are the codesets that a server process can translate to/from its native code set, for wchar and wstring data, specified as a space-delimited list of OSF codeset numbers. (The list can be empty.) This setting is needed only if both the server application and the ORB support the IDL types wchar and wstring.

When a server is configured to perform code-set conversion, the object references that it exports contain information about the server's native code sets and the additional code sets that the server supports (for both char and wchar data), based on the configuration settings above. When a client that is configured to perform code-set conversion invokes a method on such an object reference, the client selects two “transmission code sets,” the code sets in which char and wchar character data (in method parameters and return results) will be transmitted between the client and the server that exported that object reference. This selection is based on the client's native code set and the code set(s) advertised in the object reference. If the client and server are using the same native code sets, then no conversion is performed. Otherwise, a transmission code set is selected using the following priorities:

1. The server's native code set.
2. The client's native code set (if supported by the server).
3. Some other code set the server supports to which the client can translate.
4. Unicode (UTF-8 for char data, UTF-16 for wchar data).

The client then translates all character data into the transmission code set before sending it to the server. Messages from the client to the server contain information about which transmission code sets are being used, so that the server can translate the incoming character data into the server's native code set and translate outgoing character data into the transmission code set. If the client's message to the server does not specify that character data has been converted, then the server does not perform this conversion either. In this case, character data is transmitted in ISO-Latin1 (if designated by the "use ISO-Latin1" configuration setting) or is transmitted in the sending process's native code set.

To give the application an opportunity to change the native code set (for instance, using the XPG4 set_locale() interface), initialization of the ORB's code-set conversion facility is not performed until the application calls CORBA::ORB_init(). Hence, an application that requires code-set conversion must establish its native code set prior to calling CORBA::ORB_init(), and must call CORBA::ORB_init() prior to making remote method invocations.

If any errors are encountered during code-set conversion, the ORB will throw a DATA_CONVERSION error. This can occur, for example, if the configuration settings are incorrect, if an incorrect IIOP 1.1

message is received from the remote process, or if the conversion is not possible (because the client and server are using incompatible character sets, or because the client or server does not have the necessary XPG4 code-set converters available).

Dynamic Invocation Interface (DII)

The Dynamic Invocation Interface (DII) allows client applications to dynamically build and invoke requests on objects, even if the operation to be invoked is not known at compile time or the client bindings for the operation have not been compiled and linked into the client application. In addition, the DII allows a client application to make synchronous, *deferred-synchronous*, or oneway invocations. (A deferred-synchronous request is one in which the sending of the request and the receiving of the response are done separately, allowing the client application to perform other processing in the interim.) Multiple deferred-synchronous and oneway requests can be sent simultaneously, allowing batch processing.

When using DII, exceptions raised by the remote implementation are not thrown to the client, but are instead returned in Environment objects, because the client may not be prepared to catch user-defined exceptions for dynamic requests. If an exception has been raised, as indicated by the Environment object associated with the Request, then the inout/out parameter values and the return values will not be meaningful, just as with static requests.

Building a DII Request

Before invoking a DII request, the application must first construct a CORBA::Request object to represent the request. The CORBA::Request object can be created using the CORBA::Object::_create_request method or the CORBA::Object::_request method. The application invokes one of these methods on the proxy object that is the target of the DII request.

After constructing a CORBA::Request, the application should call CORBA::Request::set_return_type to update the CORBA::NamedValue contained in the Request with the appropriate operation return type.

Using CORBA::Object::_create_request

When using one of the CORBA::Object::_create_request methods, the application supplies the operation name, as well as the CORBA::NVList representing the method parameters (previously constructed using CORBA::ORB::create_list or CORBA::ORB::create_operation_list) and a CORBA::NamedValue used to contain the return result (previously constructed using CORBA::ORB::create_named_value).

Using CORBA::Object::_request

When using the CORBA::Object::_request method to construct the Request, the application supplies only the operation name; the parameters for the request and the return type must be added afterward using methods on CORBA::Request. When using this technique, the application is not required to explicitly construct a CORBA::NVList to represent the operation parameters or a CORBA::NamedValue to contain the return result.

The CORBA::Object::_create_request method is overloaded to provide two signatures. The only difference between them is that one allows the application to supply a CORBA::ContextList object and a CORBA::ExceptionList object. These objects specify a list of Context strings that must be sent with the operation, if any, and a list of the user-defined exceptions that can be thrown by the operation, if any. The application may want to provide the ContextList and ExceptionList objects to the CORBA::Object::_create_request method so that the ORB does not need to perform any potentially expensive Interface Repository lookups when the request is later invoked.

Constructing NamedValue Objects

CORBA::NamedValue objects are used in NVLists to represent operation parameters for DII requests. CORBA::NamedValue objects are also used as placeholders for return results of methods invoked using the DII.

A CORBA::NamedValue has attributes for an optional parameter name, a CORBA::Any (containing a CORBA::TypeCode representing the parameter type and a void* value pointer), and flags to indicate the parameter mode (CORBA::ARG_IN, CORBA::ARG_INOUT, or CORBA::ARG_OUT). When a CORBA::NamedValue represents a method return value, the name and flags are unused.

The CORBA::Any stored in a CORBA::NamedValue is created automatically by the CORBA::NamedValue constructor; it can then be manipulated using the usual CORBA::Any interface.

The CORBA::NamedValue objects contained in a CORBA::NVList are created and initialized automatically when the CORBA::NVList is created, alleviating the programmer from the need to explicitly create the CORBA::NamedValue objects to represent the operation parameters. See "Constructing NVList Objects" for more information. The CORBA::NamedValue objects contained in an NVList can be accessed using methods of CORBA::NVList.

Depending on how the application creates the CORBA::Request object for a DII request (see Building a Request), the application may or may not need to explicitly create the CORBA::NamedValue object to contain the return result of the request. If necessary, the application can use the CORBA::ORB::create_named_value() method to create a new CORBA::NamedValue. This method creates a NamedValue whose embedded TypeCode is CORBA::_tc_null; the application must call CORBA::Request::set_return_type (after creating a Request object to contain the NamedValue), to initialize the NamedValue for a specific IDL operation.

Constructing NVList Objects

A CORBA::NVList object contains an ordered set of CORBA::NamedValue objects, representing the method parameters to be used for a DII request invocation. Depending on how the application creates the CORBA::Request object for a DII request (see "Building a DII Request" on page 246), the application may or may not need to explicitly create the CORBA::NVList object.

CORBA::NVList objects can be created using either the CORBA::ORB::create_list or the CORBA::ORB::create_operation_list method. The difference between these two methods is that CORBA::ORB::create_list creates a generic NVList of a specified length, whose CORBA::NamedValue elements are uninitialized, whereas CORBA::ORB::create_operation_list creates an NVList whose CORBA::NamedValue elements are already initialized for a specific IDL operation (minus the parameter values). The latter approach requires, however, that the application supply a CORBA::OperationDef object that it has retrieved from the Interface Repository.

After creating an NVList using CORBA::ORB::create_operation_list, the application must initialize the parameter values in the NVList. This can be done by accessing the appropriate NamedValue in the NVList, accessing the Any in the NamedValue, then using standard Any operations to insert the appropriate value. The NamedValue objects in the NVList are ordered according to the order of parameter declarations in IDL.

As an alternative to creating a CORBA::NVList using CORBA::ORB::create_operation_list, an application can create an empty (length zero) CORBA::NVList using CORBA::ORB::create_list. The CORBA::NVList class provides several methods for adding new CORBA::NamedValue objects to an (initially empty) NVList. These methods vary in which of the NamedValue's attributes are initialized (name, value, or flags) and in whether the NamedValue takes ownership of the memory used to initialize it.

The CORBA::NVList associated with a DII request can be accessed using the CORBA::Request::arguments() method. The CORBA::NVList class provides methods for accessing and deleting a particular CORBA::NamedValue element given its index in the NVList, and a method for returning the size of the NVList.

Constructing a DII Request

To invoke a request using the Dynamic Invocation Interface (DII), the client must explicitly construct a CORBA::Request object to represent the request, and must initiate the request by invoking a method on the Request object. A Request object embodies all the information needed to invoke the request, including the proxy object on which it is to be invoked, the operation name, the operation parameters, and a place to store the return result. The operation parameters are represented in the Request by a CORBA::NVList object, that is an ordered set of CORBA::NamedValue object. Each NamedValue object represents the name and mode of a parameter, and a CORBA::Any object to hold its CORBA::TypeCode and value. The return result of the operation is stored in the Request object using another NamedValue object.

Initiating a DII Request

After a CORBA::Request object is constructed using the CORBA::Object::_request or CORBA::Object::_create_request method, the application can issue a DII request in one of the following ways:

- Invoke the request synchronously, using CORBA::Request::invoke().
- Send the request oneway (with no response expected), using CORBA::Request::send_oneway().
- Send the request, with the response to be requested at a later time, using CORBA::Request::send_deferred().
- Send the request oneway as part of a batch of requests, using CORBA::ORB::send_multiple_requests_oneway().
- Send the request as part of a batch of requests, with the response to be requested at a later time, using CORBA::ORB::send_multiple_requests_deferred().

When a request is invoked synchronously (using CORBA::Request:invoke),the results of the invocation are available immediately after calling invoke(). When a request is sent using either CORBA::Request::send_deferred or CORBA::ORB::send_multiple_requests_deferred, the application must explicitly call for a response, using CORBA::Request::get_response or CORBA::ORB::get_next_response. The response to a Request sent using CORBA::Request::send can be retrieved using either CORBA::Request::get_response or CORBA::ORB::get_next_response, and similarly with Requests sent using CORBA::ORB::send_multiple_requests_deferred. There is no guarantee that results will be returned in the same order that deferred requests were sent.

If the response is not yet available when the application calls CORBA::Request::get_response or CORBA::ORB::get_next_response, the application blocks until the response is available. Applications can avoid blocking by first calling CORBA::Request::poll_response or CORBA::ORB::poll_next_response to determine whether the response is available.

After a response to a DII request is retrieved, the application can access the inout/out parameter values and the return value, or any exception that was thrown, by examining the Request object. The inout and out parameter values can be accessed using the NVList associated with the Request, returned by CORBA::Request::arguments(). The Any containing the return value can be accessed using either the CORBA::Request::result() or CORBA::Request::return_value() methods.

If an exception was thrown by the remote request, it is stored in a CORBA::Environment object, which can be accessed using the CORBA::Request::env() method. When using DII, exceptions are not thrown to the client, but are returned in Environment objects, because the client may not be prepared to catch user-defined exceptions for dynamic requests. If an exception was thrown, as indicated by the Environment object associated with the Request, then the inout/out parameter values and the return values are not be meaningful.

Sample DII Requests

This sample application uses the DII to invoke a request with the following IDL signature:

```
interface testObject
   {string testMethod (in long input_value, out float out_value);
};
```

In the following example, the application is written with knowledge of the name and signature of the method to be invoked using DII. In general, however, an application might discover the name or signature at run time (using the Interface Repository or application input), and would create and examine the TypeCodes used to represent parameter and return types.

```
try {

// Get the OperationDef that describes testMethod:

CORBA::ORB_var myorb = CORBA::ORB_init (argc, argv, "DSOM");
CORBA::Object_var generic_IR =
myorb->resolve_initial_references ("InterfaceRepository");
CORBA::Repository_var my_IR = CORBA::Repository::_narrow (generic_IR);
CORBA::Contained_var generic_opdef = my_IR->lookup ("testObject::testMethod");
CORBA::OperationDef_var my_opdef = CORBA::OperationDef::_narrow(generic_opdef);

// Create the NVList and NamedValue for the request:

CORBA::NVList_ptr params = NULL;
myorb->create_operation_list (my_opdef, params);
CORBA::NamedValue_ptr result = NULL;
myorb->create_named_value (result);

// Create the Request object:

CORBA::Object_var my_proxy = /* get a proxy somehow */
CORBA::Request_ptr my_request;
my_proxy->_create_request (NULL, "testMethod", params, result, my_request, 0);
*(my_request->arguments()->item(0)->value()) <<= (CORBA::Long) 12345;
my_request->set_return_type (CORBA::_tc_string);

// Invoke the request and get the return value and out parameter value:

my_request->invoke();
CORBA::Exception_ptr my_exception = my_request->env()->exception();
if (!my_exception) { // no exception occurred
        CORBA::String_var return_string;
        CORBA::Float out_float;
        my_request->return_value() >>= return_string;
        *(my_request->arguments()->item(1)->value()) >>= out_float;
        // Do something application-specific with return_string and out_float.
}
else { // an exception occurred
```

```
// Do something application-specific with my_exception.
// Use my_exception->id() to determine what kind of exception it is.
}
CORBA::release (my_request);

}

catch (CORBA::SystemException) {
// appropriate exception handling

}
```

The following code example is a variation of the previous one, in which the Request object is created and initialized differently (using a technique that does not require the application to access the Interface Repository), and in which the DII request is a deferred synchronous request (rather than an asynchronous request).

```
try {

// Create the Request object:
CORBA::Object_var my_proxy = /* get a proxy somehow */
CORBA::Request_ptr my_request = my_proxy->_request ("testMethod");
my_request->add_in_arg() <<= (CORBA::Long) 12345; // sets type and value
CORBA::Float out_float;
my_request->add_out_arg() <<= out_float; // sets type
my_request->set_return_type (CORBA::_tc_string);

my_request->send_deferred();
// ... Do some application-specific processing for a while ....

// Do "my_request->poll_response();" to see if the Request is ready,
// to avoid blocking on the next instruction:

my_request->get_response();

// Get the return value and out parameter value:
CORBA::Exception_ptr my_exception = my_request->env()->exception();
if (!my_exception) { // no exception occurred
      CORBA::String_var return_string;
      my_request->return_value() >>= return_string;
      *(my_request->arguments()->item(1)->value()) >>= out_float;
      // Do something application-specific with return_string and out_float.

}

else { // an exception occurred
      // Do something application-specific with my_exception.
      // Use my_exception->id() to determine what kind of exception it is.
}

CORBA::release (my_request);

}

 catch (CORBA::SystemException) {
      // appropriate exception handling

}
```

Dynamic Skeleton Interface (DSI)

The Dynamic Skeleton Interface (DSI) provides a way for a server application to service requests on an object implementation for which it does not have server-side bindings. DSI can be thought of as the server-side equivalent to DII, although the use of DII on the client side and the use of DSI on the server side are independent. Just as a server application is unaware whether a client is using DII or client bindings, a client application is unaware whether a server is using DSI or server bindings.

To support DSI, a target object must support the CORBA::BOA::DynamicImplementation interface. The DynamicImplementation interface provides a single pure-virtual method, invoke. This method is called by the ORB/BOA to dispatch methods on the target object without requiring that the server be statically compiled and linked with the server-side bindings for the object. Implementations derived from CORBA::BOA::DynamicImplementation must provide an implementation of the invoke method, as described in “Enabling an Object for DSI Dispatching.”

The CORBA::BOA::DynamicImplementation::invoke method, implemented by application objects wishing to support DSI dispatching, takes as input a CORBA::ServerRequest object. The CORBA::ServerRequest object is similar to the client-side CORBA::Request object used for DII; it represents a dynamic request, and has methods for accessing the operation name, the parameters in the form of an NVList, etc. The CORBA::ServerRequest object is used by an application's DynamicImplementation::invoke implementation, to get information about a request to be dispatched dynamically, and to inform the ORB/BOA of the results.

- The CORBA::ServerRequest::params method is called by the application to ask the ORB to store the in/inout parameter values for the request in the given NVList. (An NVList is passed as an inout parameter to ServerRequest params; the application is responsible for initializing it with the appropriate TypeCodes and flags for the request so that the ORB knows how to demarshal the parameters.)
- The CORBA::ServerRequest::result method is invoked by the application's DynamicImplementation::invoke method, to inform the ORB/BOA of the result of a dynamically invoked request, so that it can marshal the result and any output values.
- The CORBA::ServerRequest::exception method is invoked by the application's DynamicImplementation::invoke method, to inform the ORB that an exception was thrown by a method that was dynamically invoked, so that it can marshal the exception.

Figure 15 on page 252 shows the flow of control that occurs when a method is dispatched using DSI. The shaded box shows actions that must be performed by the application; the unshaded boxes show actions performed by the ORB/BOA. When a request comes into the server, the BOA locates the target object and passes the request to the object's skeleton. When the target object is a CORBA::BOA::DynamicImplementation, the object's skeleton is (automatically) a dynamic skeleton (rather than a static skeleton provided by server-side bindings). The dynamic skeleton creates a CORBA::ServerRequest object to represent the request, and calls the invoke method on the target object, passing the CORBA::ServerRequest.

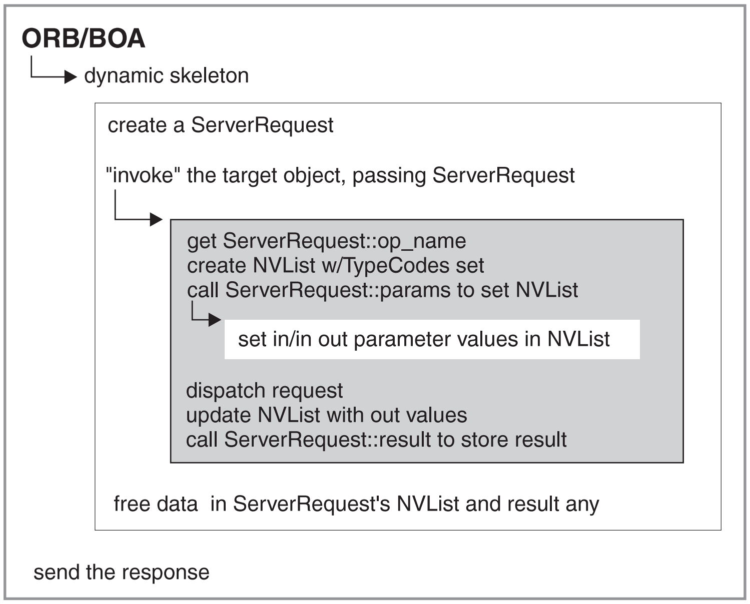


Figure 15. Dispatching a Method Using DSI

The target object's implementation of the invoke method must use the input CORBA::ServerRequest object to discover the operation name and the parameter values for the request. After the target object dispatches the method, it must update the ServerRequest with output and return values. The ORB/BOA and the dynamic skeleton are responsible for deleting the CORBA::ServerRequest object and the method parameters and return values, just as with static calls.

To support DSI, an application object must support the CORBA::BOA::DynamicImplementation interface. The DynamicImplementation interface provides a single pure-virtual method, invoke. This method is called by the ORB/BOA to dispatch methods on the target object without requiring that the server be statically compiled and linked with the server-side bindings for the object. Implementations derived from CORBA::BOA::DynamicImplementation must provide an implementation of the invoke method.

The following actions are typically performed within an application's implementation of the CORBA::BOA::DynamicImplementation:: invoke method. Every method should be supported.

1. Get the operation name to be dispatched from the input CORBA::ServerRequest object.
2. Create an appropriate CORBA::NVList, containing CORBA::TypeCode objects (but not values) for the signature of the method to be dispatched.
3. Call the params method of the ServerRequest object, passing in the new CORBA::NVList. In response, the CORBA::ServerRequest (with the help of the ORB), fills in the in and inout parameter values in the CORBA::NVList.
4. Execute the requested operation, using the in and inout parameter values now found in the CORBA::NVList, catching all exceptions.
5. If no exception occurred, store the resulting output parameter values in the same CORBA::NVList.
6. 6.If no exception occurred, and the return type of the dispatched method is not void, call the result method on the CORBA::ServerRequest object to store the result.
7. If an exception was thrown by the dispatched method, call the exception method on the CORBA::ServerRequest to record the exception.
8. Return control to the ORB. The ORB/BOA then sends a response to the waiting client.

Chapter 14. Non-IBM ORB Usage

The IBM Component Broker Java Client comes prepackaged with a Java ORB developed by IBM. It also includes client-local access to IBM implementations of security and transactions, plus pre-generated client stub bindings for naming, lifecycle, events, notification, query, externalization, identity, and properties. Component Broker also generates Java client stubs that a client can use to access Component Broker managed objects. All these client stubs work with the Component Broker Java ORB.

If you have a client environment that does not use Component Broker security and transactions, and you are willing to use non-IBM emitters to generate the client stubs for CORBA services (for example, lifecycle and events) and for Component Broker managed objects, then you can use a non-IBM client ORB to access Component Broker managed objects. The remaining parts of the section describe, by way of a simple example, how to do this.

The Example

The remaining parts of this section use a concrete example to describe how a non-IBM client ORB can be used to access a Component Broker managed object. The example is very simple. It uses the existing Component Broker Policy sample managed object and its associated PolicyHome. The example merely uses the PolicyHome to create a new instance of a Policy object and call a method on the object. The idl for this object can be found in Policy.idl:

```
#ifndef _Policy_idl
#define _Policy_idl

#include <IManagedClient.idl>
interface Policy : IManagedClient::IManageable
{
   attribute float amount;
   readonly attribute long policyNo;
   attribute float premium;
   void addBeneficiary( );
   void delBeneficiary( );
};
```

The idl for the PolicyHome is:

```
#ifndef _PolicyHome_idl
#define _PolicyHome_idl

interface Policy;
#include <IManagedClient.idl>
#include <Policy.idl>
interface PolicyHome : IManagedClient::IHome
{
   Policy create(in float premium,in float amount )
      raises (IManagedClient::IInvalidKey, IManagedClient::IDuplicateKey);
   Policy defaultCreate( )
      raises (IManagedClient::IInvalidKey, IManagedClient::IDuplicateKey);
   Policy createWithNumber(in long policyNo )
      raises (IManagedClient::IInvalidKey, IManagedClient::IDuplicateKey);
   Policy findByPolicyNumber(in long policyNo )
      raises (IManagedClient::IInvalidKey, IManagedClient::INoObjectWKey);
};
```


These idl files describe existing Component Broker managed objects.

The example creates a new Policy Object. The Java source for the example is:

```
import java.net.URL;

import CosLifeCycle.GenericFactory;

public class PolicyTest
{
   public static void main (String[] args)
   {
      try
      {
         URL                url = new URL ("http://xxx.xxx.com/bootstrap/NameServer.ior");
         Bootstrap          bs  = new Bootstrap (url, null);
         GenericFactory     gf  = bs.factory ("Policy", "object interface");
         PolicyHome         ph  = PolicyHomeHelper.narrow (gf);

         org.omg.CORBA.Object obj = ph.create ((float)100.00, (float) 10000.00);
         Policy             p   = PolicyHelper.narrow (obj);
         System.out.println ("Policy number = " + p.policyNo ());
      }
      catch (Exception e)
      {
         e.printStackTrace ();
      }
   }
}
```

The Bootstrap object created above is described in Bootstrapping. The remaining parts of this chapter describe the steps required to get the PolicyTest example to talk to the existing Component Broker PolicyHome managed object to create a new Policy object.

Bootstrapping

IBM Java clients use the methods of CBSeriesGlobal to get attached to the Component Broker name server. Since CBSeriesGlobal is not available to non-IBM ORBs we need another way to get hooked into the Component Broker name server.

We first write and run a Component Broker program to get a reference to the Component Broker Name Service, stringify the reference, and write it out to a file. This file must then be made available to the non-IBM client as a URL. In the preceding code for the PolicyTest, we assumed the URL is "http://xxx.xxx.com/bootstrap/NameServer.ior."

The following Java program illustrates one way to generate the stringified IOR. It uses the IBM Java ORB's implementation of resolve_initial_references to get a reference to the Component Broker Name Services root context. This Java program is compiled in the Component Broker environment, using the Component Broker Java ORB.

Important: Be very careful about the CLASSPATH. You must be sure that only the IBM Java ORB classes are in the CLASSPATH when compiling this class.

```
import java.applet.Applet;

import java.io.FileWriter;
import java.io.PrintWriter;

import java.util.Properties;

import org.omg.CORBA.ORB;

// WriteRootNCIOR primes the name service for access from a non-CBroker CORBA client. It does
// this by getting a reference to the root naming context and creating a file containing the Naming
// Context's IOR (NameService.IOR). This file must be placed in a well-known location accessible as
// a URL file, the root WWW directory.
// Note that this program uses IBM's ORB. It uses the CB bootstrap mechanism.

// To invoke this program:  java WriteRootNCIOR <bootstrapHost>
// Alternately, in a html file:
// <applet>
// Note:  This assumes that the bootstrap port is 900.

// This program is an application, but it is also an applet, so it COULD be run via a browser.

public class WriteRootNCIOR extends Applet
{
   public WriteRootNCIOR ()
   {
      this.args = null;
   }

   public WriteRootNCIOR (String[] args)
   {
      this.args = args;
   } // ctor

   public void init ()
   {
      try
      {
         Properties props = new Properties ();
         props.put ("org.omg.CORBA.ORBClass", "com.ibm.CORBA.iiop.ORB");
         props.put ("com.ibm.CORBA.BootstrapPort", "900");
         ORB orb = runningAsAnApplet ? ORB.init (this, props) : ORB.init (args, props);

         org.omg.CORBA.Object obj = orb.resolve_initial_references ("NameService");

         java.io.FileOutputStream fw = new java.io.FileOutputStream ("NameService.ior");
         PrintWriter pw = new PrintWriter (fw);
         pw.print (orb.object_to_string (obj));
         pw.close ();
      }
      catch (Throwable t)
      {
         System.out.println ("WriteRootNCIOR failed to create the file:  NameService.ior");
         t.printStackTrace ();
      }
   } // init

   private String[] args;
```

```
    private boolean  runningAsAnApplet = true;

    public static void main (String[] args)
    {
       WriteRootNCIOR writer = new WriteRootNCIOR (args);
       writer.runningAsAnApplet = false;
       writer.init ();
    }
}
```

Once the stringified IOR has been written to a file, we need a way in the non-IBM client to use the IOR to find the Component Broker's root naming context and then find the factory for our Policy Object. The following Java class illustrates one way to do is. This class is used in PolicyTest class. See The Example for further information.

```
import java.io.DataInputStream;
import java.io.InputStream;

import java.net.URL;

import org.omg.CORBA.ORB;

import CosNaming.NameComponent;
import CosNaming.NamingContext;
import CosNaming.NamingContextHelper;

import CosLifeCycle.FactoryFinder;
import CosLifeCycle.FactoryFinderHelper;
import CosLifeCycle.GenericFactory;
import CosLifeCycle.GenericFactoryHelper;

// Bootstrap allows a non-CB CORBA Java client to access a CB Server. It assumes a
// URL containing the IOR for the Root Naming Context resides in a well known place.

// Make sure this file is compiled with the non-CB .class files


public class Bootstrap
{
   public Bootstrap (URL bootstrapURL, String[] orbArgs)
   {
      try
      {
         // Get ORB
         orb = ORB.init (orbArgs, null);

         // Get the IOR string for the Root Naming Context
         DataInputStream input = new DataInputStream ((InputStream)bootstrapURL.getContent ());
         byte[] bytes = new byte[1024];
         int bytesRead = input.read (bytes);
         String stringifiedIOR = new String (bytes, 0, bytesRead);

         // Use the Root Naming Context IOR string to instantiate a Root Naming Context
         org.omg.CORBA.Object obj = orb.string_to_object (stringifiedIOR);
         rootNC = NamingContextHelper.narrow (obj);
      }
      catch (Exception e)
```

```
      {
         System.out.println ("Resolving the root naming context FAILED.");
         e.printStackTrace ();
      }
   } // ctor

   public NamingContext rootNamingContext ()
   {
      return rootNC;
   } // rootNamingContext

   public GenericFactory factory (String id, String kind)
   {
      try
      {
         // Resolve to the factory finder
         NameComponent[] name = new NameComponent [4];
         name[0] = new NameComponent ("host", "");
         name[1] = new NameComponent ("resources", "");
         name[2] = new NameComponent ("factory-finders", "");
         name[3] = new NameComponent ("host-scope", "");
         org.omg.CORBA.Object obj = rootNC.resolve (name);
         FactoryFinder ff = FactoryFinderHelper.narrow (obj);

         // Resolve to the factory
         name = new NameComponent [1];
         name[0] = new NameComponent (id, kind);
         org.omg.CORBA.Object[] objs = ff.find_factories (name);
         return GenericFactoryHelper.narrow (objs[0]);
      }
      catch (Exception e)
      {
         System.out.println ("Getting the factory finder for <" + id + ", " + kind + "> FAILED.");
         e.printStackTrace ();
         return null;
      }
   } // factoryFinder

   private String        bootstrapHost;
   private ORB           orb;
   private NamingContext rootNC;
}
```

Creating the Client Bindings

Now we need to create the client side Java stubs for all the CORBA and Component Broker objects used in the example. BootStrap.java uses the CosNaming and CosLifeCycle modules, so the first step is to run these through a non-IBM idl-to-Java compiler. Since we are using these interfaces to talk to Component Broker implementations, the safest thing to do is to copy the Component Broker versions of the idl files to the client rather than using versions of the files that come with the non-IBM ORB.

The non-IBM Java ORB has a command to convert CORBA idl files to Java .java files. Use this command to create .java files for the interfaces in the CosNaming and CosLifeCycle modules.

Policy.idl uses Component Broker's IManagable interface in the IManagedClient module. (See Policy.idl example in The Example). IManagedClient::IManagable, in turn uses interfaces in CORBA's CosStream, CosLifeCycle, CosNaming, and CosObjectIdentity modules. In addition, PolicyTest uses PolicyHome. So we must copy all the idl files for all these modules to the client and run them through the non-IBM ORB's IDL-to-Java compiler.

The example being used in this section is very simple. More complicated examples may use interfaces with more dependencies. The general procedure is to copy over from the server the idl files for the interface you are using, and also copy the idl for all the CORBA and Component Broker interfaces that are used by your interface, and further up the chain until all the needed idl is available. Then produce the Java client stubs for these interfaces.

The final step is to compile all client-side .java files. This includes PolicyTest.java and Bootstrap.java as well as all the .java files that are client stubs for the idl interfaces.

Important: Be very careful with the CLASSPATH. When compiling these files, be sure that only the non-IBM ORB classes are in the CLASSPATH.

Running the Example

Now we are ready to try it out. First start up the Policy server. See the *Component Broker for Windows NT and AIX Quick Beginnings* for a description of how to start a server for the Policy object. Then, at the client, run the following:

```
java PolicyTest
```

Additional Tips for non-IBM ORB Usage

Specialized Homes

PolicyHome is a specialized home, therefore a Component Broker key helper is not needed. Nonspecialized homes require the use of key helper classes, and it is cumbersome to make these classes available to a client using an non-IBM ORB. So it is best to not attempt to use non-IBM ORBs to access managed objects that do not live in specialized homes.

CORBA IIOP

The Component Broker server ORBs use, by default, IIOP level 1.1. If you find that the non-IBM ORB that you are using needs to use IIOP level 1.0, you must tell Component Broker server ORBs to use IIOP 1.0 instead of their default. If the server processes see the environment settings SOMDGETENV=1 and GENERATE_IIOP10_OBJREFS=1, then they will use IIOP 1.0.

WIN You can set these values into your user environment before you start the System Manager User Interface.

AIX You can export these values from the shell where you start the System Manager User Interface.

The ORB daemon (somdd), the name server, and the application server must all be restarted after the environment variables are set.

Trimming Client-Side Dependencies on Component Broker Interfaces

The example in this section used the existing Policy sample managed object. The Policy interface uses the IManagedClient::IManagable interface, and IManagable, in turn, uses interfaces in other CORBA modules, like CosStream and CosLifeCycle.

If you have the opportunity to influence how the Component Broker managed object is designed, you can remove the dependency on Imanagable and thus not require that client bindings be created for it and its parents. In the Policy example you could create a Policy interface with no parent. Then make a new interface, say, ManagedPolicy, that inherits from Policy and Imanagable. The ManagedPolicy is the Component Broker managed object. You can do the same for the Policy specialized home. Create a PolicyHome with no parent. Then create a ManagedPolicyHome that inherits from PolicyHome an IHome.

Now you can create client stub bindings for the Policy and PolicyHome interfaces, as described above, but you do not have to drag over idl for IManagedClient and its parents.

Chapter 15. Interlanguage Object Model

Interlanguage Object Model (IOM) is the language interoperability technology that enables objects written in C++ and objects written in Java to interact cooperatively within a single process. Although the Object Request Broker (ORB) is written in C++, you might find, as a developer, that you prefer to implement some of your distributed objects in other languages such as Java, Smalltalk, or Object Oriented COBOL. IOM is the component that makes local interactions between objects written in different languages simple and efficient.

As a developer, you provide descriptive information about object interfaces to IOM by using the IDLC Command development tool. See *Component Broker Programming Reference* for information about the IDLC command development tool.

IOM and Component Broker

Although the Component Broker Server and the Component Broker ORB are written entirely in C++, some customers will either need or prefer to implement some of their distributed objects in other languages, such as Java. IOM provides language interoperability technology to permit objects written in C++ and objects written in Java to interact cooperatively within a single process. The IOM language interoperability technology makes local interactions between objects written in different languages simple and efficient enough to be practical.

The most common strategy employed by ORB vendors to support multiple languages is to offer multiple products – one for each targeted implementation language. From a vendor perspective this strategy works reasonably well when the number of target languages is small, but as the number of languages expands, the effort of maintaining multiple ORB implementations grows proportionally. From a customer perspective, having server products segregated by programming language means that if any language integration issues ever do need to be addressed (whether dealing with legacy products, or new application prototypes), how to accomplish this is an exercise left to the customer. Using an ORB purely as a mechanism for crossing language domains will, in the best case, necessarily result in process switching for each request and response, a solution that has unattractive performance characteristics. Component Broker's IOM technology is designed to avoid these difficulties and provide a cross-language capability that is both efficient and conceptually simple.

The IOM object model provides object interoperability across language domains. The IOM object model is not a programming system; you cannot use it to implement an object. In order to implement an object, you must use an object-oriented programming language. Instead, the IOM object model allows client programs to use objects by invoking the operations they provide without knowing the precise details about how (or in what language) an object has been implemented. With the IOM object model, the form in which a request to invoke an operation on an object is expressed depends on the language in which the requesting program is written, not the language used to implement the object. This means that both object providers and object users have the flexibility to work in a language that is most suited to the problem they are solving.

It is not a coincidence that the object model described here is remarkably similar to the OMG CORBA model for distributed objects. Knowing the essential role that the CORBA standard plays in the Component Broker product, the IOM object model is closely aligned with CORBA.

Not every aspect of a C++ or Java object can be accessed using a mechanism like the IOM object model. If every feature of every supported object language were to be accessible to a user, the most natural way to accomplish this would be to have the client programmer use the same language that the object itself was written in, but this, of course, isn't multi-language programming. Consequently, not every object in the world can be fully accessed through the IOM object model. To qualify for full access, objects must be implemented to exploit the capabilities that the IOM object model supports.

However, the IOM object model is very generic. The utility of the IOM object model arises from the fact that for many objects, the specific syntax used to exercise their capabilities is more of an incidental, rather than an essential, property of the object. The essence of the object tends to be more the functionality it offers on the data it holds than a particular artifact of its implementation. As a result nearly all but the most light-weight of objects are expressible as IOM object model objects.

The IOM object model places its emphasis on those aspects of an object that must be visible to its users: the interfaces it exports and the operations they contain. In the IOM object model, the names of the object's interfaces express the type of the object, and the operations they contain define its functionality, or behavior. Types are a way of categorizing the behavior of objects, so that objects with common capabilities can be processed interchangeably, a characteristic known as polymorphism. A new type can also be derived from one or more existing types in the following way:

- Providing a new interface name.
- Defining its specific behavior by introducing operations that express it.
- Indicating the name of one or more existing interfaces (referred to as ancestor or parent interfaces) whose operations it also supports.

Although objects usually contain data, granting users direct access to the data can be problematic. Sometimes the internal consistency of an object can be compromised, or its locality unnecessarily restricted by giving users direct access to its data. A more flexible technique is to introduce a specific set of operations (typically a get operation and sometimes an accompanying set operation) to access the data. Although there is a small performance penalty associated with executing an operation to access an object's data, it also means that the object's implementation has the means to oversee the integrity and consistency of the data, and avoids the unconstrained accesses that would prohibit distributing the object to some other location. Data items accessed through methods are called attributes. The IOM object model provides access to an object's data only in the form of attributes.

Not only is the data in a IOM object model object accessed indirectly through it methods, all IOM object model objects are themselves accessed indirectly, through an object reference. When an operation is invoked on an object, it is an object reference that designates the target object. Client programs obtain new object references as results or outputs from operations performed on object references they already have, or they use a special factory call to obtain an initial object reference. Object references are “use counted” and the underlying objects that they refer to remain accessible until their last object reference is released. IOM object model objects are never allocated or freed; instead their object references are duplicated whenever a new reference is needed, and released when a reference is no longer required. When the last reference is released, the object becomes inaccessible and is presumably discarded, but what actually happens is not visible to a client programmer.

Operations invoked on IOM object model objects may take a combination of zero or more input, in/out, or output arguments and may produce a distinguished value referred to as a result. Both arguments and results are described with a type system that includes scalars, object references, aggregate types, and constructed types. Operations that encounter error conditions may return an out-of-band result referred to as an exception. User-defined exceptions must be declared as a formal part of an object's interface and may contain arbitrary information, limited only by the expressive power of the type system.

IOM, Component Broker's interlanguage interoperability technology, provides an OMG CORBA programming model for brokering object requests within a process. Component Broker's language interoperability technology is also combined with a CORBA ORB to provide the programmer with a consistent programming model for objects, which allows considerable configuration flexibility in placing objects in different computing hosts. Additionally, because the CORBA programming model is largely independent of the programming language in which it is implemented, Component Broker provides in-process capabilities for communicating across different implementation languages.

Defining IOM Interfaces and Implementations

IOM interfaces are defined by writing IDL; implementations are written following the guidelines established by the CORBA 2.0 specification.

IOM implementations are either remotable or local-only. Remotable implementations are accessed using interfaces defined using standard CORBA IDL. They can be accessed from Java or C++ either remotely across the ORB or locally within a process.

Local-only implementations are accessed using interfaces defined using standard CORBA IDL. They can be accessed from Java or C++ locally within a process. They are created using a special creation method that is part of the generated usage bindings for a particular interface that uniquely represents the implementation (the implementation interface). This interface name is related to the implementation name by the name mapping rule that interface x has implementation x_Impl.

Implementation interfaces for local-only implementations are identified to the compiler and emitters by a compilation flag so that streamlined bindings can be emitted. This flag can be specified in the form of an IDL pragma or a command line switch. Mixing local-only and remotable interfaces within a single IDL compilation is supported.

Communication between C++ and Java

C++ applications can communicate with Java objects and Java applications can communicate with C++ objects using Interlanguage Object Model (IOM). Additionally this Component Broker feature allows the communication between objects that are not Component Broker business objects. The primary use of IOM is to support Java business objects.

The following sections provide examples for the supported types of cross-language interaction.

- “Scenario: C++ Client of a Local Java Object” on page 264
- “Scenario: Java Client of a Local C++ Object (NT Only)” on page 267
- “Scenario: C++ Client of a Remote Java Object” on page 271
- “Scenario: Java Client of a Remote C++ Object” on page 276

Each example uses the simple “Hello World!” application. The object has a getMessage() method that returns the “Hello World!” string. The client calls the getMessage() method of the object and prints the result.

The examples assume:

- These examples reside in the following directory tree:

```
example
  HelloWorld
    CppJavaLocal
    JavaCppLocal
    CppJavaRemote
    JavaCppRemote
```

- The TOPDIR environment variable is set to point to the example directory.
- The Component Broker server is installed.

- The Windows NT command shell.

Scenario: C++ Client of a Local Java Object

In this example the user of the object, the client, is written in C++ and the object itself is written in Java. The name prefix CJL indicates C++ client, Java implementation, Local (that is, in the same process).

The steps in this example are:

1. Create an IDL file that describes the interface
2. Use the idlc command to produce the Java implementation files
3. Write Java code to implement the getMessage() method
4. Compile the Java files
5. Use the idlc command to produce C++ client files
6. Write the C++ client main program
7. Compile and link the client
8. Run the application

Each step is described in greater detail in the following sections.

Create the IDL File

Create the IDL files. From the command line, navigate to the `...\HelloWorld\CppJavaLocal` directory by entering:

```
cd %TOPDIR%\HelloWorld\CppJavaLocal
```

Create a file named CJL.idl with the following contents:

```
module CJL {
  interface CJLMessages {
    string getMessage();
  };
};
```

Run the idlc Command

Run the idlc command to create the implementation Java file by entering:

```
cd %TOPDIR%\HelloWorld\CppJavaLocal
idlc -e uj:sj CJL.idl
```

This creates the directory %TOPDIR%\HelloWorld\CppJavaLocal\CJL and creates the following files in that directory:

- CJLMessages.java
- CJLMessagesHelper.java
- CJLMessagesHolder.java
- _CJLMessagesImplBase.java
- _CJLMessagesSkeleton.java
- _CJLMessagesStub.java

The idlc command creates the directory that contains these files and gives the directory the same name as the name of the IDL module that contains the interface, that is, CJL. This name is also used for the name of the Java package that contains the Java interface.

CJLMessagesHelper.java provides static methods for managing and interrogating the CJLMessages type; these methods are not used in this example and the CJLMessagesHelper class will be ignored. CJLMessagesHolder.java aids in streaming objects; this file, also, is not used in this example and will be ignored.

Although the Helper and Holder classes are not used in this example, they are a required part of the CORBA specified Java/IDL mappings and would be used in more complicated examples. _CJLMessagesSkeleton.java is for internal use by IOM and need not be examined. _CJLMessagesStub.java is used on the client side and can be ignored for this example.

The two files of interest here are CJLMessages.java and _CJLMessagesImplBase.java. The file CJLMessages.java contains the Java interface definition:

```
package CJL;
public interface CJLMessages extends org.omg.CORBA.Object {
  java.lang.String getMessage();
}
```

The file _CJLMessagesImplBase.java contains the base class from which the Java implementation must derive:

```
package CJL;
abstract public class _CJLMessagesImplBase
  extends _CJLMessagesSkeleton
  implements CJL.CJLMessages
  {};
```

Write the Java Code to Implement getMessage

Now that you have compiled the IDL file and seen the files this produced, the next step is to write the Java class that implements the CJLMessages interface.

From the command line, navigate to the `...\HelloWorld\CppJavaLocal` directory by entering:

```
cd %TOPDIR%\HelloWorld\CppJavaLocal\CJL
```

Create a file named _CJLMessagesImpl.java with the following contents:

```
package CJL;

public class _CJLMessagesImpl extends _CJLMessagesImplBase {
  public String getMessage()
  {
    String message = "Hello World! (from local Java implementation)";
    return message;
    }
  };
```

There are a few things to note about the implementation:

- The name of the implementation class must be _CJLMessagesImpl. IOM assumes that if the IDL interface named CJLMessages has a Java implementation then the name of the implementation class will be _CJLMessagesImpl.
- Java expects the name of the file that holds the source code for a class to be the same as the name of the class, with the extension .java added. Therefore the new _CJLMessagesImpl class is in the file named _CJLMessagesImpl.java.

- Java expects the name of the package to match the name of the directory that holds the file. Thus, in this case the source for the package CJL is in the directory CJL.

  Note: The source for the package includes both the files emitted from the IDL (as described in "Run the idlc Command" on page 264) as well as the file created manually by the user as described in this section (Write the Java Code to Implement getMessage).

Compile the Java File

Now you are ready to use the javac command to compile the .java files by entering:

```
set CLASSPATH=%TOPDIR%\HelloWorld\CppJavaLocal;%CLASSPATH%
cd %TOPDIR%\HelloWorld\CppJavaLocal\CJL
javac *.java
```

This produces several new .class files in the `%TOPDIR%\HelloWorld\CppJavaLocal\CJL` directory; one for each of the previously created .java files. IOM uses the code in these .class files to provide access to our CJLMessages object from a C++ client.

This completes the steps needed to create the Java implementation.

Produce the C++ Client File

Now you can use the idlc command to create the C++ files that the client program will use to access the Java object. The contents of these files are called "client-side bindings," or, sometimes, just "bindings." Enter:

```
cd %TOPDIR%\HelloWorld\CppJavaLocal
idlc -mlocalonly -ehh:uc CJL.idl
```

The "-m localonly" flag is used because, in this example, you know that the client and the implementation object are in the same process, or "local" to each other. The command creates the files CJL.hh and CJL_C.cpp. The file CJL.hh is the header file that declares the CJLMessages object. It contains (only the parts of interest to this example are shown, and the contents have been lightly reformatted):

```
class CJLMessages : virtual public CORBA::Object
{
  public:
    static const char* CJLMessages_CN;
    static const char* CJLMessages_RID;
    CJLMessages () { }
    virtual  CJLMessages () { }
    static CJLMessages_ptr _duplicate(CJLMessages_ptr obj);
    static CJLMessages_ptr _narrow (CORBA::Object_ptr);
    virtual void* _has_ancestor(const char* classname);

    #ifdef _MSC_VER
       void* __CJL__CJLMessages__has__ancestor(const char* classname);
    #endif //_MSC_VER
     static CJLMessages_ptr _nil ()
     {
       return (CJLMessages_ptr) ((void*)CORBA::Object::_nil());
     }
     virtual void *_SOMThis(const char *& ifname);
     static CJLMessages_ptr _weakProxy(CJLMessages_ptr obj);
     static CJLMessages_ptr _strongProxy(CJLMessages_ptr obj);
     /* static create method(s)*/
     static CJLMessages_ptr _create();
```

```
      virtual  char *  getMessage()=0;
}; // end nesting scope for interface class ::CJL::CJLMessages
```

For this simple example the only methods you use are _create(), to create a new instance of the object, and getMessage(), to get the “Hello World” string.

Write the C++ Client main Program

The next step is to create a C++ client application. There are no constraints on the name of the file that holds the application. This example uses the name CJLClient.cpp, and you will put it in the `%TOPDIR%\HelloWorld\CppJavaLocal` directory.

From the command line, navigate to the `%TOPDIR%\HelloWorld\CppJavaLocal` directory by entering:

```
cd %TOPDIR%\HelloWorld\CppJavaLocal
```

Create a file named CJLClient.cpp with the following contents:

```
#include <iostream.h>
#include "CJL.hh"

void main()
{
  CJL::CJLMessages_ptr p = CJL::CJLMessages::_create();
  CORBA::String_var message = p->getMessage();
  cout << message << endl;
}
```

Compile and Link to the Client

The next step is to compile and link the two C++ files, CJLclient.cpp and CJL_c.cpp. Enter:

```
cd %TOPDIR%\HelloWorld\CppJavaLocal
icc /Ti+ /c /Ge+ CJL_C.cpp
icc /Ti+ /c /Ge+ CJLClient.cpp
ilink /debug /out:CJLClient.exe CJL_C.obj CJLClient.obj somsh.lib  /
                 somshcpi.lib somorori.lib
```

Run the Application

Now you can run the application by entering:

```
cd %TOPDIR%\HelloWorld\CppJavaLocal
CJLClient
```

The `Hello World! (from local Java implementation)` message is printed to the console.

Scenario: Java Client of a Local C++ Object (NT Only)

In this example the user of the object, the client, is written in Java and the object itself written in C++. The name prefix JCL indicates Java client, C++ implementation, Local (that is, in the same process).

The basic procedure for this example is:

1. Create an IDL file that describes the interface
2. Use the idlc command to produce implementation C++ files
3. Write C++ code to implement the getMessage() method

4. Compile and link the C++ pieces into a DLL
5. Use the idlc command to produce a Java client Stub
6. Compile the Java client files
7. Write the Java client program and compile it
8. Run the application

Each step is described in greater detail in the following sections.

Create the IDL File

Create the IDL file. From the command line, navigate to the `...\HelloWorld\JavaCppLocal` directory by entering:

```
cd %TOPDIR%\HelloWorld\JavaCppLocal
```

Use an editor to create a file named JCL.idl and put into it the following contents:

```
module JCL {
  interface JCLMessages{
    string getMessage();
  };
};
```

Produce the Implementation-Side C++ Binding Files

Use the idlc command to produce the implementation side C++ binding files by entering:

```
cd %TOPDIR%\HelloWorld\JavaCppLocal
idlc -ehh:ih:uc:sc -mlocalonly -mdllname=JCL JCL.idl
```

This produces the files JCL.hh, JCL_C.cpp, JCL.ih and JCL_S.cpp In this example you are building a C++ object implementation. The JCL.hh and JCL_C.cpp files are client side files; they must be emitted only because some of the implementation side files include them. JCL_S.cpp contains methods used internally by IOM to dispatch requests to the implementation object. The JCL.ih file contains the header for the implementation:

```
class JCL_JCLMessages_Impl : public virtual ::JCL::JCLMessages_Skeleton
{
  public: char*  getMessage ();
};
```

The idlc command parameter "-mdllname=JCL" causes the necessary import/export statements to be added to declarations and definitions.

Write the C++ Code to Implement getMessage

You need to provide an implementation of JCL_JCLMessages_Impl::getMessage(). To do this, run the idlc command to produce the implementation file by entering:

```
cd %TOPDIR%\HelloWorld\JavaCppLocal
idlc -eic -mlocalonly -mdllname=JCL JCL.idl
```

This causes the JCL_I.cpp file to be emitted. This file contains:

```
char* JCL_JCLMessages_Impl::getMessage () { }
```

Use an editor to add the actual implementation to the getMessage() method. So this section of the JCL_I.cpp file becomes:

```
char* JCL_JCLMessages_Impl::getMessage ()
{
  return CORBA::string_dup("Hello World! (From local C++ implementation)");
}

JCL::JCLMessages_ptr JCL::JCLMessages::_create ()
{
  return new JCL_JCLMessages_Impl();
}
```

Note: When the idlc command is told to produce an _I.cpp file (that is, when the "ic" emitter is specified with the -e or -s flag) the idlc command will attempt to produce a new copy of the file. Because this new file would wipe out any previous file which might contain manually introduced implementations, the idlc command will fail if there is a previously existing _I.cpp file. If a new version of the _I.cpp file is needed then you should rename the original, re-emit the new, and then manually re-integrate your implementations.

Compile and Link the C++ Piece to the DLL

The DLL file name will be JCL.dll. Enter:

```
cd %TOPDIR%\HelloWorld\JavaCppLocal
icc /Ti+ /Ge- /c /DSOM_DLL_JCL JCL_S.cpp
icc /Ti+ /Ge- /c /DSOM_DLL_JCL JCL_I.cpp
ilib /GENI:JCL.lib JCL_S.obj JCL_I.obj
ilink /DLL /OUT:JCL.dll JCL_S.obj JCL_I.obj JCL.exp somsh.lib  \
                     somshcpi.lib somorori.lib
```

Produce the Client Stub

Use the idlc command to produce a Java client Stub. Build the Java proxy for the JCLMessages object by entering:

```
cd %TOPDIR%\HelloWorld\JavaCppLocal
idlc -euj JCL.idl
```

This creates the directory `%TOPDIR%\HelloWorld\JavaCppLocal\JCL` and creates the following files in that directory:

- JCLMessages.java
- JCLMessagesHelper.java
- JCLMessagesHolder.java
- JCLMessagesStub.java

The idlc command creates the directory that contains these files and gives the directory the same name as the name of the IDL module that contains the interface, that is, "JCL." This name is also used for the name of the Java package that contains the Java interface.

JCLMessagesHelper.java provides static methods for managing and interrogating the JCLMessages type; these methods are not used in this example and the JCLMessagesHelper class will be ignored. JCLMessagesHolder.java aids in streaming objects; this file, also, is not used in this example and will be ignored. Although the Helper and Holder classes are not used in this example, they are a required part of the CORBA specified Java/IDL mappings and would be used in more complicated examples.

The two files of interest here are JCLMessages.java and JCLMessagesStub.java. The file JCLMessages.java contains the Java interface definition:

```
package JCL;
public interface JCLMessages extends org.omg.CORBA.Object {
  java.lang.String getMessage();
}
```

The file JCLMessagesStub.java contains the class JCLMessagesStub which provides an implementation of this interface. The implementation does not, however, contain the actual code to produce the message string. Instead, it contains code to connect to the IOM run time. The IOM run time connects to the C++ implementation that was created earlier, calls JCL_JCLMessages_Impl::getMessage(), and returns the result.

Compile the Java Files

Now you are ready to use the javac command to compile the .java files by entering:

```
set CLASSPATH=%TOPDIR%\HelloWorld\JavaCppLocal;%CLASSPATH%
cd %TOPDIR%\HelloWorld\JavaCppLocal\JCL
javac *.java
```

Write and Compile the Java Client Program

Create a main program, in Java, to create the object and call its getMessage() method. In the directory `%TOPDIR%\HelloWorld\JavaCppLocal`, use an editor to create a file named JCLClient.java and put into it the following contents:

```
import JCL.*;
class JCLClient {
  public static void main(String args[]) {
    System.loadLibrary("JCL");
    try
    {
      JCL.JCLMessages hw = JCL.JCLMessagesHelper._create();
      String m = hw.getMessage();
      System.out.println(m);
    }
    catch ( Exception e)
    {
      System.out.println("JCL.JCLMessagesStub._create() threw an exception");
      System.out.println("\t" + e.toString());
      Runtime.getRuntime().exit(1);
    }
  }
}
```

The line System.loadLibrary(“JCL”); loads the DLL that was built to hold the C++ inplementation. Notice, also that the the JCLMessageStub's _create() method is used, instead of a Java “new” to create the proxy.

Now, compile the JCLClient by entering:

```
cd %TOPDIR%\HelloWorld\JavaCppLocal
javac *.java
```

Run the Application

Now you can run the application by entering:

```
cd %TOPDIR%\HelloWorld\JavaCppLocal
java JCLClient
```

The `Hello World! (From local C++ implementation)` message is printed to the console.

Scenario: C++ Client of a Remote Java Object

In this example the user of the object, the client, is written in C++ and the object itself, the implementation, is written in Java, and the client and implementation are in different processes. The Component Broker C++ CORBA Object Request Broker (ORB) is used to provide communication between the client process and the server process where the implementation lives.

The client is written in C++ and the ORB is also implemented in C++. Therefore Interlanguage Object Model (IOM) is not used in the client process.

In the server process there is a Java implementation interacting with a C++ ORB. When the C++ ORB receives a request from a remote client, the ORB knows how to dispatch the request to a C++ implementation.

```
Client --> network --> ORB --> C++ Implementation
```

If, however, the implementation is written in Java, the ORB does not know how to dispatch across the language boundary. To solve this problem, the idlc command can be told to emit a C++ “ORB adapter” that appears to the ORB to be a normal C++ implementation but that knows how to use IOM to dispatch across the language boundary to the real Java implementation.

```
Client --> network --> ORB --> ORB Adapter --> IOM -->Java Implementation
```

There is a limitation in IOM that prevents having a local and a remote implementation of the same interface. This example will have an abstract interface, CJRAbstractMessage, and a concrete interface, CJRConcreteMessage, that derives from CJRAbstract. The implemenation for the example will be of CJRConcreteMessage. Other uses of the CJRAbstractMessage interface can derive their own concrete interface and use IOM to implement it.

Portions of the ORB interfaces are IOM-enabled; so that Java implementations can call their methods, but the BOA interface has not yet been made available to Java programs. Therefore, even though the example CJRMessages implementation can be completely written in Java, you must use C++ code to initailize the ORB, instantiate objects, and export IORs. This code resides in the CJRServer.cpp.

The basic procedure for this example is:

1. Create the IDL files
2. Run the idlc command to produce the Java implementation bindings
3. Write the Java implementation of the getMessage() method
4. Compile the Java pieces
5. Create the C++ ORB Adapter
6. Create the Java server code
7. Compile the server code
8. Create the client program
9. Compile and link the client program
10. Run the application

Each step is described in greater detail in the following sections.

Create the IDL Files

Create the IDL files. From the command line, navigate to the `...\HelloWorld\CppJavaRemote` directory by entering:

```
cd %TOPDIR%\HelloWorld\CppJavaRemote
```

Create the file CJRAbstract.idl and put into it the following contents:

```
module CJRAbstract {
  interface CJRAbstractMessages {
    string getMessage();
  };
};
```

Create CJRConcrete.idl and put into it the following contents.

Note: The “orbadapter” pragma informs the idlc command that this is a Java server side implementation. The emitter emits special C++ bindings capable of dispatching method invocation through IOM run time to the Java implementation. Another way to create an ORB adapter is via the “—m orbadapter” modifier to the idlc command, when emitting C++ bindings for this IDL file

```
#include "CJRAbstract.idl"
module CJRConcrete {
  interface CJRConcreteMessages : CJRAbstract::CJRAbstractMessages { };
  #pragma meta CJRConcreteMessages orbadapter
};
```

Produce the Java Implementation Bindings

Run the idlc command to produce the Java Implementation bindings by entering.

```
cd %TOPDIR%\HelloWorld\CppJavaRemote
idlc -euj CJRAbastract.idl
```

You need only the usage bindings for the abstract interface. Enter:

```
idlc -euj:sj CJRConcrete.idl
```

Write the Java Implementation of getMessage()

The next step is to write the Java class that implements the CJLConcrete interface. Enter:

```
cd %TOPDIR%\HelloWorld\CppJavaRemote\CJRConcrete
```

Use an editor to create a file named _CJRConcreteMessagesImpl.java and put into it the following contents:

```
package CJRConcrete;
class _CJRConcreteMessagesImpl extends _CJRConcreteMessagesImplBase {
private final String message = "HelloWorld! (From remote Java implementation)";
  public String getMessage() {
    return message;
  }
}
```

Compile the Java Pieces

Compile the Java pieces by entering:

```
set CLASSPATH=%TOPDIR%\HelloWorld\CppJavaRemote;%CLASSPATH%
cd %TOPDIR%\HelloWorld\JavaCppRemote\CJRConcrete
javac *.java
cd %TOPDIR%\HelloWorld\JavaCppRemote\CJRAbstract
javac *.java
```

Create the C++ ORB Adapter

Create two different DLL files: CJRAbstract.dll that contains the client-side bindings of the abstract interface and CJRConcrete.dll for the concrete implementation. Enter:

```
cd %TOPDIR%\HelloWorld\JavaCppRemote
idlc -ehh:uc -mdllname=CJRAbstract CJRAbstract.idl
idlc -ehh:uc:sc -mdllname=CJRConcrete CJRConcrete.idl
icc /Ti+ /c /Ge- /DSMO_DLL_CJRAbstract CJRAbstract_C.cpp
ilib /geni:CJRAbstract.lib CJRAbstract_C.obj
ilink /DLL /debug /out:CJRAbstract.dll CJRAbstract_C.obj \
      CJRAbstract.exp somshcpi.lib somsh.lib somorori.ib
icc /Ti+ /c /Ge- /DSMO_DLL_CJRConcrete CJRConcrete_S.cpp
ilib /geni:CJRConcrete.lib CJRConcrete_S.obj
ilink /DLL /debug /out:CJRConcrete.dll CJRConcrete_S.obj \
      CJRConcrete.exp somshcpi.lib somsh.lib somorori.lib CJRAbstract.lib
```

Create the Java Server Code

Now you can create the Java portion of the server process, that is, the Java code that interacts with the BOA interfaces. Enter:

```
cd %TOPDIR%\HelloWorld\JavaCppRemote
```

Use an editor to create a file named CJRServer.cpp and put into it the following contents:

```
public class CJRServer {
  public static void main(String argv[]){
    try {
      /* Load the appropriate DLLs */
      System.loadLibrary("CJRConcrete");
      System.loadLibrary("somshcpi");
      System.loadLibrary("somshori");

      org.omg.CORBA.ImplementationDef imp =
              org.omg.CORBA.ImplementationDefHelper._create();
      imp.set_protocols("SOMD_TCPIP");
      org.omg.CORBA.ORB op;
      org.omg.CORBA.BOA bp;
      int stat;
      java.io.FileOutputStream fout =
              new java.io.FileOutputStream("OBJREF.OUT");
      op = org.omg.CORBA.ORB.init(argv, null);
      System.out.println("ORB_init has run");

      com.ibm.som.corba.rt.PseudoOrb pso =
              com.ibm.som.corba.rt.DelagateImpl.getPseudoOrb();
      bp = pso.BOA_init (
              new com.ibm.com.corba.rt.PseudoOrbPackage.string_seqHolder(argv),
              "DSMO_BOA");
      System.out.println("BOA_init has run");
```

```
      bp.imp_is_ready(imp, false);
      System.out.println("impl_is_ready has run");

      CJRConcrete.CJRConcreteMessages cobj =
              CJRConcrete.CJRConcreteMessagesHelper._create();
      /* This is special code for Java server needed to pin a
         remotable Java implementation so that it is callable by the
         C++ ORB. Use unpinRemotableProxy() below when the instance
         is no longer needed.
       */
      pso.pinRemotableProxy(cobj);

      String asd = op.object_to_string(cobj);
      System.out.println("Object Reference = ");
      System.out.println(asd);

      /* Write asd to file */
      int len - asd.length();
      byte [] bytes = new byte[len];
      for (int i=0; i< len; i++)
        bytes[i] = (byte)asd.charAt(i);
      fout.write(bytes);
      fout.close();

      System.out.println("Server Listening ...");
      stat = bp.execute_request_loop(0);

      bp.deactivate_impl(imp);

      /* Do not need cobj any more */
      pso.unpinRemotableProxy(cobj);
    }
    catch(Exception e) {
      System.out.println("caugh exception" + e);
      e.printStackTrace();
    }
  }
};
```

This example is similar to the provided example in “Scenario: Java Client of a Remote C++ Object” on page 276; you initialize the ORB, create an instance of CJRConcreteMessages, write the string version of the IOR to a file, and start the BOA request loop. However, there are two major differences:

- You need to load the appropriate C++ libraries using System.loadLibrary. CJRConcrete.dll contains the C++ bindings for the ORB adaptor, while somshori.dll contains the interlanguage requirements for the C++ run time needed to communicate with the BOA from Java.
- You need to control the lifetime of the C++ ORB adaptor that corresponds to the Java implementation. Controlling the lifetime is done by pinning the C++ ORB adaptor in memory immediately after a remotable object is created. When we are sure that the object can be removed, you unpin its C++ ORB adaptor from memory.

  The pinning and unpinning are necessary for all remotable Java objects from Java source code. They are unnecessary if the server is written in C++, because in C++, only a reference can be held (and therefore the Orb adaptor exists).

Compile and Link the Server

Compile and link the server by entering:

```
cd %TOPDIR%\HelloWorld\JavaCppRemote
javac CJRServer.java
```

Create the Client Program

You are now ready to work on the client program. First create the CJRClient.cpp file by entering:

```
cd %TOPDIR%\HelloWorld\JavaCppRemote
```

Use an editor to create a file named CJRClient.cpp and put into it the following contents:

```
#include "CJRAbstract.hh"
#include <fstream.h>
#include <orb.h>
#include <stdlib.h>
#include <stdio.h>

char * infile = "OBJREF.OUT";
int main(int argc, char * argv[])
{
  try {
    CORBA::ORB_ptr op;
    op = CORBA::ORB_init(argc, argv, "DSOM");

    // read stringified IOR from file
    ifstream fin(infile);
    char objref[512];
    memset(objref, 512, '\0');
    fin >> objref;

    // Convert the string into a proxy object
    CORBA::Object_var optr = op->string_to_object(objref);

    // Call method on remote object
    CJRAbstract::CJRAbstractMessages_var aobj =
                 CJRAbstract::CJRAbstractMessages::_narrow(optr);
    CORBA::String_var  message = aobj->getMessage();
    cout << message << endl;

    return 0;
  }
  catch (...)
  {
    cout << "\t an exception was thrown" << endl;
    return -1;
  };
}
```

Compile and Link the Client Program

Compile and link the client by entering:

```
cd %TOPDIR%\HelloWorld\JavaCppRemote
icc /Ti+ /c /Ge+ CJRClient.cpp
ilink /debug /out:CJRClient.exe CJRClient.obj CJRAbstract.lib  \
          somsh.lib somshcpi.lib somorori.lib
```

Run the Application

Now you can run the application. First start the ORB daemon by entering:

```
cd %TOPDIR%\HelloWorld\CppJavaRemote
start somorbd
```

Wait for the daemon window to appear and display a “location server ready” message. Start the server by entering:

```
start CJRServer
```

Wait for the server window to appear and display a “server listening...” message. Run the application by entering:

```
java CJRClient
```

At this point the message `HelloWorld! (From remote Java implementation)` displays.

The ORB daemon and the server windows must be manually closed.

Scenario: Java Client of a Remote C++ Object

In this example the user of the object, the client, is written in Java and the object itself is written in C++. In contrast to the previous examples, in which the client and implementation were in the same process, the client and implementation are, in this example, in different processes. The Component Broker C++ CORBA Object Request Broker (ORB) is used to provide communication between the client and implementation in the server processes.

The implementation object is written in C++ and the server process's ORB is also C++. Therefore IOM's language interoperatility is not needed in the server process.

Component Broker ships a client ORB written in Java, and one option would be to use this Java Client ORB, together with the Java client, in a homogeneous Java process. This option would not require IOM's interprocess technology. This example assumes, however, that the client process contains a mixture of C++ and Java code and that the Component Broker C++ ORB is used in the client. The client side of this example explains how to build a Java client that uses the C++ ORB to communicate with a remote CORBA object.

The basic procedure for this example is:

1. Create an IDL file that describes the interface
2. Use the idlc command to produce a set of C++ implementation classes
3. Write C++ code to implement the getMessage() method
4. Write C++ code for the main server program
5. Compile and link the server program that hosts the implementation
6. Compile and link the DLL that contains the C++ portions of the client program
7. Write the Java client program and compile it
8. Run the application

Each step is described in greater detail in the following sections.

Create the IDL File

Create an IDL file that describes the interface. From the command line, navigate to the `...\HelloWorld\JavaCppRemote` directory by entering:

```
cd %TOPDIR%\HelloWorld\JavaCppRemote
```

Use an editor to create a file named JCR.idl and put into it the following contents:

```
module JCR {
  interface JCRMessages{
    string getMessage();
  };
};
```

Produce a Set of C++ Implementation Classes

Use the idlc command to produce a set of C++ implementation classes by entering:

```
cd %TOPDIR%\HelloWorld\JavaCppRemote
idlc -ehh:ih:uc:sc -mdllname=JCR JCR.idl
```

This produces the files JCR.hh, JCR_C.cpp, JCR.ih and JCR_S.cpp. In this example you are building a C++ implementation. The JCR.hh and JCR_C.cpp files are client side files; they must be emitted only because some of the implementation side files include them. JCR_S.cpp contains methods used internally by IOM to dispatch requests to the implementation object. The JCR.ih file contains the header for the implementation:

```
class JCR_JCRMessages_Impl : public virtual ::JCR::JCRMessages_Skeleton {
  public:
  char* getMessage ();
};
```

The idlc command parameter “-mdllname=JCR” causes the necessary import/export statements to be added to declarations and definitions. If you were only building the C++ server process and linking it from .obj files, then this flag would not be necessary in this example. However, the same JCR.hh files will be used later to implement the Java client, and in this case a DLL, and the associated import/export statements, will be needed.

Now you need to provide an implementation of JCR_JCRMessages_Impl::getMessage(). To do this run the idlc command to produce the implementation file by entering:

```
cd %TOPDIR%\HelloWorld\JavaCppRemote
idlc -eic JCR.idl
```

This causes the JCR_I.cpp file to be emitted. This file contains:

```
char* JCR_JCRMessages_Impl::getMessage () {}
```

Write the C++ Code to Implement getMessage

Write C++ code to implement the getMessage() method. Use an editor to add the actual implementation to the getMessage() method. This section of the JCR_I.cpp file then becomes:

```
char* JCR_JCRMessages_Impl::getMessage ()
{
  return CORBA::string_dup(
     "Hello World! (From remote C++ implementation)");
}
```

Note: When the idlc command is told to produce an _I.cpp file (that is, when the “ic” emitter is specified with the -e or -s flag) the idlc command will attempt to produce a new copy of the file. Because this new file would wipe out any previous file which might contain manually introduced implementations, the idlc command will fail if there is a previously existing _I.cpp file. If a new version of the _I.cpp file is needed then you should rename the original, re-emit the new, and then manually re-integrate your implementations.

Write the C++ Code for the Main Server Program

Write C++ code for the main server program. Now you need a main program that initializes and connects to the ORB, creates an instance of the JCRMessages object, and makes a CORBA IOR available to the client. From the command line, navigate to the `...\HelloWorld\JavaCppRemote` directory by entering:

```
cd %TOPDIR%\HelloWorld\JavaCppRemote
```

Create a file named JCRServer.cpp and use an editor to put into it the following contents:

```
#include <iostream.h>
#include <fstream.h>
#include <stdlib.h>
#include <corba.h>

#include "JCR.ih"

void main(int argc, char *argv[])
{
  static CORBA::ORB_ptr op;
  static CORBA::BOA_ptr bp;
  CORBA::Status stat;
  ofstream fout("OBJREF.OUT");

  // Initialize the ORB
  CORBA::ImplDef * imp = new CORBA::ImplDef();
  imp->set_protocols("SOMD_TCPIP");
  op = CORBA::ORB_init(argc, argv, "DSOM");
  bp = op->BOA_init(argc, argv, "DSOM_BOA");
  bp->impl_is_ready(imp,0);

  // Create an Instance of a JCR_JCRMessages_Impl object
  JCR_JCRMessages_Impl  msgs_Impl;

  // Create a "stringified" IOR
  char *asd = op->object_to_string(&msgs_Impl);
  fout << asd;
  fout.close();
  CORBA::string_free(asd);

  cout << endl;
  cout << "server listening...." << endl;
  cout.flush();

  // Start the BOA request loop.
  stat=bp->execute_request_loop(CORBA::BOA::SOMD_WAIT);

  bp->deactivate_impl(imp);
  CORBA::release(imp);
}
```

In the real world, objects in the server process might be created by factory objects and the client might learn the IORs for the factory objects from a name server. By creating a stringified IOR you avoid implementing factories and dealing with name servers, but you must have a way for the client to learn the IOR for the remote object. The simple solution used in this example is for the server to write the IOR string to a file with the well known name “objref.out.” You will soon see the client code open this file and read the IOR string.

Compile and Link the C++ Pieces to the DLL

Compile and link the server program that hosts the implementation. Now you have all of the pieces needed to build the server process. It is time to compile and link by entering.

```
cd %TOPDIR%\HelloWorld\JavaCppRemote
icc /Ti+ /Ge+ /c JCRServer.cpp
icc /Ti+ /Ge+ /c /DSOM_DLL_JCR JCR_S.cpp
icc /Ti+ /Ge+ /c /DSOM_DLL_JCR JCR_I.cpp
ilink /DEBUG /OUT:JCRServer.exe JCRServer.obj JCR_S.obj JCR_I.obj \
                 somsh.lib somshcpi.lib somorori.lib
```

Compile and Link the DLL

Compile and link the DLL that contains the C++ portions of the client program. Now it is time to build the client.

Working your way back from the implementation toward the client, you see:

- The actual object implementation is in a remote server, and you must deal with an ORB to talk to the remote server.
- The ORB you are using in this example is written in C++, so you must have a C++ entity to talk to the ORB.
- The client is written in Java, so you need to use IOM and its run-time support to allow the Java client to talk with the C++ binding.
- The Java client program deals with a Java stub, which, to the client, looks like it provides an implementation of the object.

You can build the C++ binding from the JCR_I.cpp and JCR_S.cpp files that were emitted earlier. For use in the client, however, you should compile them for use in a DLL and then link the DLL. Enter:

```
cd %TOPDIR%\HelloWorld\JavaCppRemote
icc /Ti+ /Ge- /c /DSOM_DLL_JCR JCR_S.cpp
icc /Ti+ /Ge- /c /DSOM_DLL_JCR JCR_I.cpp
ilib /GENI:JCR.lib JCR_S.obj JCR_I.obj
ilink /DLL /DEBUG /OUT:JCR.dll JCR_S.obj JCR_I.obj JCR.exp \
                 somsh.lib somshcpi.lib somorori.lib
```

In a future step you will load this DLL into the Java client program.

Write and Compile the Java Client Program

Write the Java client program and compile it. You can now prepare the Java portions of the client program. You can build the Java stub by running the idlc command to produce the stub files and then compiling these files. Enter:

```
cd %TOPDIR%\HelloWorld\JavaCppRemote
idlc -euj JCR.idl
cd %TOPDIR%\HelloWorld\JavaCppRemote\JCR
javac *.java
```

Now you can build the Java main program. From the command line, navigate to the `...\HelloWorld\JavaCppRemote` directory by entering:

```
cd %TOPDIR%\HelloWorld\JavaCppRemote
```

Use an editor to create a file named JCRClient.java and put into it the following contents:

```
import org.omg.CORBA.*;
import java.io.*;
import JCR.*;

class JCRClient
{

  public static void main (String argv[])
  {
    try
    {
       System.loadLibrary("JCR");

       ORB orb = org.omg.CORBA.ORB.init(argv, null);
       BufferedReader fin = new BufferedReader(new InputStreamReader
          (new FileInputStream("OBJREF.OUT")));
       String objref = fin.readLine();
       fin.close();
       org.omg.CORBA.Object obj = orb.string_to_object(objref);

       JCR.JCRMessages msgs= JCR.JCRMessagesHelper.narrow(obj);

       System.out.println(msgs.getMessage());
    }
    catch(Exception e)
    {
      System.out.println(e.toString());
    }
  }
}
```

In a previous step the server process wrote out the IOR to a file named OBJREF.OUT. The following lines read in this IOR and convert it to a usable object reference:

```
ORB orb = org.omg.CORBA.ORB.init(argv, null);
BufferedReader fin = new BufferedReader(new InputStreamReader
   (new FileInputStream("OBJREF.OUT")));
String objref = fin.readLine();
fin.close();
org.omg.CORBA.Object obj = orb.string_to_object(objref);
```

You can now compile the Java main program by entering:

```
cd %TOPDIR%\HelloWorld\JavaCppRemote
javac *.java
```

Run the Application

You have now built the example and are ready to run it. You must first start the ORB daemon by entering:

```
cd %TOPDIR%\HelloWorld\JavaCppRemote
start somorbd
```

Wait for the daemon's window to appear and show a “location service ready” message. Start the server process that hosts the implementation by entering:

```
start JCRServer.exe
```

Wait for the server window to appear and show a “server listening ...” message. Run the Java client program by entering:

```
java JCRClient
```

At this point the message `Hello World! (From remote C++ implementation)` displays.

The ORB daemon and the server windows must be manually closed.

Chapter 16. Workload Management

The following chapter is platform-dependent and does NOT apply to OS/390 Component Broker. See *OS/390 Component Broker Planning and Installation* for further information on Workload Management.

This section includes the following topics:

Programming Model

This section includes the following topics:

Overview

Workload Management, as the term implies, is the discipline of defining, monitoring and actively managing work in your CB system network. In a CB context, "work" is taken to mean the dispatch, routing and receipt of requests between objects in the distributed network and their eventual execution within a CB Application Server. As more clients use an application the amount of 'work' increases and the 'load' on the servers increases.

The aspect of WLM which is of most interest to application programmers is the workload distribution mechanism. This capability allows the CB runtime to dynamically allocate an Application Server to process a request. If clients are statically allocated to servers then the possibility exists for some servers to be heavily loaded whilst others are relatively idle. The aim of workload distribution is to minimize client request response times and maximize server throughput by reducing load imbalance.

The key to workload distribution in CB is the use of a server group to define multiple Application Servers with a common configuration. In addition the server group must be configured with a Managing Host which designates one Host to provide management services across the group. This configuration is known as a *controlled server group*.

Group Identity

In the CORBA programming model an object 'belongs' to the server on which it was created. An object reference uniquely identifies the server (or "implementation" and the object instance which will handle requests. In the simple case, in which an application is installed on one server, there are few complications. The client obtains the object reference to a Business Object on that server and sends requests to it. In the CB environment, however, it will be typical to install an application on more than one server e.g. by using a server group. Each server in the group can provide the application services required by a client but one approach is to configure a client to use only one server in particular. Different clients may each use a different server. With this approach we have sufficient capacity in our network to provide the application services required but our static client allocation scheme means load imbalance is almost a certainty.

If the client needs to access a particular Business Object, then it could be programmed to locate all the Homes in the network which handle that type of Business Object. It could then use findByPrimaryKey() to retrieve object references to each object instance, i.e. one instance per server in the group. The client could then choose which of these objects to use to process any subsequent request to that Business Object. This approach is impractical and very intrusive to the client programming model. Conceptually what is required is a way to give an object reference a form of "group identity", so that there is only one object reference and the object 'belongs' to the server group, rather than one particular server. This concept is known as the Single Object and Single Server Image property. The ideal is for the client application programmer to write the client application as if there is always one object reference and one server, whereas this may not be the reality.

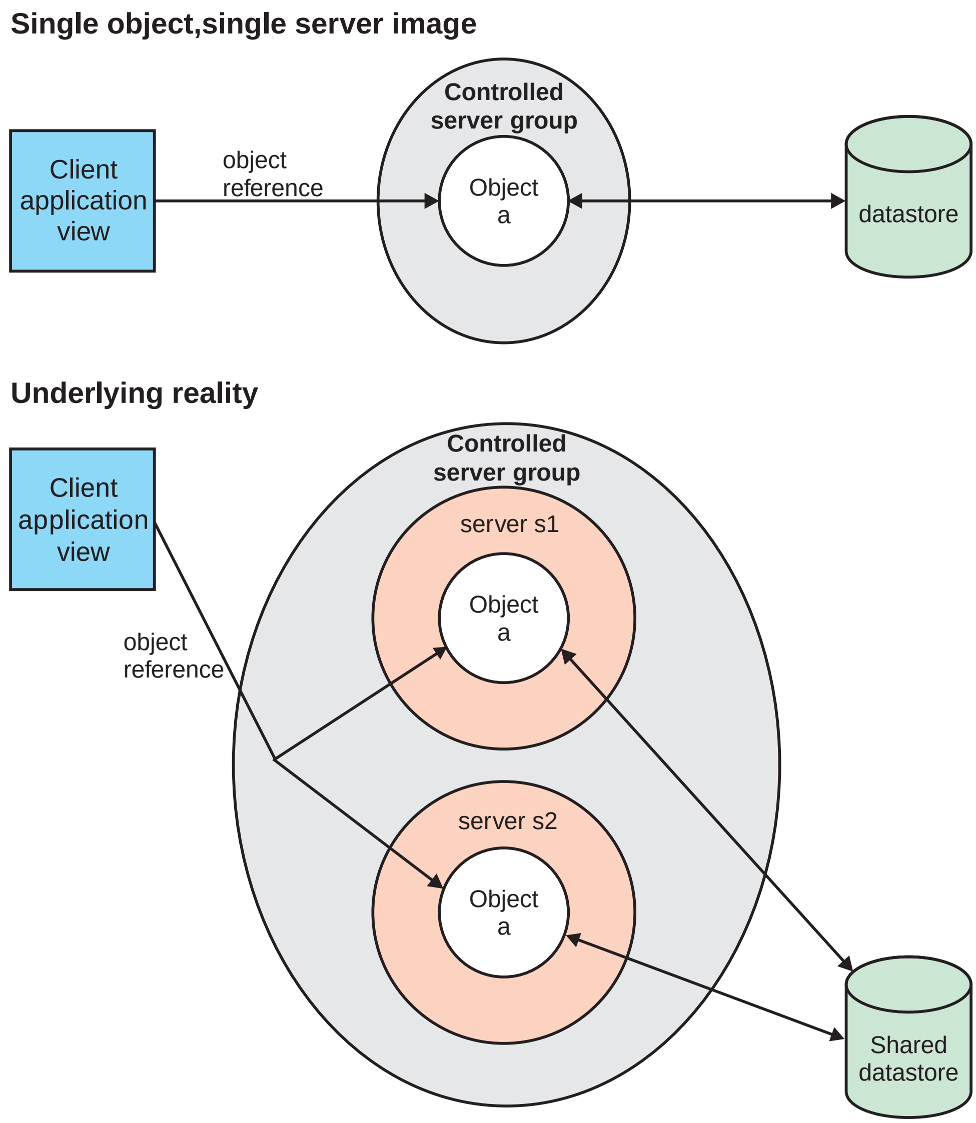


Figure 16. Single object, single server image

Objects can only exist with a group identity in a controlled server group configuration.

Workload Manageable Objects

Almost any Managed Object could be given a "group identity" and be subject to workload management. However, you do not use all Managed Objects in an Application in the same way and there are overheads caused by workload management which should be avoided if there will be little return from the investment. In the design and packaging stages you should identify which objects are workload management candidates, that is, identify *workload manageable objects*. If the application is subsequently installed and configured to run on a controlled server group then these objects will be *workload managed* (WLM) objects.

The opportunity for workload distribution occurs when requests are sent remotely across the ORB from a 'client' to a server; not forgetting that servers can be clients of other servers. An obvious candidate for workload management is therefore any Managed Object which may be called remotely.

WLM Homes

All workload manageable objects are automatically associated with a workload manageable Home. A Home is an excellent example of a workload manageable object as it is often one of the first types of object to be accessed remotely. Many client applications will locate a Home for a required Business Object, perhaps using a factory finder, and then use that Home to find or create that Business Object on the Home's server. It is just as desirable to distribute the work involved in finding, creating and processing queries for Business Objects as it is for the work involved in subsequent operational requests.

References to Other Objects

There are already good reasons to be careful about how references to other objects are managed. For example, imagine the case where an insurance agent uses a client application assigned to server S1 to create a new Policy object P1 and relate it to a new Customer object C1. Let's assume that P1 stores a reference to C1 persistently as a stringified object reference. Some time later another agent may have reason to check this policy and cause an object P1-prime to be activated, this time on server S2. If P1-prime now de-references the stored string form of C1 it will obtain a proxy object which relates back to the original instance of C1 on server S1. It is not normally desirable to increase the inter-server dependencies in this way. Alternative methods of storing object references are provided (e.g. home/key handles and foreign key relationships) which avoid this problem.

In the above example, if we assume that Policy objects are workload managed but that Customer objects are not, then the advice to avoid stringified object references should not be ignored. However, it should be noted that references to workload managed objects will always be de-referenced to a local instance whenever possible. Thus, in this example, the use of stringified object references is acceptable if the Customer objects are also workload managed.

Using Object Builder

The discussions in the previous sections have been intended to provide information about workload management considerations, specifically workload distribution, relevant to your application design. This section provides additional information to help you implement and configure CB to support your application. There are two steps:

1. Define WLM Containers which are configured to contain WLM objects.
2. Designate WLM Managed Objects as you package them into an Application.

Adding a Container

A Container is an Application Adaptor's unit of configuration management. For each unique set of configuration criteria which your application requires you will have to define a separate Container. One of these configuration criteria concerns workload management. When a reference to a Managed Object is exported from a CB Application Server, the Application Adaptor refers to the object's Container to determine whether the object is a candidate for workload management. When you define a new Container using Object Builder you designate that the Container will contain workload managed objects using the WLM checkbox. The Application Adaptor will then know at runtime to export additional metadata.

In the Application Family definition which Object Builder creates, each Container which has been configured to contain WLM objects will have an associated Policy Group object. A Policy Group is a Systems Management object which feeds configuration information to the workload distribution mechanism at runtime. Because CB currently supports only one Policy Group configuration there is no provision in Object Builder to modify the Policy Group settings.

Adding a Managed Object to an Application

One of the final steps in creating an application package with Object Builder is the packaging of the Managed Objects and other ancillary files into applications and client applications within an application family. When you select to *Add a Managed Object* to an application you are presented with the Configure a Managed Object wizard.

On the Container panel you can select a checkbox for WLM objects. This will cause only WLM Containers, which also match the other MO characteristics, to be presented for selection. On the subsequent Home panel you can either select a default Home implementation (BOIMHomeOfRegWLMHomes) or a Customized Home implementation. The MO for a Customized Home must also be added to the same application. The Customized Home MO must itself be a WLM object if it is to provide the Home implementation for a WLM MO. You will need to select the WLM checkbox when you add the Customized Home MO to the application.

If the application is subsequently installed into a controlled server group configuration then, because the MO will be managed by a WLM Container, it will be identified to the CB runtime as a WLM object. Method requests to instances of the MO class will be subject to workload distribution.

Scenario Considerations

WLM objects can be used to good effect to increase the scaleability and the availability of an application. However it probably won't come as a complete surprise that there are some restrictions and potential problems in certain application scenarios.

Affinity Management

Workload distribution has the unique potential to cause a single object reference to be resolved to multiple target instances over the lifetime of a client proxy. The first time a client sends a request to a WLM object causes a server to be chosen to be the target of that request subject to configured bind policy. On the next request we have to decide whether to use the same server or choose a different one. What we need to know is whether there is any residual affinity between the client and the first chosen server which dictates that it be reselected.

A strong affinity between client and server is established if the client initiates a session or transaction context which will scope a series of method requests to the same objects. When a server is chosen to process the first request in that context it will cause an instance of that object to be activated on that server and for locks to be held by that server for that context. Subsequent requests to that object in the same scope must be dispatched to the same server or else lock conflicts will occur and the application will deadlock. Once the context is committed, or ends for some other reason, then the affinity is broken and the option is available to choose a new server for the next request.

Affinity management is a key technical requirement for workload distribution which is addressed today by the single, default client bind affinity configuration. This behavior sets up an affinity between a client process and the first chosen server which is never broken (unless the server fails or terminates for some reason). This results in a stronger affinity setting than is strictly required for transaction or session management.

An affinity also exists if an object instance is left activated in the first chosen server. Examples here include the use of transient objects or other objects with an application-managed activation cycle. The client bind affinity configuration works here too.

Multiple Activation

Although we've just described transaction and session affinity as a client-server affinity it is more accurately an object-server affinity. Once an object instance has been activated within a transaction scope, for example, all subsequent requests to that object in the same scope must be dispatched to that same object instance. The client bind affinity configuration just mentioned ensures that this will be the case for all requests originating from the same client. In a more complex application deployment it is possible for requests to originate from multiple clients.

Consider the case where a client X accesses a WLM object C1 in application A1 on server S1, a member of controlled server group G1. Let's assume that C1 then creates an object P1 in application A2 on server T1. If C1 calls P1, passing an object reference to itself, and then P1 makes a return call to C1 then a problem can occur. We have a potential object flow like X->C1[S1]->P1[T1]->C1[S2]. Note that server T1 had no affinity with a server in server group G1 and picked server S2 at random, just as X had chosen S1. The result is lock conflict caused by multiple activation of C1 within the same scope.

The workload distribution mechanism can cause multiple activation in certain multi-application topologies. It is an application design requirement to avoid multiple activation in the same scope. This is an application design restriction.

Note that multiple activation can occur in other scenarios not related to workload distribution, for example, in the use of home/key handles.

Local Activation

One of the main principles of workload distribution in Component Broker is that work initiated by a server should always be executed on that server whenever possible. So whenever a server imports a WLM object reference it will always de-reference to a local instance of that object if it exists. This avoids any network overhead in needlessly sending requests to remote servers which could have been processed locally.

Automatic Rebind

When a client initiates a request to a WLM object, the client-side ORB function invites the workload distribution mechanism to select a target server for the request. If the ORB is subsequently unable to dispatch the request to that server the workload distribution mechanism is informed and has the opportunity to choose a different server. This will only occur if the request was not dispatched remotely. If the request was dispatched but a CORBA::SystemException is generated the exception will still be reported back to the client application. This includes situations in which the client request timeout is exceeded and when the server terminates unexpectedly while processing a request.

Scenario Examples

This section includes the following topics:

Application Objects

One of the simplest WLM scenarios is based on the thin-client application model. In such an application the client initiates requests to an Application Object (AO) on the server. The AO contains the business process logic and interacts with Business Objects in the same application on that server in order to process the client's request.

Each request to the AO is a self-contained piece of work. In fact it may be appropriate to configure the AO to use a Container which provides an atomic (per-method) transaction quality of service. In this configuration each request to the AO runs as a transaction in the server. The AO is passivated at the end of the transaction.

This design does not establish an affinity between the client and the server. It would therefore be permissible for each method's workload to be distributed to a different server in the group. With the default client bind affinity this will not occur.

If the chosen server should become unavailable when no request is pending then the next request should be routed successfully to another available server. Server failure while a request is being processed will be reported to the client application. However the client application may proceed to send further requests to the same object.

Transient Objects

A variation on the Application Object scenario is the use of a transient object. If the transient object is marked as a WLM object then its Home will also be a WLM object. This means that when the transient object is created (for example by createFromPrimaryKeyString()) the request to the Home will be subject to workload distribution. The effect is that the transient object is created on one of the servers in the group chosen at random.

Subsequent requests to the transient object will be routed to the same server. If the chosen server should become unavailable when no request is pending then the next request will be routed to another available server. This will result in a CORBA::INV_OBJREF exception as the object will not be known to the other server. If the server fails while a request is being processed then this will be reported to the client application in the normal way. In either case the client application may proceed by creating another transient object. The new object will be created on one of the other servers in the group which is still available.

Business Objects

Business objects tend to be persistent objects which must be activated within some transaction or session context to ensure adequate and correct concurrent access. There has already been a discussion above about affinity management and the need to avoid multiple activation in this scenario.

If a server fails when no context is established then the next request to a WLM BO object will cause a new server to be selected and the client affinity moved to the new server. The workload is switched without concerning the client. If a context has been established and a server fails while a request is pending then that context will be terminated e.g. a transaction will be rolled back. The failure will be reported to the client application in the normal way.

A special case exists when a context is active but no request is pending when the server fails. The next request will choose a different server and the system will try to include that server in the active context. The new server may attempt to immediately register itself with the context coordinator and this may fail. In some circumstances registration may be deferred and requests may continue to be processed, only for the context to be rolled back at commit.

Depending on the state of the active context and the resources involved, it may not always be possible to retry the same business transaction using another server in the group. It may be necessary for the original server to restart and perform recovery of the aborted transaction or session before all locks are released. However it should be possible to continue to use the application in the general sense.

Client Programming Model

This section includes the following topics:

- "Using Factory Finders"
- "Exceptions and Recovery" on page 291

Using Factory Finders

The CB client programming model depends to a large extent on the factory finding capabilities of the LifeCycle service. Almost all applications will use a Factory Finder to locate the Homes of their Managed Objects. When an application is first loaded by a server, each Home has the opportunity to register with the LifeCycle service. This registration effectively records the existence of each Home as a resource in the distributed Name Space in such a way that a Factory Finder, given a suitable "Location" in which to look, can search for an object by its specified properties.

The introduction of objects with "group identity" causes some disruption to the basic LifeCycle registration process. Homes are normally registered as server and host-scope resources i.e. as resources belonging to the server where they exist and to the host on which that server is configured. Individual Homes can optionally be registered as workgroup or cell resources and all the Homes on a server can also be made visible at the workgroup or cell scope. The difference with WLM Homes which manage WLM objects is that the Home is now a server group resource, rather than a server resource. The server group is also not restricted to just one host. WLM Homes are therefore resources of the server group and the common workgroup preferred by all participating hosts. They may optionally be individually registered at the cell level and the server group may be made visible at the cell level.

When first learning to use factory finders a commonly cited example is to use the system-provided host-scope factory finder which can be resolved from the Name Space with the name /host/resources/factory-finders/host-scope. This factory finder will only look for the requested Home as a resource on the local host. It will therefore not be able to find any WLM Home. As your first application is unlikely to feature WLM objects, this is probably not a problem. However it is something you need to take into account as you add WLM capabilities to an application.

Assuming you only have one server group per workgroup configured for a particular application, then client applications could use the /workgroup/resources/factory- finders/workgroup-scope factory finder. This assumes that all the clients will run on, or be bootstrapped by, a host which prefers the same workgroup as the hosts participating in the server group configuration. This is a reasonable assumption as it is necessary for client-initiated workload distribution anyway. Note that this factory finder will not find non-WLM Homes unless they have been configured to be visible at the workgroup level.

For server-side code which needs to use a factory-finder to locate Homes within the same application, use of the default workgroup-scope factory finder is not recommended. If the application isn't installed on a controlled server group then the Homes will not be WLM. If they are made visible at the workgroup level, a general workgroup-scope search is not guaranteed to find the instance on the same server. This same problem can arise using host-scope if more than one server supporting the same application is installed on the same host. In the workgroup scenario the coincidence of multiple servers is expected to be much higher.

The recommended approach for server-side code is to use the system-provided multi-location factory finder bound at /host/resources/factory-finders/server-name-server-scope-widened. This will search for the registered Home as a resource of both the local server and, when the server is a member of a controlled server group, the appropriate server group.

For more information on use of Factory Finders refer to “Factory Finders” on page 87.

Exceptions and Recovery

In a CORBA environment there are many opportunities for the system to generate exception conditions which are reported back to the originating application code. An application must adopt a rigorous programming discipline to catch, handle, report and recover from these exceptions.

The workload distribution mechanism can often reduce the probability of exceptions being seen by the client application, because it is able to reroute requests to an available server and preserve the single server image property. Where requests are dispatched remotely but subsequently some failure occurs, the client application will still receive appropriate exceptions.

Note that the CORBA::NO_IMPLEMENT exception is normally generated by the ORB to signify that the server targeted by a request is not available or is no longer defined. In a controlled server group environment this exception will be generated if the Server Group Control Point is unavailable and therefore the client cannot determine which servers in the group are available. It can also be caused by the fact that no servers have registered with the SGCP (i.e. no servers are available) or that an attempt has been made to contact each available server without success.

Application Adaptors

Application Adaptors add a quality of service to the managed objects. One of the quality of services is the support of WLM. Supporting WLM causes some side effects to the programming model. These are described in the “An Overview of Application Adaptors” topic in the “Assembling and Installing Business Objects” section of the *Component Broker Programming Guide*.

BOIM Application Adaptors

When objects are workload managed, each client has its own copy of an object. Please refer to the “An Overview of BOIM” topic in the “Assembling and Installing Business Objects” section of the *Component Broker Programming Guide*, which discusses the impact of application adaptors when developing business objects, and the issues involved with having multiple copies of the same object.

Chapter 17. Interface Repository

This section contains procedures for the Interface Repository (IR):

Configuring ODBC for NT

WIN ODBC is normally configured for the user during the Component Broker install procedure. The following procedure is used if the IR database is moved or a new database is added after Component Broker is installed. This procedure assumes that you have the VisualAge C++ Data Access Builder installed or another ODBC database driver installed.

If ODBC needs to be reconfigured for a different user, the following procedure can be used:

1. Open a new DOS command prompt window.
2. Run the following command:

   ```
   makeudsn drive:\<directory>
   ```

   using the directory where Component Broker was installed.

The program makeudsn assumes that the IR database is located under the Component Broker installed directory. If the IR database is moved, or a new database is added, then the following procedure can be used:

1. Open the WIndows NT Control Panel.
2. Double click on the ODBC icon to open the ODBC Data Source Administrator.
3. Click on the **User DSN** tab. If you do not see a **User DSN** tab, then Version 3.00 ODBC Driver Manager is not running.
4. Click on the **Add** button. The Create New Data Source window is displayed.
5. Select the `INTERSOLV 2.11 32-bit dBASEFile (*.dbf)` driver.
6. Click the **Finish** button. The ODBC dBASE Driver Setup window is displayed.
7. Fill in the following fields:

   Data Source Name
   Interface Repository

   Description
   Interface Respository

   Database Directory
   The fully-qualified path of the IR database tables.
8. Click the **OK** button on the ODBC dBASE Driver Setup window. This creates the User DSN and redisplays the ODBC Data Source Administrator window. A User DSN for the Interface Repository is in the displayed list of User Data Sources.
9. Click the **OK** button on the ODBC Data Source Administrator window.

Configuring ODBC for AIX

AIX ODBC should be configured by Component Broker installation, however if you move your ODBC data files or drivers, you can use these instructions to reconfigure.

1. Determine if you have an .odbc.ini configuration file that is already installed on your system.

   The ODBC configuration file is located in your $HOME directory. Change to your $HOME directory and check to see if the .odbc.ini file exists. Enter:

   ```
   ls -a
   ```

   - If the $HOME/.odbc.ini file does exist, you will need to add the contents of the etc/irdbase/odbc.ini file to the $HOME/.odbc.ini file.
   - If the $HOME/.odbc.ini file does not exist, copy the odbc.ini file that is found in the etc/irdbase directory to the $HOME/.odbc.ini file.

2. Determine where you want the IR database files to reside, whether in the current install directory or moved to some other (perhaps permanent) data directory.

   Note: On an install image the IR database files are located in etc/irdbase. The file names must be in upper case.

3. Edit the $HOME/.odbc.ini file.

   a. Change the Driver line to be the location of the IBdbf08.so share library.

      The IBdbf08.so file is located in the lib directory on the install image.

   b. Change the Database line to be the location of the IR database files.

The .odbc.ini file looks like this:

```
[ODBC Data Sources]
Interface Repository=Interface Repository
;
; Define ODBC Database Drivers Below - Driver Configuration Section
;
; Copy this file to $HOME/.odbc.ini and modify all instances of
; CBCInstallPath to the appropriate path (your pushed project name).
; Also create a directory under CBCInstallPath/etc called 'irdbase'
; and copy all files from CBCInstallPath/src/orb/src/irstore/irdbase
; to that directory. Note: All files copied to ...etc/irdbase have to be
; renamed using uppercase letters.
;
[Interface Repository]
Driver=/build/boss/lib/IBdbf08.so
Description=INTERSOLV dBase V ODBC Driver for IBM Interface Repository
; Database if set informs the driver where to locate tables.
Database=/home/bossbld/irwork
CacheSize=20
CreateType=DBASE5
```

Building an Interface Repository Database

The idlc IR emitter can be used to create information in the Interface Repository database that is representative of an Interface Definition Language (IDL) file. The information in the Interface Repository database can be accessed at runtime by an application using the Interface Repository Framework API. Typical use of the Interface Repository in a run time environment includes retrieving interface related information for use with the Dynamic Invocation Interface (DII).

The idlc IR emitter currently will emit code which, when compiled and linked, can be run to populate the Interface Repository.

The following steps show how to use the idlc IR emitter to create information in the IR database:

1. Run the idlc IR emitter to generate the source code to create objects in the Interface Repository database:

   ```
   idlc -eir test.idl
   ```

   This creates a source file named test_IR.cpp that contains logic that creates the appropriate objects in the Interface Repository database.

2. After compiling and linking the generated source code, run the resulting application with the following option:

   ```
   test_IR
   ```

   This invocation of the idlc program throws an exception if it attempts to create a named object that is already in the Interface Repository database.

3. In the event the names of new objects collide with the names of existing objects in the IR database, the following option causes the program to remove the existing objects from the IR database and replaces them with the new object definitions:

   ```
   test_IR IRforce
   ```

Displaying the Contents

The irdump provides a means to access the contents of the IR from a command line program. The IRBrowser provides a rich user interface, but cannot be run from a script or command line in an automated fashion.

The irdump tool is invoked using by typing `irdump > irdump.out` from a command prompt.

This section contains:

- A simple IDL file called Test.idl
- The makefile used to create the executable
- The command to run the makefile
- The command to run the executable
- The command to invoke irdump with its output

The Test.idl File

The example that follows shows a simple IDL file Test.idl.

```
module sample_module {
interface sample_interface
{
 }; /* end module */
```

The Makefile

The following is a simple makefile that generates source code to create objects in the IR and compile the source.

```
#----------------------------
The targets we need to build
#----------------------------
SRC_FILES = \
    test_IR.cpp
IR_OBJ_FILES = \
    test_IR.obj
EXE_FILES = \
    test_IR.exe

MAP_FILES = $(EXE_FILES:.exe=.map)

#---------------------------------------------------------------
The CBConnector system libraries we need to link our DLL
#---------------------------------------------------------------
IR_EXE_LIBS = \
    somorori.lib

#---------------------------------------------------------------
# Pseudo targets to run as part of an "nmake clean"
#---------------------------------------------------------------

CLEAN_TARGETS = \

#---------------------------------------------------------------
# After setting our variables but before defining our recipes
# we include "obdll.mk" which contains variables and recipes
# common to makefiles generated by the CBToolkit Object Builder
#---------------------------------------------------------------

!include $(IVB_DRIVER_PATH) \bin\obdll.mk

#---------------------------------------------------------------
# Recipes for the interface files
#---------------------------------------------------------------

test_IR.cpp: test.idl
    $(_IDL_) $(IDL_IR_FLAGS) test.idl

test_IR.obj: test_IR.cpp

test_IR.exe: test_IR.obj
    $(_LDEXE_) $(LD_EXE_FLAGS) /OUT:$@ /MAP:$*.map test_IR.obj
$(IR_EXE_LIBS)

clean_test:
     $(_REMOVE_) test_IR.exe
     $(_REMOVE_) test_IR.obj
```

```
    $(_REMOVE_) test_IR.cpp

#----------------------------------------------------------------
# End
#----------------------------------------------------------------
```

Running the Makefile

To run the makefile, enter:

```
c:\irtest->make -f test.mak
```

Running the Executable

To run the executable you just built, enter:

```
c:\irtest->test_IR.exe
```

Running irdump

Run irdump to show the IR contents, enter:

```
c:\irtest->irdump
```

The following code is the output from the irdump command.

```
  ============================================================
  InterfaceDef: ::sample_module::sample_interface
  ============================================================
  RepositoryID: IDL:sample_module/sample_interface
  Defined in: sample_module
  Version: 1.0

Interface is empty!
```

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