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Cincom Smalltalk™

VisualWorks®

Distributed Smalltalk Developer's Guide

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About This Book

This manual gives an overview of the Distributed Smalltalk development process, and describes programming resources for building distributed applications.

Audience

Distributed Smalltalk is a CORBA 2.1-compliant framework for developing distributed applications, and supports several of the primary CORBA Object Services (COS).

This book is written for experienced Smalltalk developers who are writing their first Distributed Smalltalk application. Readers should have a good understanding of VisualWorks®; review the VisualWorks manuals for more information. For additional help, a large number of books and tutorials are available from commercial book sellers and on the world-wide web. In addition, Cincom and some of its partners provide VisualWorks training classes. This book does not assume any prior knowledge of Distributed Smalltalk or of CORBA.

Be sure to read Chapters 1-4 to understand basic Distributed Smalltalk concepts. After reading Chapter 4, decide whether to use the Implicit Invocation Interface (I3) or IDL interfaces in your application and then read the corresponding chapter.

Conventions

We have followed a variety of conventions, which are standard in the VisualWorks documentation.

Typographic Conventions

The following fonts are used to indicate special terms:

Example	Description
template	Indicates new terms where they are defined, emphasized words, book titles, and words as words.
`cover.doc`	Indicates filenames, pathnames, commands, and other constructs to be entered outside VisualWorks (for example, at a command line).
`filename.xwd`	Indicates a variable element for which you must substitute a value.
windowSpec	Indicates Smalltalk constructs; it also indicates any other information that you enter through the VisualWorks graphical user interface.
Edit menu	Indicates VisualWorks user-interface labels for menu names, dialog-box fields, and buttons; it also indicates emphasis in Smalltalk code samples.

Special Symbols

This book uses the following symbols to designate certain items or relationships:

Examples	Description
File > New	Indicates the name of an item (**New**) on a menu (**File**).
<Return> key <Select> button <Operate> menu	Indicates the name of a keyboard key or mouse button; it also indicates the pop-up menu that is displayed by pressing the mouse button of the same name.
<Control>-<g>	Indicates two keys that must be pressed simultaneously.
<Escape> <c>	Indicates two keys that must be pressed sequentially.
Integer>>asCharacter	Indicates an instance method defined in a class.
Float class>>pi	Indicates a class method defined in a class.

Mouse Buttons and Menus

VisualWorks supports a one-, two-, or three-button mouse common on various platforms. Smalltalk traditionally expects a three-button mouse, where the buttons are denoted by the logical names <Select>, <Operate>, and <Window>:

<Select> button	*Select* (or choose) a window location or a menu item, position the text cursor, or highlight text.
<Operate> button	Bring up a menu of *operations* that are appropriate for the current view or selection. The menu that is displayed is referred to as the *<Operate> menu*.
<Window> button	Bring up the menu of actions that can be performed on any VisualWorks *window* (except dialogs), such as **move** and **close**. The menu that is displayed is referred to as the *<Window> menu*.

These buttons correspond to the following mouse buttons or combinations:

	3-Button	2-Button	1-Button
<Select>	Left button	Left button	Button
<Operate>	Right button	Right button	<Option>+<Select>
<Window>	Middle button	<Ctrl> + <Select>	<Command>+<Select>

Getting Help

There are many sources of technical help available to users of VisualWorks. Cincom technical support options are available to users who have purchased a commercial license. Public support options are available to both commercial and non-commercial license holders.

Commercial Licensees

If, after reading the documentation, you find that you need additional help, you can contact Cincom Technical Support. Cincom provides all customers with help on product installation. For other problems there are several service plans available.

Before Contacting Technical Support

When you need to contact a technical support representative, please be prepared to provide the following information:

- The *version id,* which indicates the version of the product you are using. Choose **Help > About VisualWorks** in the VisualWorks main window. The version number can be found in the resulting dialog under **Version Id:**.
- Any modifications (*patch files*) distributed by Cincom that you have imported into the standard image. Choose **Help > About VisualWorks** in the VisualWorks main window. All installed patches can be found in the resulting dialog under **Patches:**.
- The complete error message and stack trace, if an error notifier is the symptom of the problem. To do so, select **Copy stack** in the error notifier window (or in the stack view of the spawned Debugger). Then paste the text into a file that you can send to technical support.

Contacting Technical Support

Cincom Technical Support provides assistance by:

Electronic Mail

To get technical assistance on VisualWorks products, send email to:

supportweb@cincom.com.

Web

In addition to product and company information, technical support information is available on the Cincom website:

http://supportweb.cincom.com

Telephone

Within North America, you can call Cincom Technical Support at (800) 727-3525. Operating hours are Monday through Friday from 8:30 a.m. to 5:00 p.m., Eastern time.

Outside North America, you must contact the local authorized reseller of Cincom products to find out the telephone numbers and hours for technical support.

Non-Commercial Licensees

VisualWorks Personal Use License (PUL) is provided “as is,” without any technical support from Cincom. There are, however, on-line sources of help available on VisualWorks and its add-on components. Be assured, you are *not* alone. Many of these resources are valuable to commercial licensees as well.

The University of Illinois at Urbana-Champaign very kindly provides an important public resource for VisualWorks developers:

- A mailing list for users of VisualWorks PUL, which serves a growing community of users. To subscribe or unsubscribe, send a message to: vwnc-request@cs.uiuc.edu.

  with the SUBJECT of **subscribe** or **unsubscribe**. You can then address emails to: vwnc@cs.uiuc.edu.

The Smalltalk news group, comp.lang.smalltalk, carries on general discussions about different dialects of Smalltalk, including VisualWorks, and is a good source for advice.

Additional Sources of Information

Cincom provides a variety of tutorials, specifically for VisualWorks:

http://www.cincomsmalltalk.com/main/products/visualworks/visualworks-tutorials/

The guide you are reading is but one manual in the VisualWorks library. The Cincom Smalltalk publications website:

http://www.cincomsmalltalk.com/main/products/documentation/

is a resource for the most up to date versions of VisualWorks manuals and additional information pertaining to Cincom Smalltalk.

1

Introducing Distributed Smalltalk

Distributed Smalltalk is an integrated set of frameworks providing an advanced object-oriented environment for rapid development and deployment of multi-user, enterprise-wide distributed applications. Distributed Smalltalk provides a superior environment for rapid prototyping, application development, and deployment of CORBA-compliant applications.

Distributed Objects

Modern corporations have moved from the old mainframe paradigm, in which all programs ran on one central computer, to decentralized computing, in which many different computers cooperate to run programs. In this distributed environment, it is no longer practical to design each program as a stand-alone system; programs must be designed to share and exchange data and services. Distributed object systems can be both more robust and more powerful than either conventional object-oriented systems or conventional client-server systems.

Designs based on distributed objects offer all the power of object-oriented design, and in addition allow widely separated applications to collaborate. Distributed applications also facilitate load distribution among clients and servers and provide increased reliability by facilitating mirroring and replication.

What is CORBA?

In 1989, the Object Management Group (OMG) began to specify the Common Object Request Broker Architecture (CORBA). This standard defines common methods of communication between

distributed objects on disparate platforms. A revised CORBA standard, version 2.0, was agreed to in late 1994. By 1996, there were many different CORBA implementations on the market; such major software vendors as Oracle and Netscape have announced support for CORBA interoperability. The CORBA standard has continued to undergo revision and update since then.

An application that is based on the CORBA infrastructure is well-positioned to be integrated into today's diverse computing environment.

Why Distributed Smalltalk?

Distributed Smalltalk allows you to develop applications that are compliant with the CORBA 2.1 standard, while offering the superior application-development facilities of VisualWorks. Distributed Smalltalk hides some of the complexity of CORBA, while making its full power available to developers.

Distributed Smalltalk is a complete implementation of CORBA 2.0, with additions to comply to the 2.1 standard. Distributed Smalltalk's CORBA compliance provides the basis for object- and application-interoperability. Distributed Smalltalk also offers the Implicit Invocation Interface (I3), an extension to the CORBA facilities that provides a more natural Smalltalk paradigm for developing distributed object systems.

How Distributed Smalltalk Works

An application written in Distributed Smalltalk is able to respond to service requests from remote systems and to request services in its turn. Remote entities that request services of an application need not be written in Distributed Smalltalk, as long as they use an OMG-standard Object Request Broker to make the requests.

The component objects that make up a Distributed Smalltalk application are often themselves distributed across several systems. These distributed objects can interact transparently, without regard to object location or platform.

To a running application, remote message sends appear to be taking place in the local image. What actually happens to implement a remote send is more interesting.

Assume that an object, “Arthur”, running on Machine A, wants to make a request of an object, “Bonita”, on Machine B (refer to the graphic following the procedure).

1 Arthur obtains an object reference for Bonita.

2 Arthur sends a message to the object reference.

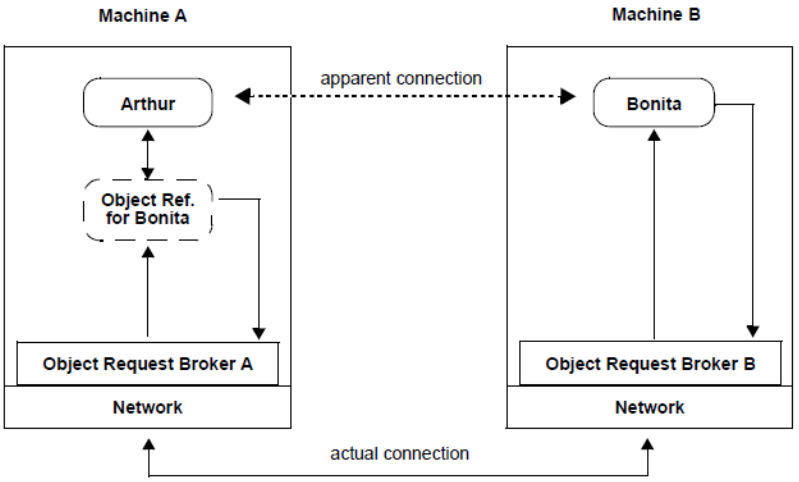
3 The Object Request Broker on machine A (ORB A) translates the message and its arguments into a platform-neutral format (“marshalls the message”) and transmits the message over the network to the ORB on machine B (ORB B).

4 ORB B translates the platform-neutral message back into Smalltalk (“unmarshalls the message”) and sends the message to Bonita for processing.

5 Bonita processes the message and returns a value to ORB B.

6 ORB B marshalls the return value and transmits it over the network to ORB A.

7 ORB A unmarshalls the return value and returns it to Arthur.



CORBA Components

CORBA 2.1 specifies core functions that are required of an Object Request Broker in order to support interoperable distributed computing. The CORBA specification requires the following core components, all of which Distributed Smalltalk supplies:

- Object Request Broker (ORB)

  The ORB is the brain of a CORBA implementation. It facilitates the transmission and interpretation of messages across diverse software and hardware platforms.

- Interface Definition Language (IDL) Compiler

  The Interface Definition Language is used to define objects' public interfaces in a language- and platform-independent fashion, so that object services may be requested from any supported environment.

- Internet Inter-Orb Protocol (IIOP)

  The Internet Inter-Orb Protocol is used to communicate between ORBs. An object running on one ORB can make requests of objects served by any other connected ORB, whether those objects were written in Smalltalk, C, C++, Ada, or COBOL. Developers can build distributed systems using multiple languages where appropriate. Thus, a Smalltalk object may request services from or provide services to a C++ object, an Ada object, or any object that supports an IDL interface.

- Interface Repository (IR)

  The Interface Repository is the registry of distributable object interfaces for a given system. Any remotely accessible object has an interface in the Interface Repository. Interface Repository interfaces are described in IDL.

The CORBA standard also specifies optional object services (CORBAservices) which may be provided by CORBA implementations. DST implements support for some of these, as described below.

Object Request Broker (ORB)

The Object Request Broker (ORB) is the key to distribution support. By providing an ORB on each system, Distributed Smalltalk makes the location of any object transparent to clients requesting services from the object.

When a message is sent to a local object, the activity is handled normally. When a message is sent to a remote object, the remote object's local object reference (a proxy created automatically by the ORB) intercepts the message, then uses the ORB to locate the remote object and communicate with it. Results returned to the calling object appear exactly the same, whether the message went to a local or remote object.

An ORB performs all of the following tasks:

- Marshalling and unmarshalling messages (translating objects to and from byte streams for network transmission)
- Locating objects in other images or systems
- Routing messages between surrogates and the objects they represent

While a request is active, both client and server ORBs exchange packet information to track the course of the request and resolve any network or transmission errors that might occur.

Interface Definition Language (IDL) Compiler

When distributed objects collaborate in an application, they interact by sending messages to one another's interfaces. These interfaces are described in the Interface Definition Language; this makes the interface descriptions language-independent. Because external clients have access to an object's services only through the object's interface, the implementation of the object is private. This privacy provides a variety of benefits, including security, language independence, encapsulation, and the freedom to modify the implementation of how a service is performed without external repercussions. The IDL compiler translates interface definitions into the objects used by the ORB and Interface Repository.

Internet Inter-Orb Protocol (IIOP)

The Internet Inter-Orb Protocol (IIOP) is the protocol used for communication between ORBs. The IIOP is based on TCP/IP, and adds some additional message exchanges to provide a backbone protocol.

Interface Repository (IR)

The Interface Repository stores all of the IDL interfaces for objects available through an ORB.

CORBAservices

Object services extend the core ORB capabilities to support more advanced object interaction. Distributed Smalltalk implements several of OMG's CORBAservices. These services extend CORBA to provide protocols for common operations like creating, exporting, and destroying objects (Lifecycle), locating objects (Naming), managing transactions, and providing asynchronous event notification.

Distributed Smalltalk provides the following CORBAservices:

Naming

Assigns an object a unique user-visible name. Names are used to identify and locate both local and remote objects.

Basic Lifecycle

Provides standard mechanisms for creating and initializing, deleting, externalizing (preparing for transmission to remote systems), and internalizing.

Event Notification

Allows objects to notify each other of an interesting occurrence using an agreed protocol and set of objects.

Concurrency Control

Enables multiple clients to coordinate access to shared resources. This service supports two modes of operation: transactional and non-transactional. Concurrent use of a resource is regulated with locks. Each lock is associated with a single resource and a single client. There are several lock modes: read/write/update and intention-mode.

Transaction

Provides the infrastructure supporting the ACID (atomicity, consistency, isolation, and durability) transaction properties for operations among multiple objects. There is support for multiple transaction models. This service also provides transaction wrappers for existing applications and support for transaction monitors.

Implicit Interface Invocation (I3)

DST includes an implicit interface invocation mechanism that provides Smalltalk-to-Smalltalk communication without the need for IDL. This is useful especially for rapid prototype development between a DST server and client. The interface is then easlity translatable into IDL for more general deployment.

2

Installing and Configuring DST

This chapter describes how to install Distributed Smalltalk into a VisualWorks image, and how to configure DST images as Naming Service servers and clients. This is the recommended configuration.

Installing Distributed Smalltalk

Distributed Smalltalk is provided as a collection of parcels with the standard VisualWorks distribution. Installation of the DST parcels is optional. Refer to the VisualWorks Installation Guide for instructions on installing the VisualWorks components.

DST Directory Structure

The DST parcels are installed with Distributed Smalltalk in the **`dst/`** subdirectory.

Under this directory are two further subdirectories, icons/unselect. This directory contains icon files required by DST, and so must be present.

Loading DST into the Image

To use the VisualWorks components, you load them into the Distributed Smalltalk image, typically using the Parcel Manager. The components you load depends on which features of DST you intend to use. These four commonly loaded components are listed in the Parcel Manager **Distributed Computing** folder:

DST_COS_Services

DST with CORBA COS services.

DST_I3

DST with Implicit Invocation Interface (I3) support, only.

DST_Tools_Development

Adds the DST Settings pages and Launcher menu.

DST_Sample

DST_COS_Services and DST_I3, plus the examples mentioned in the DST documentation.

Loading these components also loads their prerequisite parcels.

Configuring Naming Services

When dealing with multiple images on a single system or between systems, it is necessary to configure the following settings. You only need to do this configuration if you communicate with or connect to other images (ORBs).

IIOP Transport

Internet Inter-ORB Protocol that enables objects and applications to interoperate over a network with other OMG CORBA applications.

Naming Service

This service supports naming and locating local and remote objects.

Repository

A service used to share the interface repository on a remote system.

Configuring the Naming Service Server Image

1 Create a new image:

a Start a Distributed Smalltalk image. This image should have DST_Tools_Development loaded.

b Save a copy of that image, to be configured as the Naming Service server image.

In the main window, select **File > Save As**. In the resulting dialog, supply the name of the new image, such as “naming”.

2 If the DST main window is not open, execute the expression

```
DSTTool open.
```

3 Open the DST Settings tool (**File > Settings**).

4 Set the **IIOP Transport** settings.

   a From the Distributed Smalltalk main window, in the **Transports** menu, make sure that **IIOP Transport** is turned on (checked).

   b In the Settings notebook, select the **IIOP Transport** page.

   c In the **IIOP Port Number** box, select **Configured To**. Leave the port number unchanged.

   d If you changed a setting, click **Accept**.

5 Set the **Naming Service** to **Local**.

   a In the Settings notebook, select the **Naming Service** page.

   b Click **Local**.

   c If you changed the setting, click **Accept**.

6 Set the **Repository** to **Local**.

   a In the Settings notebook, select the **Repository** page.

   b Click **Local**.

   c If you changed the setting, click **Accept**.

7 Save the configured image.

8 Click **Start** in the Distributed Smalltalk main window to start the request broker.

Configuring a Naming Service Client Image

1 Create a new image:

   a Start a Distributed Smalltalk image. This image should have DST_Tools_Development loaded.

   b Save a copy of that image, to be configured as the Naming Service client image.

   In the main window, select **File > Save As**. In the resulting dialog, supply the name of the new image, such as “client01”.

2 If the DST main window is not open, execute the expression

```
DSTTool open.
```

3 Open the DST Settings tool (**File > Settings**).

4 Set the **IIOP Transport** settings:

   a From the Distributed Smalltalk main window, in the **Transports** menu, make sure that **IIOP Transport** is turned on.

   b In the Settings notebook, select the **IIOP Transport** page.

   c In the **IIOP Port Number** box, select **Dynamically Allocated**.

   d If you changed the setting, click **Accept**.

5 Set the **Naming Service** settings:

   a In the Settings notebook, select the **Naming Service** page.

   b Click **Hostname**.

   c Enter the hostname of the Naming Service server image (localhost, the machine name, and the IP address, are all acceptable entries).

   d Check that the port shown is the port that the Naming Service server image is configured to use for IIOP transport.

   e Click **Accept**.

6 Set the **Repository** settings:

   a In the Settings notebook, select the **Repository** page.

   b Click **Local**.

   c If you changed the setting, click **Accept**.

7 Save the configured image.

8 Click **Start** in the Distributed Smalltalk main window to start the request broker.

Advanced Configurations

This section shows how to configure a set of Distributed Smalltalk images so they can share the responsibility of providing locating, naming, repository and security services. The standard configuration,

in which all such responsibilities are centralized in a single image, is described above, in Configuring Naming Services. This section deals with more selective arrangements.

The DST Settings are used to obtain one or more of the services from a foreign image. First, this chapter explains the kinds of settings that are involved, and limitations that apply to them. Next, the benefits of sharing a master image's interface repository are explored. Finally, this chapter presents an example configuration involving three images that obtain services from one another.

Types of Settings

Each ORB image in a network of ORBs needs to know which ORB provides the Naming and Repository services and, if in use, the optional Security service. The DST Settings are used to identify the provider of each service, using either the provider's hostname or the name of a file containing an object reference to the provider. This section discusses each of these ways of identifying a service provider.

In addition, communications between ORBs require the use of a port number, which is also described in this section.

Filename

Some configuration pages in the DST Settings notebook provide a **Filename** field. This field is expected to contain the name of a file. The file is expected to contain an object reference to the ORB that supplies a particular service.

To export an object reference to a file, make sure your ORB is running, then execute the following:

```
ORBObject referenceToFile: 'filename' object: anObject
```

To get an object reference from a file, make sure your ORB is running, then execute the following:

```
ORBObject referenceFromFile: 'filename'
```

Port Number

In the DST Settings, port numbers can be dynamically allocated by Distributed Smalltalk, or you can specify them explicitly.

If you choose to let the system allocate a port number, it will change each time the ORB is restarted.

If you choose to specify a port number, it must be an integer between 1024 and 65536. Port numbers between 1 and 1023 are reserved. The port number can be reused in the Naming Service configuration.

Sharing an Interface Repository

In Distributed Smalltalk, each image contains an interface repository, which provides an object interface for each distributed service that is requested. Successful interaction among distributed objects requires that the interface repositories in all participating systems be identical. When they are not identical, errors will be reported and communication will be interrupted.

The shared interface repository service helps you maintain identical interface repositories on different systems. When you set up your systems to use a shared repository, one of the connected systems holds the master interface repository; other systems hold a subset of the master interface repository, which they build on an as-needed basis.

About the Master Interface Repository

Generally, the master interface repository should be on a system that is:

- Available at all times
- Easily accessed on the local- or wide-area network (to optimize communications overhead)
- Not stripped of the compiler and repository classes (classes in categories CORBA-Compilers and CORBA-Repository)

Systems That Share a Master Interface Repository

Other systems, which share the master interface repository, each start with a minimum set of interfaces in their local interface repositories (the minimum required for basic communications). When another interface is requested, it is loaded along with its superclass interfaces. These newly loaded interfaces are cached locally and retained for the remainder of the session. At the end of a session (when you stop the ORB), the interface cache is cleared.

When you are preparing to deploy an application that will run on a system with a shared interface repository, you can remove all classes in categories CORBA-Repository and CORBA-Compilers.

Establishing a Shared Repository

By default, each image has its own (nonshared) interface repository. You can change an image to use a shared interface repository by following these steps:

1 If a session is running, stop it. In the Request Broker panel, click on **Stop**.

2 Open a DST Settings window by selecting **File > Settings** in the **Distributed Smalltalk** main window.

3 In the Settings notebook, select the **Repository** page.

4 Supply either a **Filename** or a **Hostname** to identify the master interface repository.

Interface Version Control

Distributed objects can only communicate correctly through compatible interfaces. Each interface is identified by a RepositoryId. One of the fields in the RepositoryId is the version number and this version number can be modified by using the VERSION pragma. The default is version 1.0.

For more information on using version control, see Version Pragma in Chapter 9, “Mapping of IDL to Smalltalk”.

Advanced Configuration Example

As an example of an advanced configuration, suppose you want to connect three separate images as follows:

- Image 1 provides the user security database for all images.
- Image 2 provides the naming service for all images.
- Image 3 provides the repository for image 2.

In this case, you should configure the images as follows:

1 In Image 1:

   a Configure the IIOP ports to known ports.

   b Set the **Naming Service**, **Repository** and **Security** settings to **Local**. (The **Naming Service** will be reset later.)

   c Start the ORB.

2 In Image 1:

a Set the **Naming Service** to Image 2's **Hostname**.

3 In Image 2:

a Let the IIOP ports be dynamically allocated.

b Set the **Naming Service** to **Local**.

c For now, set the **Repository** to **Local**.

d Set **Security** to Image 1's **Hostname**.

e Start the ORB.

4 In Image 3:

a Let the IIOP ports be dynamically allocated.

b Set the **Naming Service** to Image 2's **Hostname**.

c Set the **Repository** to **Local**.

d Set **Security** to Image 1's **Hostname**.

e Start the ORB.

5 In Image 2:

a Set the **Repository** to Image 3's **Hostname**.

3

A Distributed Smalltalk Example

This chapter examines a simple DST application, DSTSampleComputeService. DSTSampleComputeService is designed to perform some expensive computation on a dedicated compute server and return the results to the caller. The server provides a named service that performs the computation, which a client applications can then request.

The initial implementation uses the DST I3 mechanism, for simple communication between two Smalltalk images. Later in the chapter, the interface is converted to IDL, so the service can be accessed by non-Smalltalk programs using CORBA services.

Preparing the Example

Load the Example Parcel

DSTSampleComputeService is installed separately from the development tools. To load the example, load both the DST_Sample and the DST_Tools_Development parcels using the Parcel Manager.

Configuring Images to Support the Example

Before you test the example, you must configure two Distributed Smalltalk images: a server image that runs the Naming service, and a client image requests the service from the server. This configuration is described in under Configuring Naming Services in Chapter 2, “Installing and Configuring DST”.

After both images are configured, go to the DST Settings (**DST** > **Settings**) in each image, check **Implicit Invocation Interface (I3)**, and click **ORB Running** in the DST menu.

Running DSTSampleComputeService

The DSTSampleComputeService example contains both server and client functionality, for simplicity. In most applications, this functionality would be factored into separate classes.

The server functionality responds to a request for its named service, DSTSampleComputeService, performs a computation, and returns the result to the request client.

To run the example, do the following:

1 In both images, enable the I3 transport on the IIOP page of DST Settings (**DST** > **Settings**) and click **ORB Running** in the DST menu.

2 In a workspace in the server image, evaluate (**DoIt**) the message:

```
DSTSampleComputeService createDefaultService.
```

This message creates an instance of the compute service and registers it with the ORB and Naming service.

3 In a workspace in the client image, evaluate the following messages:

```
| namingService aName objRef |

namingService := ORBObject namingService.
aName := DSTName on:
    (DSTName onString: 'DSTSampleComputeService').
objRef := namingService contextResolve: aName.
Transcript cr; show:
    (objRef slowComputationWith: 5100000 and: 5200000) asString.
```

Note that this is a very slow computation, and may take several minutes to return. The Transcript should show 5148001.

4 To disable the service, evaluate this message in a workspace in the server image:

```
DSTSampleComputeService destroyDefaultService
```

Exploring DSTSampleComputeService

DSTSampleComputeService is designed to run some expensive computation on a dedicated compute server. It provides a service method, slowComputationWith:and: which invokes another method to

perform the calculation, and returns the result. All other DSTSampleComputeService methods are support methods necessary to providing a distributed service or do the actual calculation.

Class Methods: naming

A crucial difference between developing applications in Distributed Smalltalk and in local Smalltalk is in retrieving well-known instances. In non-distributed Smalltalk, applications retrieve well-known instances from some globally accessible location in the local image. In order to share objects with other images, distributed applications must also retrieve shared objects from other images. The most common way to do this is through the CORBA Naming service.

DSTSampleComputeService manages its interactions with the Naming service through the class messages defaultService and destroyDefaultService in the naming protocol. DSTSampleComputeService uses a class variable, DefaultService, to hold the unique instance of the class. The class method createDefaultService returns the unique instance, creating it if necessary; destroyDefaultService destroys the instance.

createDefaultService

This method returns the unique instance of the compute service, creating it if necessary.

```
createDefaultService
    "Return the service.  If no instance exists, create
one and, register it with
    the naming service."

    "DSTSampleComputeService createDefaultService"

    DefaultService isNil
        ifTrue: [ DefaultService := DSTSampleComputeService
            new.
    ORBObject namingService contextBind: self serviceName
        to: DefaultService
        ].
    ^DefaultService
```

If the instance already exists, createDefaultService returns it; otherwise, it creates the instance.

Before requesting services from the Naming service, createDefaultService must get an object reference to the Naming service itself. The method gets that reference from the class

ORBObject. This class always holds valid references to the Interface Repository, Naming service, factory finder, and user security database.

After the instance exists, createDefaultService binds the instance to the name DSTSampleComputeService. Binding an instance to a name associates the name with the instance for the life of the image containing the Naming service.

After the instance has been created and bound to a name in the Name service server image (by sending the message DSTSampleComputeService createDefaultService), other images can get an object reference for DSTSampleComputeService by sending the contextResolve: message to the Naming service.

```
| namingService aName objRef |
namingService := ORBObject namingService.
aName := DSTName on:
   (DSTName onString: 'DSTSampleComputeService').
objRef := namingService contextResolve: aName.
```

destroyDefaultService

This message destroys the unique instance of the class.

```
destroyDefaultService
   "Remove the singleton instance of the service from the
class variable,
   the naming service, and the lifecycle service."

   "DSTSampleComputeService destroyDefaultService"

   ( DefaultService isNil )
      ifFalse:
      [  ORBObject namingService contextUnBind: self serviceName.
            DefaultService release.
            DefaultService := nil
      ]
```

The instance is destroyed in three steps. First the method unbinds the instance from the Naming service (destroys the association between the name and the instance), then it releases the instance, and finally it resets the instance variable to nil. An instance must be unbound before it is released.

Instance Methods: initialize-release

These are the standard instance creation and destruction methods.

```
initialize
    "Register instance with lifecycle service"

    DSTObjRef registerObject: self

release
    "Remove reference to object from lifecycle service."

    DSTObjRef unRegisterObject: self
```

Because instances of this class must interact with remote objects, each instance should be registered with the ORB when it is created, and unregistered when it is no longer useful.

Instance Methods: computing

There are several computation methods, providing alternate calculations. At this point, we are only concerned with slowComputationWith:and:.

slowComputationWith:and:

The slowComputationWith:and: method invokes another method, carmichaelNumber:, which actually performs the computation. Neither method contains DST-specific code.

```
aPositiveInteger1 to: aPositiveInteger2 do:
    [ :n | ( self carmichaelNumber: n ) ifTrue: [ ^n ] ].
^0
```

Browse other calculation methods for implementations. These calculation methods can be invoked directly, by replacing the Transcript display and calculation line in the workspace with, for example:

```
5100000 to: 5200000 do: [ :n | (objRef carmichaelNumber:
n)
    ifTrue: [Transcript cr; show: n] ]
```

Adding IDL Interfaces

This section demonstrates how to convert an I3 application into an IDL-interface application, by creating IDL interface definitions.

A sample IDL module is provided, as well as required methods that you can rename and use for the rest of the example. In this example, you will edit the sample to configure both the server and client images with their own local IDL repositories. Although it is possible for Distributed Smalltalk images to share a single repository, we will not use that feature here.

Editing the Sample IDL

A complete IDL module for the computational methods in DSTSampleComputeService is provided, together with the CORBAName and abstractID methods required to support service lookup. They are, however, named differently than is required. You can simply rename the sample definitions and proceed.

To use these definitions:

1 In the server image, browse the DSTRepository class, DSTSampleComputeService0 method in the **DEMO** method category. Past the comment lines, find the line:

```
module DSTSampleComputeService0 {
```

and remove the 0, so it is now:

```
module DSTSampleComputeService {
```

Accept the change. You now have a DSTSampleComputeService method.

2 Also in the server image, browse the DSTSampleComputeService class in the browser, and select the **repository** method category. Edit the method selectors, changing:

CORBAName0 to CORBAName, and

abstractID0 to abstractID.

Accept the changes. You now have new methods matching the required names.

3 In each client image, make the same change as in step 1, renaming the module to DSTSampleComputeService.

The CORBAName and abstractID methods are not needed in the client images, so you don't need to do anything with them. You are now set to proceed with .

Running DSTSampleComputeService with IDL

You test the example with IDL interfaces exactly as before:

1 Turn off I3 in both server and client images, by unchecking **Implicity Invocation Interface (I3)** in DST Settings.

2 In a workspace in the server image, send the message

```
DSTSampleComputeService createDefaultService
```

This message creates an instance of the compute service and registers it with the ORB and Naming service.

3 In a workspace in the local image, send the following messages:

```
| namingService aName objRef |

namingService := ORBObject namingService.
aName := DSTName on:
    (DSTName onString: 'DSTSampleComputeService').
objRef := namingService contextResolve: aName.
Transcript cr; show:
    (objRef slowComputationWith: 5100000 and: 5200000) asString.
```

This is the same workspace as we used for the I3 example. The Transcript should show 5148001, though the processing may be slow since this is a slow computation.

4 In a workspace in the server image, remove the service from the ORB and naming services by sending the message

```
DSTSampleComputeService destroyDefaultService.
```

Instance Methods: repository

When browsing these methods, realize that they are not yet assigned to either a parcel or a package. Browse by Category or select **Unparceled**.

abstractClassID

The abstractClassID method returns a unique identifier for the class, for example (the identifier in your image will be different from the one shown here):

```
abstractClassId
    "return the abstract class Id of the receiver"
    ^'7883b3d3-3fe7-0000-02c7-bec093000000' asUUID
```

This number is generated uniquely for each class. Never copy this identifier from one class to another. Whenever you create a new class, create a new abstractClassID by sending the ORBObject newId message and copying the returned value into the new class's abstractClassID method.

CORBAName

The CORBAName method provides the link between a Smalltalk class and its IDL definition. When invoked, the method returns the symbol corresponding to the IDL definition's entry in the Interface Repository.

```
CORBAName
    "return the name of my CORBA interface in the repository"
    ^#'::DSTSampleComputeService::DSTSampleComputeServiceInterface'
```

IDL Definition: DSTRepository>>DSTSampleComputeService

To examine the IDL definition itself, browse the DSTRepository method DSTSampleComputeService. This method, which is written in IDL rather than Smalltalk, looks like this (with the lengthy comment omitted):

```
// DSTSampleComputeService
// This module defines the types and interfaces which
form the DSTSampleComputeService
// protocol or service.
//
module DSTSampleComputeService  {

        #pragma  selector slowComputationWithAnd
            slowComputationWith:and:
        // This computation is not really slow enough to justify
a remote
        // message send.
        unsigned long long slowComputationWithAnd (
                                in unsigned long a,
                                in unsigned long b);
    };
};
```

Note: If instead you renamed the provided IDL method DSTSampleComputeService0, the code is somewhat longer, providing more IDL interfaces.

IDL syntax is discussed in detail in Chapter 8, “Defining IDL Interfaces”. For now, examine the line that actually describes the method:

```
unsigned long long slowComputationWithAnd (
    in unsigned long a,
    in unsigned long b);
```

In particular, examine the datatypes that are assigned IDL datatypes to the return value and the arguments of the slowComputationWith:and: message. Getting the datatypes incorrect is a major issue in distributed computer, so take care to select appropriate values, as described in Chapter 9, “Mapping of IDL to Smalltalk”.

4

System Architecture

Summary of Services

Distributed Smalltalk lets you develop and deliver *distributed* applications, that is, applications built with objects that may be running at different locations and on different systems. To do this, Distributed Smalltalk provides a range of services, from example code and developer's tools, to a full implementation of industry standards for distributed object systems.

Service layer	Service provided	
Developer Services	Administrative interface, Conversation monitoring, IDL interface generation, Interface Repository browsing	Remote class browsingRemote debuggingSimulated RPC testing
Object Services and Policies	Naming, Event notificationLifecycle (basic and compound)Concurrency & TransactionsRelationships (links, containment)Properties and property sets	Distributed Smalltalk specific:Application objects and assistants Presentation/ Semantic split
Core Services (CORBA)	Object Request Broker, with: IDL compiler Interface Repository	Static & Dynamic invocation interfaces
Communication Support	RPC (NCS 1.5.1) conversations and packet transfer (Distributed Smalltalk to Distributed Smalltalk communication only)Internet Inter-ORB Protocol (IIOP) — CORBA 2.0 specifies this protocol that enables objects and applications to interoperate over a network with other OMG CORBA applications	

Object Services and Policies

VisualWorks implements OMG's *CORBAservices Volumes 1 and 2* specification that extends CORBA to provide protocols for common operations such as creating and destroying objects (lifecycle), locating objects (naming), and asynchronous event notification.

Naming Service

A standard for assigning each object a unique user-visible name. Naming policies set a standard for identifying and locating objects in both local and remote images, and in non-Distributed Smalltalk systems. Distributed Smalltalk provides a complete naming service based on the containment model of object organization. Application developers can use this service as implemented, or create their own naming services from Distributed Smalltalk's basic naming policy and interface support. (The naming service is specified in OMG's CORBAServices)

Event Notification Service

This service allows objects to notify each other of interesting occurrences using agreed protocols. The Distributed Smalltalk implementation of event notification provides decoupled, asynchronous communication between objects. It allows graceful object interactions even when objects are temporarily unavailable because the network or a remote system is "down." Developers can extend the event notification service to support specific types or levels of service. (The event notification service is specified in OMG's CORBAservices)

Basic Lifecycle

Standard ways for objects to implement activities such as create and initialize, delete, copy and move both simple and compound objects, externalize, and internalize.

Concurrency Control Service

This enables multiple distributed objects to coordinate access to shared resources. There is support for two modes of operation: transactional and non-transactional. Concurrent use of a resource is regulated with locks. Each lock is associated with a single resource

and a single client. There are several lock modes: read/write/update and intention-mode. (The concurreny control service is specified in CORBAservices)

Transaction Service

The Transaction Service defines interfaces that allow multiple, distributed objects to cooperatively to provide transaction atomicity, consistency, isolation, and durability (ACID properties). There is support for multiple transaction models, including the flat and nested models. Also, transaction wrappers are provided for existing applications and support for transaction monitors. (The transaction service is specified in CORBAservices).

Persistence

Distributed Smalltalk implements persistence within the Smalltalk image and does not conform to the CORBAservices standard.

Implementation of the CORBA Specification

The Object Request Broker and the services it provides are at the core of Distributed Smalltalk. The ORB and its components provide the services that allow object systems, objects, and applications to interoperate.

Components of the ORB

CORBA 2.0 or the Object Management Group's *Common Object Request Broker Architecture*, is the industry-standard specification for an ORB architecture. The CORBA specification describes the following core services as part of an ORB:

Interface Definition Language (IDL) Compiler

OMG has defined the IDL language to be independent of other programming languages. IDL is used for public interfaces, so that both service providers and service requestors can be written in Smalltalk, C, C++, or another language. See Chapter 8, "Defining IDL Interfaces", and for instructions on using IDL and Smalltalk-to-IDL mappings.Chapter 9, "Mapping of IDL to Smalltalk".

Interface Repository (IR)

The registry of distributable object interfaces for a given system. Any object that remote objects can access has an interface in the Interface Repository. IR interfaces are written in the OMG-defined IDL, thus allowing language independence and interoperability for service providers (servers) and requestors (clients).

Static Invocation Interface (SII)

The SII supports requests for specific operations on remote objects and surrogate object creation. One of two invocation interfaces specified by CORBA, the SII is a better choice for Smalltalk applications, since the invocation of the static interface is dynamic in Smalltalk.

Dynamic Invocation Interface (DII)

The DII supports dynamic object request building and sending, thus providing an alternative to the SII for languages that do not support dynamic binding. The DII is included in Distributed Smalltalk for completeness, but it is not recommended.

While Distributed Smalltalk supports DII as specified, it is not recommended for use. Smalltalk supports dynamic binding, and thus DII is redundant and inefficient. (For more information on DII, see the implementation of the two classes that support dynamic invocation: ORBNVList and ORBRequest.)

CORBA Terminology

The CORBA specification defines the following terms and concepts:

ORB

CORBA specifies an Object Request Broker (*ORB*) to serve as the interface that isolates external service requestors (*clients*) from internal service providers (*objects*).

Clients send service requests to an ORB. When the ORB receives a request, the ORB translates it into the local implementation language (for example, Smalltalk), then locates the object that will provide the service, and forwards the request to the object. When the request is complete, control and output values are returned to the client.

object

An encapsulated entity that provides one or more services that can be requested by a client. Sometimes referred to as a *server object* or a *CORBA object*.

Smalltalk objects are more numerous than CORBA objects. While some of the Smalltalk objects are also CORBA objects, most provide support services within an image and are not accessible to external service requests from clients.

Objects in Distributed Smalltalk can function both as CORBA clients and CORBA objects, that is, both as requesters and providers of services.

client

An entity capable of requesting a service. A client need not be implemented in an object-oriented language. A client requesting services need not know where the object is located, nor how it is implemented.

Within and between Distributed Smalltalk images, objects interact as peers, without the implied hierarchy of clients and servers. Each object requests and/or provides services as necessary.

request

The communication between a client and an object. A request specifies: (1) an operation to be performed, (2) an object reference identifying the object that will perform the service, and (3, optionally) parameters that the object needs to perform the request.

interface

Defines which tasks (*operations*) a CORBA object can do and what information it needs to do those tasks. An object's interface is distinct from its implementation. Interfaces are stored in the *Interface Repository*, within the ORB.

IDL

Interface Definition Language. An implementation-neutral language specified by OMG as part of the CORBA core services. In all CORBA-compliant systems, interface definitions are written in IDL. By sending messages written in IDL between systems, objects implemented in different languages can communicate.

object reference

Identifies the server object, acting as an intermediary between client and object. An object reference identifies the same object each time the reference is used in a request. A single object may be denoted by multiple, distinct object references.

Distributed Smalltalk's ORB Implementation

Distributed Smalltalk includes a complete implementation of CORBA 2.0 that includes Internet Inter-ORB Protocol (IIOP). This protocol enables objects and applications to interoperate over a network with other OMG CORBA applications. This section provides an overview of the OMG CORBA implementation.

Distributed Smalltalk's ORB extends VisualWorks to support communication with objects that may be in the current local image, *or* in another image running either locally or remotely. Access to remote objects is generally transparent to the Smalltalk programmer; however, when defining an object that will be accessible remotely, the programmer must define an IDL interface (including operations) for it.

Interface Definition Language (IDL) Compiler

In Distributed Smalltalk, class IDLCompiler implements the IDL parser/compiler. IDL is a compiled language. (When you add or make changes to interface definitions in the Interface Repository, it will recompile.)

Note that the IDL compiler does not support ValueTypes.

Interface Repository (IR)

Class DSTRepository is the repository for CORBA object interfaces that are available for access by remote clients in Distributed Smalltalk. Interface definitions in DSTRepository specify the messages, or operations, that can be sent between objects in different images, as well as attributes, types, constants and exceptions. Before you can communicate with objects outside the current local image, you must define interfaces for these objects in the Interface Repository.

Of course, not all Smalltalk objects are CORBA objects, and only CORBA objects need an interface.

DSTRepository modules contain IDL (the Interface Definition Language); this is the only Distributed Smalltalk class where an application developer needs to write in IDL. For information on working with interfaces and IDL Syntax, see Chapter 10, "Working with Object Interfaces".

Invocation Interface

As specified in CORBA, the invocation interface handles message sending and object invocation. While both the Dynamic and Static Invocation Interfaces are available in Distributed Smalltalk, it is more efficient to use the Static Invocation Interface, since dynamic binding is already provided by the Smalltalk language itself.

Sending Messages via Surrogates and Object References

In making a service request, a client need not know where a server object is located in order to send it messages. If the server is on the same system as the client (that is, local), the request is a normal Smalltalk request. However, if the server is on a remote system, the ORB gets involved to intercept and forward the message appropriately.

When a client requests a service, Distributed Smalltalk either sends the message directly to the object, if it is local, or to the *object reference*, if the object is remote. (An object reference identifies the server object, acting as an intermediary between client and object.) Object references act as publicly available *surrogates* for remote objects.

Specifically, since the surrogate cannot implement the operation (method) requested, it sends itself the message doesNotUnderstand:. Distributed Smalltalk traps the doesNotUnderstand: message and uses its own mechanisms (including the ORB and RPC) to locate and communicate with the remote object.

Results returned to the client appear exactly the same, whether the message went to a local or remote object. (The only difference a programmer or end-user sees is that the performance of a remote object request is, naturally, somewhat slower than that of a local request.)

> Note: During remote execution, the local process thread is blocked until the result values have been received and decoded into internal Smalltalk representation. At that point, the local thread is resumed and local execution continues.

Implementing Surrogate Objects — DSTObjRef

DSTObjRef and its subclasses are instantiated to create the surrogates for remote objects. A direct subclass of Object, DSTObjRef provides the basic mechanisms for transparent distribution using the ORB RPC mechanism.

- In a local object message invocation (“local” with respect to the client system), message invocation is unaffected by these distribution mechanisms.

  If the server object is a remote object, then the client holds an object reference that is an instance of DSTObjRef or one of its subclasses. Since this instance has none of the methods which the client object is expecting of the server, the local message send results in a #doesNotUnderstand: call instead. The method #doesNotUnderstand: is overridden so that it actually starts the remote RPC operation (see also #perform:on:, implemented in DSTObjRef, DSTObjRefWidened, and DSTObjRefLocal). Smalltalk objects may be referenced directly, or also via instances of DSTObjRef subclasses:

- Inactive — Local objects which normally exist within this image but which are currently residing as passive data on a mass storage device, such as an ODBMS, may be referenced by a suitable DSTObjRefInactive instance.

- Local — Local objects may be referenced by a DSTObjRefLocal so that messages sent to them will be processed by the ORB instead of the normal method invocation.

- Remote — Objects which exist on remote systems are accessed locally via an instance of a DSTObjRefRemote.

- Widened — Local objects may choose to allow a subset of their most derived interface operations to be made available to clients by returning a suitable DSTObjRefWidened instance as a result value rather than self.

Object Identification

In Distributed Smalltalk, the CORBAName is the tie between an interface and its corresponding implementation. That is, any object that has an interface (that is, a CORBA object), must implement the CORBAName method, which specifies the interface name. When the ORB receives an incoming request, it locates the interface in the Interface Repository, and the Smalltalk class by this CORBAName.

For information on writing and using CORBAName methods, see Chapter 10, "Working with Object Interfaces".

Object Creation Using Factories and Factory Finders

As in standard Smalltalk, classes function as what CORBA refers to as *factories*, templates for creating object instances. The ORB uses its factory finder to locate a class. That is, when a client requests a service of an uninstantiated (non-existent) object, the ORB is able to instantiate the object if its class has been registered with the factory finder.

To register with the factory finder, a class needs the method abstractClassId, which returns a UUID (universally unique identifier) for the class.

For information on writing and using abstractClassId methods, see Chapter 10, "Working with Object Interfaces".

Marshaling and Unmarshaling

The ORB is also responsible for converting Smalltalk objects into a byte stream for transmission to a remote server, a process called *marshaling*. (Unmarshalling creates a Smalltalk object from a marshaled byte stream.)

5

The DST Development Process

Choosing a Paradigm

DST offers two development paradigms: Implicit Invocation Interface (I3) and IDL-interface.

- IDL-interface supports all the interfaces specified in the CORBA 2.1 Smalltalk mapping. In this paradigm, developers explicitly describe the interfaces of distributed classes using the IDL language.
- I3 is an enhancement to IDL-interface that provides a more natural Smalltalk development paradigm. I3 allows developers to create distributed Smalltalk applications without having to define IDL interfaces.

Each of the two development paradigms has its advantages. The following table lists factors that might encourage you to choose one over the other.

Comparison of I3 and IDL-Interface Development Paradigms

Design Goal	I3	IDL-interface
Prototype quickly and easily	x	
Use natural Smalltalk development paradigm	x	
Interoperate with non-Smalltalk applications or with other ORBs		x
Achieve maximum performance		x
Define external interfaces explicitly		x

It is straightforward to take an application developed with I3 and create explicit interfaces for all or part of it. This means that an application can be developed under any of three paradigms: I3; IDL-interface; or prototype in I3, then add IDL interfaces later.

Issues in Distributed Computing

The architecture and implementation of Distributed Smalltalk facilitates, but does not dictate, distributed application design. To make your applications robust and efficient, you should understand both basic distribution concepts and how to use Distributed Smalltalk to your best advantage. This section introduces some of the issues you should consider while you are designing distributed applications.

Optimizing Distributed Resources

A distributed environment can provide a rich environment and a variety of resources. However, network traffic can be a performance bottleneck, unless your system optimizes communications, network traffic, and processing resource sharing. While the most powerful workstations and servers on a network should perform the most difficult processing, transfering information across the network should also be kept to a reasonable minimum.

Wise use of Distributed Smalltalk's *presentation/semantic split* can help you optimize both processor and network resources. For suggestions on using the presentation/semantic split, see Chapter 5, "The DST Development Process".

Remote System Autonomy

In a distributed computing environment, the local system cannot control remote systems or the networks that connect them. This issue is critical in a distributed object environment, where collaborating objects and clients requesting object services can "live" in more than one image, and on both local and remote systems.

Distributed Smalltalk provides graceful ways to handle situations when a network or remote system becomes unexpectedly unavailable, including:

- Link policies allow various levels of existence guarantees between objects that make up an application.

- Lifecycle policies allow correct creation, destruction, copying, and moving of applications that contain objects existing in different images.
- Event notification policies allow delayed delivery of messages in case of temporary network unavailability.

Shared Objects

A strength of distributed systems (and a challenge to software developers and administrators) is that more than one user may have access to any given object. Shared information is one of the most important advantages of distributed computing.

Distributed Smalltalk's fundamental architecture supports multiple representations of shared objects, using the presentation/semantic split. This way, different users can see different presentations, while the underlying object and its information remain consistent for all users.

Interoperability Through Standards Compliance

Communication between objects on different systems, and written in languages other than Smalltalk, is only possible if they support standard interfaces and use the same network protocol.

VisualWorks implements OMG's CORBA core and CORBAservices, Internet Inter-ORB Protocol (IIOP) and other standards including NCS RPC.

IIOP is the CORBA 2.0 protocol that specifies objects and applications to interoperate over a network with other OMG CORBA applications.

In addition, Distributed Smalltalk's Interface Definition Language (IDL) implementation provides a language-neutral interface between objects created in both Smalltalk and other programming languages.

Creating Applications with Distributed Smalltalk

As with any object-oriented software project, the process of designing and implementing an Distributed Smalltalk application is iterative. You are likely to revise and refine the initial design as the application needs become clearer or change.

In general, the development processes for the I3 interface is simpler than for the IDL-interface, since you do not have to create and register the IDL.

During each iteration, you follow these basic steps:

1 Design. Refer to Chapter 6, “Designing and Implementing””

2 Implement objects. Use standard object-oriented design and analysis tools to create the basic design. Then, use the structures that Distributed Smalltalk provides to refine the design for making effective distributed applications. Be sure the application runs successfully in a local environment before distributing it.

3 Write IDL. Refer to Chapter 8, “Defining IDL Interfaces”. Write IDL that will reside in the Interface Repository to support communication between distributed objects.

4 Register interfaces. Refer to Chapter 10, “Working with Object Interfaces”. When you create new distributable classes, you define identifier methods that CORBA objects need to be registered with the factory finder and the Interface Repository. Classes that can be instantiated in response to remote client requests must be registered with the local *Factory Finder*. The interfaces for all new and changed objects that can respond to remote requests must be registered in the *Interface Repository*.

5 Test, tune, and distribute. Refer to Chapter 17, “Debugging and Tuning”. Use Distributed Smalltalk’s simulated remote testing tools to verify the interfaces specified in the Interface Repository, track messages, and tune performance.

   Once the application is tested and tuned, you can distribute it to other systems that are running Distributed Smalltalk. Be sure to update the Interface Repository for all images.

6 Create a runtime package (optional). Refer to Chapter 18, “Creating a Deployment Image” If you wish to distribute the application as a runtime system, you can remove unneeded classes. This helps you create applications that are protected and require minimal system resources.

There are, of course, variations on this general procedure. In some development models, the first step might be defining the IDL interfaces and then doing the Smalltalk implementation.

6

Designing and Implementing

The design of distributed systems is a complex topic, on which many books have been written. This chapter highlights only some of the more common issues that you should consider when designing Distributed Smalltalk applications. See the Bibliography for some suggestions for further reading.

General Design

Sharing Objects

Distributed objects, by their nature, are shared. Because distributed objects can be accessed by multiple images running on different processors, they are effectively executing in a multi-threaded environment.

The effect of this is that you cannot send two messages in succession to a remote object and assume that the object's state when receiving the second message is identical to the object's state immediately after processing the first message; another image may have sent intervening messages to the object that changed its state. Use the Transaction and Concurrency services to preserve object consistency.

Creating and Destroying Objects

Use the Lifecycle service, not the `new`: message, to create remote objects.

If you create remote objects by sending instance-creation messages to their classes, the objects will get garbage collected, because no objects on the remote machines will hold references to them. Create and destroy remote objects with the Lifecycle Service.

Referencing Remote Objects

Remote object references can become invalid without warning. If a machine goes down or there are network problems, a valid object reference can become invalid between one message and the next. It is the designer's responsibility to trap unprocessed remote messages and recover gracefully.

Object references are short-lived; they cannot outlive the process that contains their ORB. You cannot assume that an object reference is valid across image invocations. While the client image was not executing, the remote object may have been deleted, moved, or modified. Applications must retrieve their remote object references anew whenever they begin executing.

Performance Considerations

Performance issues are very important in a distributed application, since too much delay in a transaction can effectively cripple an application. The following suggestions may help improve your application's performance.

- Local information should be local; shared information should be distributed.

  This is a platitude, but it's an important design consideration nonetheless. Many of the objects in a Distributed Smalltalk application will not have CORBA interfaces. There are performance costs to making objects distributed, and designers should not incur those costs unless they are necessary.

- Remote messages are costly.

  Remote message sends are approximately a hundred times slower than local message sends. The latency for remote messages is measured in milliseconds; the latency for local messages is measured in microseconds. Since the overhead for a remote message is so high, you should design to make each remote message give as much value as possible.

- The expense of remote messages increases with the size of the objects being marshalled.

  It is slower to transmit a 1000-element Dictionary than to transmit an Integer. Where possible, design so that large objects are transmitted rarely.

There is a conflict between the last two suggestions. You must trade the two off against one another depending on your application's goals and constraints.

Avoiding Traps

There are some common traps in designing a distributed application. To avoid these, follow these suggestions:

- Keep class definitions synchronized in local and remote images.

  Any object that is passed by value (in attribute parameter) must have identical instance variables, declared in the same order, in both images. In general, be sure to propagate instance variable changes to all images.

- Avoid passing blocks in remote messages. Blocks are not usually meaningful outside their local context; in particular, they are not meaningful to non-Distributed Smalltalk applications.

7

Implicit Invocation Interface (I3)

The Implicit Invocation Interface (I3) provides a Smalltalk-to-Smalltalk mechanism for developing Distributed Smalltalk applications. Instead of explicitly specifying their distributed classes' interfaces in IDL, developers can turn on the I3 message transmission mechanism and allow I3 to handle object marshalling and unmarshalling. I3 is useful for rapid prototype development of a distributed application, as well as for developing a purely Smalltalk distributed application.

This chapter discusses how to develop applications that take advantage of I3.

How I3 Works

I3 is a mechanism for message transmission. When I3 is turned on, remote messages that have IDL operation definitions are sent by the normal mechanism; remote messages that have no IDL operation definitions are sent by the I3 mechanism. When I3 is turned off, remote messages that have no IDL operation definition fail.

Whether a particular message is transported by I3 or through an IDL interface is determined per-message, not per-class. Two ORBS that both have I3 message transmission turned on can send and receive messages that do not have IDL operation definitions, no matter what class sends or receives the message. For convenience, this chapter refers to classes that have no IDL interface definition of their own as interfaceless classes, and to messages that have no corresponding IDL operation definition as interfaceless messages.

One of the functions of the operation definitions in an IDL interface is to give the ORB information on how to marshall and unmarshall messages. Since not all methods in an image with I3 enabled have

operation definitions, it is up to the class developer to provide marshalling hints. These hints can be provided on a per-class or a per-instance basis, as appropriate.

Required Methods

All classes whose instances may be passed or returned in remote message sends without IDL operation definitions must understand the instance method isPassedByValue.

This method determines how instances of the class are treated when they are passed as arguments to a remote message. If an object's isPassedByValue method returns true, then instances of the class are passed by value: the receiver gets local copies of the instances. (If the receiver modifies the copies, the changes are not propagated to the sender.) If an object's isPassedByValue method returns false, then instances of the class are passed by reference: the receiver gets remote object references to the instance, and the receiver can both read and modify the objects referred to by those references.

By default, objects are passed by reference. However, some base classes are passed by value. The following table shows which base Smalltalk classes are passed by value.

Smalltalk Classes I3 Passes by Value

BOSSCompiledCodeHolder	BOSSContents	BOSSRegisteredObject	Class (only class name is passed)
Collection (except SystemDictionary)	CompiledBlock	DSTI3ObjRef	Exception
Filename	Geometric	Magnitude	Menu
Message	Metaclass	ReadStream	RemoteString
Signal	UndefinedObject	UninterpretedBytes	

If you are creating an isPassedByValue method for a class, you need to decide whether instances of the class are allowed to override the class's pass-by-value setting.

If instances are allowed to override the class's setting, the isPassedByValue method should look like the following:

```
isPassedByValue
    ^self isPassedByValueDefault: aBoolean
```

where you replace aBoolean by either true or false.

> **Note:** No class should override the isPassedByValueDefault: method.

If instances are not allowed to override the class's setting, the isPassedByValue method should look like:

```
isPassedByValue
    ^aBoolean
```

where you replace aBoolean by either true or false.

Instance Methods

To change the way in which an instance is passed, the developer sends the passByValue or passByReference messages, as appropriate. If the class's isPassedByValue method does not invoke isPassedByValueDefault:, the passByValue and passByReference messages are ignored.

Developers can specify how each of an object's instance variable should be passed by overriding passInstVars. passInstVars returns an array containing one entry for each of the object's instance variables; the array entries specify how the instance variables are passed. Each entry in the array must be #true, #false, #ref, or #value.

Meaning of Entries in passInstVars Argument Array

Value	Interpretation
#true	Pass this instance variable as specified by its class's isPassedByValue method.
#false	Pass nil instead of this instance variable.
#ref	Pass this instance variable by reference.
#value	Pass this instance variable by value.

If a class overrides the default passInstVars method, the passInstVars settings takes precedence over the passing strategy for any individual instance, which in turn takes precedence over the passing strategy for the class.

Return Values

Marshalling of return values is controlled by the class definitions in the image that is returning the value. Objects are returned by value if their classes are passed by value, or if the returned instance has received the passByValue message. All other objects are returned by reference. The sender can determine whether a returned object is local (passed by value) or remote (passed by reference) by sending the object the isLocal or isRemote messages.

Passing Classes

By default, all classes are passed by value; the value passed is the class's name. The receiving ORB looks for a class with a matching name and uses it.

> Caution: It is the developer's responsibility to keep classes on all ORBs identical. DST will not detect incompatibilities between classes on remote and local ORBs. If classes with identical names have different instance variables or instance variables in different orders, the application will not behave as expected.

I3 Instances and Garbage Collection

In general, remote objects are garbage collected unless some object in the same image holds a reference to them. There are two methods of explicitly preventing remote objects from being garbage collected: through the lifecycle service, and implicitly through I3.

- Since the Lifecycle service depends on the corbaName and abstractClassID methods, you cannot conveniently use it with interfaceless objects.
- When I3 is active, all objects passed by reference (or returned by reference) through I3 messages are protected from garbage collection for the life of the ORB on the image that passed or returned the objects. If you stop an ORB, any objects that had no

local references will be subject to garbage collection, and object references to those objects in remote images can become invalid.

I3 Traps

- Because I3 is a Distributed Smalltalk extension to CORBA, messages that have no IDL operation definition cannot be sent from or received by non-DST ORBs.
- If an application attempts to modify an object that was passed or returned by value, the local copy of that object is modified; the change does not propagate to the remote object. Developers be consistent when handling objects passed by value.
- Developers should be careful not to destroy remote instances until they have verified that no other image has object references to those instances.

8

Defining IDL Interfaces

The language-neutral Interface Definition Language (IDL) is a declarative language used to describe interfaces that client objects call and object implementations provide. All ORBs speak IDL as their common language, and you use IDL to define the interfaces for an application's remotely-accessible objects. In these interfaces, you define the externally visible functionality of each object (but you implement this functionality elsewhere in VisualWorks Smalltalk). A critical part of an ORB's activities is the translation service (via a language binding) between the local language (such as Smalltalk) and IDL.

The interface definition specifies the operations the object is prepared to perform, the input and output parameters required, and any exceptions that might be generated. The interface constitutes a contract with clients of the object, who use the same interface definition to build and dispatch invocations as the object implementation uses to receive and respond to these requests.

Interfaces form the backbone of the IDL framework. A "good" set of interfaces embodies a coherent structure that clearly defines how a service, or set of services, can be used.

This chapter describes the basic IDL syntax. It provides an introduction to coding in IDL, and describes how to declare:

- Modules
- Interfaces
- Constants
- Data types
- Operations

- Exceptions
- Attributes

It also provides information about:

- Inheritance
- IDL preprocessing
- Scopes

SeeChapter 9, “Mapping of IDL to Smalltalk” for information about how Smalltalk-to-IDL language binding is implemented in Distributed Smalltalk, and how to use it.

Comparing Smalltalk & IDL

Smalltalk is a general-purpose programming language; IDL is an interface definition language, which specifies interfaces but does not (and cannot) specify implementation.

Smalltalk is a dynamically typed language, one in which the type of an object is defined by the set of messages it can process. IDL is a statically typed language, which specifies the type of each argument to a message at IDL compilation time. As a result, IDL definitions can seem unnecessarily restrictive to Smalltalk programmers.

Basic IDL Syntax

The IDL grammar is a subset of ANSI C++, with additional constructs to support the operation invocation mechanism. IDL, which is a declarative language, supports the C++ syntax for constant, type, and operation declarations; it does not include any algorithmic structures or variables.

An IDL specification consists of one or more interfaces declared in one or more IDL files. Interfaces are usually organized into modules, which represent services such as “mail services” or “display services.”

By convention, a source file containing interface specifications written in IDL has an .idl extension. For example, the file orb.idl contains IDL-type definitions.

See Chapter A, “IDL Lexical Conventions” for a description of IDL lexical conventions.

IDL Specification

An IDL specification consists of one or more type definitions, constant definitions, exception definitions, or module definitions. The syntax is:

```
<specification>::= <definition>+
<definition>    ::= <type_dcl>“;”
                |   <const_dcl>“;”
                |   <except_dcl>“;”
                |   <interface> “;”
                |   <module> “;”
```

Refer to the following sections for further expansion of these definitions.

Declaring Modules

The module construct is used to scope IDL identifiers (see Names and Scopes). You should limit each IDL file to either a single module or a set of small modules that are related to each other.

A module declaration takes the form:

```
module identifier
{
   module_definition;
   […]
};
```

Example

```
module CentralOffice  {
   interface Depot {
      #pragma  selector find_item_info
         findItemInfo:barCode:quantity:itemInfo:
      void find_item_info (
               in AStore::AStoreId store_id,
               in POS::Barcode item,
               in long quantity,
               out AStore::ItemInfo item_info)
               raises (AStore::BarcodeNotFound);
      };
};
```

Note: A module frequently includes two or more related interfaces. For example, when a single logical object is split between presentation and semantic objects, the module would include interfaces for both.

The identifier is a scoped name of a module.

The module_definition can include:

- Type declarations (see Declaring Data Types)
- Constant declarations (see Declaring Constants)
- Exception declarations (see Declaring Exceptions)
- Interface declarations (see Declaring Interfaces)
- Another module

Getting Information About a Module

To search a module registered in the ORB's Interface Repository for the module contents, use either of the following methods to access it:

```
ORBObject class >> lookupName:levels:limit:excludeInherited:
ORBObject class >> lookup:
```

You can also use the IR Browser.

Declaring Interfaces

An interface declaration, which provides the information needed to develop clients that use the interface's operations, takes the form:

```
interface identifier
{
    [interface_definition;
    […;]]
};
```

The identifier, which defines a new legal type name representing a reference to an object, can be used anywhere a type name is legal. For example, it can be used as a parameter or return value of an operation, or as a member of a struct or union. Since an identifier represents a reference to an object, the meaning of a parameter or member that uses that name is the same as a reference to the object supporting the interface. Empty interfaces are legal in IDL.

Example

```
interface Store {
    readonly attribute AStoreId store_id;
    readonly attribute float store_total;
    readonly attribute float store_tax_total;
    #pragma selector login login:
    StoreAccess login (in POS::POSId id);
    #pragma selector get_POS_totals getPOSTotals:
    void get_POS_totals (out POSList POS_list);
    #pragma selector update_store_totals updateStoreTotals:price:taxes:
    void update_store_totals (in POS::POSId id, in float price,
     in float taxes);
};
```

The interface_definition can include:

- Type declarations (see Declaring Data Types)
- Constant declarations (see Declaring Constants)
- Exception declarations (see Declaring Exceptions)
- Operation declarations (see Declaring Operations)
- Attribute declarations (see Declaring Attributes)

Inheritance

An interface can be derived from one or more previously defined (base) interfaces (see). Both single and multiple inheritance are allowed. An inherited interface declaration can be identical to its parent, or it can extend or override inherited definitions. (Overriding is allowed for all types, constants, and exceptions but not for operations and attributes.)

> **Note:** Name overloading is not allowed in IDL. Thus, multiple inheritance should never lead to a situation where an interface inherits from two interfaces (or interface components) of the same name but differing definitions.

An interface is separated from its parent interfaces with a single colon. Commas separate multiple parent interfaces. When an interface inherits from an interface that is declared in another module, its declaration should include both module and interface, separated by two colons.

Thus, for example:

- The AudioMedia interface does not inherit from other interfaces:

```
interface AudioMedia {};
```

- The UserPres interface inherits from the ContainerPres and Message interfaces, all of which are defined in the same module.

```
interface UserPres : ContainerPres, Message {};
```

- The TypedPushConsumer interface inherits from the PushConsumer interface, which is defined in the CosEventComm module.

```
interface TypedPushConsumer :
CosEventComm::PushConsumer
            Object
get_typed_consumer();
```

Forward Declaration

In addition, an interface declaration can declare the name of another interface without defining it. This is called a “forward declaration” of an interface. A forward declaration makes it possible for the definition of interfaces to refer to each other.

The syntax for specifying a forward declaration is:

```
interface identifier;
```

Forward declarations are useful when two interfaces make reference to each other, as in the following example:

```
interface WindowObject;
interface Notifier
{
   void addWindow(in WindowObject win);
};

interface WindowObject
{
   void addNotifier(in Notifier notifier);
};
```

In this example, Notifier contains an operation, addWindow(), that takes a WindowObject as its argument, but the IDL compiler won’t know what a WindowObject is unless it has been declared. In addition, WindowObject itself contains an operation, addNotifier(), that refers to Notifier. Regardless of whether WindowObject or Notifer is declared first, the IDL compiler needs to know about the existence of the interface that has not yet been defined.

Note: You can specify multiple forward declarations of the same name, but you cannot derive an interface from a forward-declared interface (see Inheritance). Furthermore, to reduce the possibility of creating circular dependencies on modules, the IDL syntax does not support forward declaration of an interface from another module.

Pass by Reference

It is very important to realize that interfaces are passed by reference; otherwise it is passed by value. It is by carefully using base types, constructed types, and typedefs, or structures of these, rather than interface names, that you determine what will and will not be passed as a copy or passed as an object reference.

Declaring Constants

Constants are identifiers that represent values of a given type. They can be declared anywhere in an IDL file using const. A constant declaration takes the form:

```
const constant_type identifier = constant_expression;
```

Valid constant_types

Data Type	Description
long	Integer from -231 to 231 - 1.
short	Integer from -215 to 215 - 1.
unsigned long	Integer from 0 to 232 - 1.
unsigned short	Integer from 0 to 216 - 1.
char	8-bit character. See Chapter B, “IDL Grammar” for a complete list of the space, alphabetic, digit, and graphic characters, as well as the meaning and value of the null and formatting characters. The meaning of all other characters is implementation-specific.
boolean	Value of TRUE or FALSE.
float	Floating point constants are coerced to double-precision floating point numbers.
string	Bounded or unbounded sequence of 8-bit quantities, except null.
scoped_name	Previously defined name of an integer type, character type, boolean type, floating point type, or string type.

The identifier is a name representing a constant.

The constant_expression is a sequence of operators and operands that specifies a computation.

Operators that can be used in a constant_expression

Operator[1]	Description
Unary Operators (+, -, ~)	Unary + and - operators are valid for either floating point or integer expressions.Unary ~ generates the bit-complement of the expression to which it is applied. For the purposes of such expressions, the values are 2's complement numbers. Thus, the complement of a long integer is generated as -(value+1), and the complement of an unsigned long integer is generated as (232 - 1)-value. It is valid for integer expressions.
*	Binary “multiplication” operator generates the product of the operands. It is valid for either floating point or integer expressions.
/	Binary “division” operator generates the quotient of the operands. It is valid for either floating point or integer expressions.
%	Binary “remainder” operator generates the remainder from the division of the first expression by the second. If the second operand is 0, the result is undefined; otherwise (a/b)*b+a%b is equal to a. If both operands are non-negative, the remainder is non-negative; otherwise the sign of the remainder is implementation-dependent. It is valid for integer expressions.
+	Binary “addition” operator generates the sum of the operands. It is valid for either floating point or integer expressions.
-	Binary “subtraction” operator generates the difference between the operands. It is valid for either floating point or integer expressions.
<<	Binary “left shift” operator shifts the value of the left operand left the number of bits specified in the right operand, with 0 fill for the vacated bits; the right operand must be in the range 0 - 31, inclusive. It is valid for integer expressions.
>>	Binary “right shift” operator shifts the value of the left operand right the number of bits specified in the right operand, with 0 fill for the vacated bits; the right operand must be in the range 0 - 31, inclusive. It is valid for integer expressions.
&	Binary “and” operator generates the logical, bitwise AND of the left and right operands. It is valid for integer expressions.

Operator[1]	Description
^	Binary “exclusive or” operator generates the logical, bitwise EXCLUSIVE-OR of the left and right operands. It is valid for integer expressions.
|	Binary “or” operator generates the logical, bitwise OR of the left and right operands. It is valid for integer expressions.

1.The operators are listed in order of precedence. Parentheses override operator precedence.

An integer constant_expression is evaluated as unsigned long unless it contains a negated integer literal or the name of an integer constant with a negative value; if it contains the name of an integer constant with a negative value, the constant_expression is evaluated as signed long. The computed value is coerced back to the specified constant_expression in constant initializers. An error condition occurs if the computed value exceeds the precision of the specified constant_expression, or if any intermediate value exceeds the range of the evaluated-as type (long or unsigned long).

Floating point literals are double, all floating point constants are coerced to double, and floating point expressions are computed as doubles; the computed double value is coerced back to the specified constant_expression in constant initializers. An error condition occurs if the coercion back to the specified constant_expression fails, or if any intermediate values (when evaluating the expression) exceed the range of double.

> Note: It is not legal to mix type expressions. For example, you cannot mix integer types with floating point types in a constant declaration.

A constant_expression can contain a unary expression, which takes the form:

```
unary_operator primary_expression;
```

The table above describes the unary operators that can be used. A primary_expression is defined as a:

- Scoped name (see Names and Scopes)
- Literal (integer, string, character, floating point, or boolean)
- Constant_expression

If the primary_expression contains a constant_expression, the constant_expression must be contained in a “( )” combination.

> Note: The operands in a constant_expression are literals or scoped names that have been previously defined in constant declarations.

In the example:

```
const short MODIFY_PERMISSION = 0x01;
```

the constant declares that whenever the MODIFY_PERMISSION identifier is specified, the short integer 0x01 is to be used.

One constant can be the base for a family of other constants. This allows you to change the values of the entire family at once. In the example:

```
const long SIZE = 8;
const long wordsize = 4 * SIZE;
const long segments = 1024 / SIZE;
```

SIZE represents the size of the basic storage unit of a computer (byte), and wordsize and segments change when the declaration of the constant SIZE changes.

Declaring Data Types

IDL provides constructs for naming data types. Specifically, IDL uses the typedef keyword, as well as constructed type declarations to IDL defines a set of type specifiers to represent typed values. The type specifiers are:

- Simple type specifiers
- Constructed type specifiers

Using Declarators to Give a Name to a Type

The declarator can be an:

- Identifier
- Array

An identifier is a type name.

An array can specify a fixed-size array (of one or more dimensions) whose size is fixed at compile time. An array declarator contains an identifier (as described above) and the size of each dimension; the syntax is:

```
identifier[constant_expression][[[constant_expression]]…]
```

Note: Each constant_expression must result in a positive integer constant.

Use a "[ ]" combination to specify the size of each dimension. For example:

```
table[6][7]
```

defines table as a two-dimensional array whose dimensions are 6 elements by 7 elements.

When an array is passed as a parameter in an operation invocation, all elements of the array are transmitted. However, because the implementation of array indexes is language mapping-specific, passing an array index as a parameter may yield incorrect results.

typedef

The typedef keyword can be used anywhere in an IDL file to declare new data type names. The syntax for a using typedef to associate a name with a data type is:

```
typedef type_specifier declarator[[,declarator]…];
```

For example:

```
typedef long AStoreId;
```

The type_specifier can be a:

- Base data type (see Base Data Types)
- Template type (see Template Types)
- Constructed type (see Constructed Types)
- Scoped name (see Names and Scopes), which must be the name of a type

Note: Scoped names must be defined before they can appear in a typedef.

Simple Types

Simple type specifiers can be:

- Base data type (see Base Data Types)
- Template types (see Template Types)
- Scoped names (see Names and Scopes)

Base Data Types

Base data Types Supported by IDL

Data Type	Description
float	IEEE single-precision floating point number.
double	IEEE double-precision floating point number.
long	Any integer from -231 to 231 - 1.
short	Any integer from -215 to 215 - 1.
unsigned long	Any integer from 0 to 232 - 1.
unsigned short	Any integer from 0 to 216 - 1.
boolean	Value of TRUE or FALSE.
octet	8-bit quantity (no conversion).
char	8-bit character. See “IDL Grammar” on page 255 for a complete list of the space, alphabetic, digit, and graphic characters, as well as the meaning and value of the null and formatting characters. The meaning of all other characters is implementation-specific.
any	The any type permits the specification of values that can express any IDL type.

Each data type is mapped to a base data type via the appropriate language mapping (see Chapter 9, “Mapping of IDL to Smalltalk” for information about the Smalltalk language mappings). For example, to declare a long integer x, use the following IDL statement:

```
long x;
```

Template Types

IDL supports the following template types:

- String
- Sequence

Strings

A string can be any 8-bit quantity except null. It is similar to a sequence of chars. Prior to passing a string as a function of an argument (or an member in a struct or union), the length of the string must be set in a language-mapping dependent manner.

A string identifier takes the form:

```
string [<constant_expression>]
```

The constant_expression, if specified, is a sequence of operators and operands that specifies a computation. The table above lists the operators that can be used in a constant_expression.

> **Note:** The constant_expression must result in a positive integer constant.

A string can be unbounded (that is, have no specified maximum size) or can be bounded (that is, include the max_size, enclosed in a "< >" combination, as the first parameter). For example:

```
string address;
string <16> name;
```

The first string, address, is unbounded (that is, no upper limit of characters is specified). The second string, name, has a maximum length of 16 characters.

> **Note:** Strings are defined as a separate data type because many languages have special built-in functions or standard library functions for string manipulation. This allows substantial optimization in the handling of strings compared to what can be done with sequences of general types.

Sequence

A sequence is a one-dimensional array with a maximum size (which is fixed at compile time), and a length (which is determined at run time). It can be unbounded (that is, have no specified maximum size) or bounded (that is, include the max_size parameter).

A sequence type identifier takes the form:

```
sequence < simple_type_specifier[,constant_expression] >
```

For example:

```
typedef sequence<POSInfo> POSList;
```

The simple_type_specifier can be a:

- Base data type (see Base Data Types)
- Template type (Template Types)
- Scoped name (see Names and Scopes), which must the name of a type

The optional constant_expression is a sequence of operators and operands that specifies a computation. The table ablve lists the operators that can be used in a constant_expression.

> **Note:** The constant_expression must result in a positive integer constant.

You must enclose the type name in a "< >" combination to specify the type of data that belongs in the sequence and, optionally, the upper limit of the number of elements. For example:

```
sequence < long > list;
sequence < float,20 > datapoints;
```

In this example, list is an unbounded sequence of long data types, and datapoints is a sequence of up to 20 floating point data types.

Sequences of strings are useful for describing multi-line text fields. For example:

```
sequence < string<80> > body;
```

declares body, which is made up of an indefinite (unbounded) number of lines, each of which cannot exceed 80 characters.

Before an unbounded sequence can be passed as a function argument (or as a field in a struct or union), the length and maximum size of the sequence, as well as the address of a buffer to hold the sequence, must be set in a language-mapping dependent manner. After receiving such a sequence result from an operation invocation, the length of the returned sequence, which can be obtained in a language-mapping dependent manner, will have been set.

Before a bounded sequence can be passed as a function argument (or as a field in a struct or union), the length of the sequence must be set in a language-mapping dependent manner. After receiving such a sequence result from an operation invocation, the length of the returned sequence, which can be obtained in a language-mapping dependent manner, will have been set.

Constructed Types

IDL supports the following constructed types:

- Structures
- Enumerations
- Discriminated unions

Structures

Declaring a structure with struct defines a new legal data type. The syntax of a structure data type is:

```
struct struct_identifier
{
   member +;//one or more members
};
```

The value of a struct is the value of all of its members.

For example:

```
struct POSInfo {
   POS::POSId id;
   Object store_access_reference;
   float total_sales;
   float total_taxes;
};
```

A struct_identifier is the type name of the structure.

> **Note:** Structure types can also be named using a typedef declaration (see typedef).

The syntax for a member is:

```
type_specifier declarator[[,declarator]…]
```

> **Note:** Each member in the structure must have a unique name.

The type_specifier can be a:

- Base data type (see Base Data Types)
- Template type (see Template Types)
- Constructed type (see Constructed Types)
- Scoped name (see Names and Scopes)

In the example:

```
struct mystructure
{
    long x,y;
    double z;
};
```

mystructure is declared to be a structure data type containing three members: x, y, and z.

By default mapping, a struct is mapped to a Smalltalk Dictionary, which is answered by any operation with a structure as a return value type. When a structure is specified as a parameter type, then under the default mapping, an appropriate Dictionary must be explicitly constructed on the Smalltalk side to serve as the parameter. For example, here is an invocation of a has_middle_name operation that takes a single personalName structure as an input parameter:

```
relevantObject hasMiddleName:
    ((Dictionary new)
        at: #firstNameput: 'Max';
        at: #middleNameput: 'Karl';
        at: #surnameput: 'Scheler';
        yourself).
```

A structure may be mapped to the instance of a named class by using the class pragma.

Enumerations

An enumeration (enum) is an ordered set of identifiers, called enumerators, that specify all of the legal values that a variable may have. As such, an enumeration defines a new data type that takes one of that set of specified values. The syntax of an enumeration data type is:

```
enum enum_identifier
{
    enumerator[[,enumerator]…]
}
```

An enum_identifier is the type name of the enumerator.

For example:

```
enum colors_allowed
{
    red,blue,white,green
};
```

declares that variables of the type colors_allowed can be assigned the values red, blue, white, or green.

> **Note:** Enumeration types can also be named using a typedef declaration (see typedef).

Each enumerator in the enumeration must specify a unique name. The maximum number of enumerators is 232; therefore, the enumerated names must be mapped to a native data type capable of representing a maximally-sized enumeration.

An identifier in an enumerator that is declared as a constant.

The order in which the enumerators are listed defines their relative order. Enumerators can be compared, and a successor/predecessor function defined on the type will reflect the ordering.

From within Smalltalk code, both enumerations and enumerators are accessed via the CORBAConstants dictionary, an entity specified in the Smalltalk Binding. For example, given the declaration

```
module Music {
   enum WIND_INSTRUMENTS { oboe, recorder, clarinet, flute };
   enum BRASS { trombone, french_horn, trumpet };
};
```

the windInstruments enumeration is accessed by

```
(CORBAConstants at: #'::music::WIND_INSTRUMENTS').
```

This answers an instance of class Array that contains symbols. An enumerator is accessed similarly. For example, the oboe enumerator is accessed by

```
(CORBAConstants at: #'::Music::WIND_INSTRUMENTS::oboe').
```

This does not answer an instance of Symbol, but rather an instance of class DSTEnumerator.

Discriminated Unions

IDL unions are a cross between C union and switch statements. IDL unions must be discriminated; that is, the header must specify a typed tag field that determines which union member is valid.

Discriminated unions are the preferred way of returning a value of one of a limited number of data types. If an interface's operation, for example, is to return one of three kinds of values, use a union rather than the data type any.

The syntax of a discriminated union data type is:

```
union?union_identifier
(switch?switch_type_specifier)
{
   case constant_expression : element_specifier;
   default : element_specifier;
   …;

};
```

For example:

```
union cell_value
switch(enum cell_content {numeric, string, formula})
{
   case numeric:numeric_valuenumber;
   case string:stringvalue;
   case formula:formula_valuethe_formula;
};
interface cell
{
   attribute cell_value value;
   …
};
```

declares a spreadsheet cell value that can be either a numeric, a string constant, or a formula. The reasons for defining a spreadsheet_cell with union (rather than any) in this example are that it:

- Describes the interface most accurately because it specifies all allowed types.
- Makes the resulting code easier to work with because the potential types of data that the caller must deal with are specified.

Discriminated union types can also be named using a typedef declaration. The default is optional.

A union_identifier is the type name of the union.

A switch_type_specifier specifies the type with which the cases contstant_expression must be consistent.

Valid Switch_Type_Specifiers

Data Type	Description
long	Any integer from -231 to 231 - 1.
short	Any integer from -215 to 215 - 1.

Data Type	Description
unsigned long	Any integer from 0 to 232 - 1.
unsigned short	Integer from 0 to 216 - 1.
char	8-bit character. See Chapter B, “IDL Grammar” for a complete list of the space, alphabetic, digit, and graphic characters, as well as the meaning and value of the null and formatting characters. The meaning of all other characters is implementation-specific.
boolean	Value of TRUE or FALSE.
enum	Any enumerator for the discriminator enum type. The identifier for the enumeration is in the scope of the union; it must be distinct from the member declarators.
scoped_name	Previously defined name of an integer type, character type, boolean type, or enum type.

The constant_expression is a sequence of operators and operands that specifies a computation. The table above lists the operators that can be used in a constant_expression.

The constant_expression must be consistent with the switch_type_specifier. The syntax for a element_specifier is:

```
type_specifier declarator[[,declarator]…]
```

Class DSTUnion is the Smalltalk implementation of the CORBA union protocol. DSTUnion has two instance variables, discriminator and value. Instances of DSTUnion are usually created using the asCORBAUnion: method, implemented in class Object. This may be sent to any object and must have an appropriate discriminator value as its argument. Sample IDL for using an explicit mapping is shown below:

```
#pragma class AccountNumber DSTUnion
union AccountNumber switch(boolean) {
    case true: long l;
    case false: string s;
};
```

This code explicitly maps a declared union to the DSTUnion implemenatation class. The mention of DSTUnion in the class pragma could be replaced by the name of any class that also supported the CORBA union protocol: value, value:, discriminator, discriminator:, a class side instance creation method named discriminator:value:, and the semantics that goes with these messages.

Each element in the discriminated union must specify a unique name.

The type_specifier can be a:

- Base data type (see Base Data Types)
- Template type (see Template Types)
- Constructed type (see Constructed Types)
- Scoped name (see Names and Scopes)

An identifier is a name of an element.

An array can specify a fixed-size array (of one or more dimensions) whose size is fixed at compile time.

case declarations must match or be automatically castable to the defined type of the discriminator.

The following table shows matching rules for consistency check between case constant_expressions and switch_type_specifiers.

Matching rules

Data Type	Description
long	Integer value in the value range of long.
short	Integer value in the value range of short.
unsigned long	Integer value in the value range of unsigned long.
unsigned short	Integer value in the value range of unsigned short.
char	char.
boolean	Value of TRUE or FALSE.
enum	Enumerator for the discriminator enum type.

It is not necessary to list all possible values of the unions. The value of a union is the value of the discriminator together with one of the following:

- If the discriminator value is listed explicitly in the case statement, the value of the element associated with the case statement
- If the default case label is specified, the value of the element associated with the default case label

  Note: default can appear no more than once.

- No additional value

Declaring Operations

An interface can have operations. Operation declarations define the set of operations that a client can invoke on an object supporting the interface. You declare operations within the interface definition.

> **Note:** A derived interface (see Inheritance) automatically supports any operations in the interface(s) it inherits from, and can add its own operations. However, a derived interface cannot re-declare any of the operations it inherits.

The syntax of an operation declaration is:

```
[oneway] operation_type_specifier identifier
   ([parameter_declaration[,parameter_declaration]…])
   [raises (scoped_name[,scoped_name]…)]

   [context (string_literal[[,string_literal]…])];
```

The oneway operation attribute is optional. When it is not specified and an exception is raised, the operation is invoked no more than once. If, however, an exception is not raised, the operation is invoked exactly once. When it is specified, the operation is invoked no more than once, which does not guarantee that the call will be delivered successfully.

> **Note:** If the optional oneway operation attribute is specified, the operation cannot contain any output parameters, and must specify a void return type. In addition, a one-way operation cannot include a raises expression; however, invocation of the operation may raise a standard exception.

Example

```
void find_price (
   in POS::Barcode item,
   in long quantity,
   in long store_id,
   out float item_price,
   out float item_tax_price,
   out ItemInfo item_info)
   raises (BarcodeNotFound);
};
```

The operation_type_specifier can be a:

- Base data type (see Base Data Types)
- Template type (see Template Types)
- Scoped name (see Names and Scopes)
- void return type

The identifier is the type name of the operation. Identifiers are used at runtime by both the static and dynamic interfaces. As a result, all operations that might apply to a particular object must have unique names. This requirement prohibits redefining an operation name in a derived class, as well as inheriting two operations with the same name.

The syntax for a parameter_declaration is:

```
parameter_attribute simple_type_specifier declarator[[,declarator]…]
```

The parameter_attribute must specify:

- In (passed from client to server)
- Out (passed from server to client)
- Inout (passed in both directions)

Note: Implementations should not attempt to modify an in parameter; the ability to do so is language-mapping specific, and the effect is undefined. Also, you should avoid using the inout parameter because some languages have difficulty managing the memory associated with processing inout.

The simple_type_specifier can be a:

- Base data type (see Base Data Types)
- Template type (see Template Types)
- Scoped name (see Names and Scopes)

Note: When an unbounded string or sequence is passed as an inout parameter, the returned value cannot be longer than the input value.

An identifier is the type name of a parameter of the operation.

The following example defines an interface to a stack object that supports pop() and push() operations for long integer elements and an is_empty() operation:

```
interface Stack
{
   long pop();
   void push(in long n);
   boolean is_empty();
};
```

In this example, pop() takes no argument but returns a long integer, and push() makes use of an in parameter, indicating that the parameter is passed from client to server.

Raise Exceptions

You can declare an operation to raise user-defined exceptions (see User-Defined Exceptions) as a result of an invocation of the operation.

Note: Standard (CORBA predefined) exceptions cannot be listed in raises expressions.

The syntax of an optional raises expressions is:

```
raises(scoped_name[[,scoped_name]…]);
```

Note: If the optional oneway operation attribute is specified, the operation cannot include a raises expression; however, invocation of the operation may raise a standard exception.

Each scoped_name specified in an optional raises expression must be a previously defined exception.

Note: An invocation can raise a standard exception even though standard exceptions cannot be listed in raises expressions; that is, the absence of raises expressions does not prevent an operation from raising standard exceptions.

Context Expressions

You can also declare which elements of the client's context can affect the performance of a request by the object. The syntax of an optional context expression is:

```
context(string_literal[[,string_literal]…]);
```

Each string_literal is an arbitrarily long sequence of alphabetic, digit, period (.), underscore (_), and asterisk (*) characters.

> **Note:** The first character of a string_literal must be an alphabetic character. Furthermore, an asterisk can be used only as the last character in the string.

The value associated with each string_literal in the client's context is provided to the object implementation when the request is delivered. The object can use the information in this request context during request resolution and performance.

> **Note:** The absence of a context expression indicates that there is no request context associated with requests for this operation.

In the following example, the values associated with create_request_op_id are available for requests resolution and to the object implementation when the request is delivered:

```
interface Stack
{ …
   long pop()
      context(create_request_op_id);
…
};
```

Declaring Exceptions

Exceptions are alternate results that an operation can return when it encounters an exceptional condition (usually an error).

> **Note:** If an exception is raised, the out and normal return values are not valid; instead, only the values of the raised exception's members are valid.

In addition to the standard exceptions specified by CORBA (see Standard Exceptions), user-defined exceptions can be declared anywhere in an IDL file.

User-Defined Exceptions

The syntax for declaring user-defined exceptions is:

```
exception exception_identifier
{
   [[member;]
   …]
};
```

An exception_identifier is the type name of an exception. When an exception is returned as the outcome of a request, the value of the exception identifier can be accessed to determine which exception was raised.

If an exception is declared with members, you can access the values of those members when an exception is raised. If no members are specified, however, no additional information can be accessed.

Example

```
// The barcodeNotFound exception indicates that the
// input barcode does not match to any known item.
exception BarcodeNotFound {POS::Barcode item; };
```

The syntax for a member is:

```
type_specifier declarator[[,declarator]…]
```

Note: Each member in the exception structure must specify a unique name.

The type_specifier can be a:

- Base data type (see Base Data Types)
- Template type (see Template Types)
- Constructed type (see Constructed Types)
- Scoped name (see Names and Scopes)

An identifier is the type name of a member.

The following Stack interface example includes two exception conditions: underflow and overflow. The overflow exception is defined such that the client code can examine the value of size_limit, which, in this implementation, is defined to be the maximum stack size.

```
interface Stack
{
    exception underflow {};
    exception overflow
    {
        long size_limit;
    };
    readonly attribute long size;
    long pop()
        raises(underflow);
    void push(in long n)
        raises(overflow);
    boolean is_empty();
};
```

Note: This example contains operations, raises operations, and attributes (see Declaring Operationsand Declaring Attributes).

Standard Exceptions

Standard exceptions can be returned as a result of any operation invocation, regardless of the interface specification.

Note: Standard exceptions cannot be listed in raises expressions.

The CORBA specification keeps the set of standard exceptions to a manageable size in order to reduce the complexity of handling them. This constraint requires the definition of equivalence classes of exceptions rather than enumerating many similar exceptions. For example, an operation invocation can fail at many different points due to the inability to allocate dynamic memory. Rather than specify several different exceptions corresponding to the different ways that memory allocation failure causes the exception (during marshalling, unmarshalling, in the client, in the object implementation, allocating network packets, and so on), a single exception corresponding to dynamic memory allocation failure is defined.

Each standard exception also includes a completion_status code which takes one of the values YES, NO, or MAYBE. "Completion," from the client's point of view, means exception-free execution of the requested operation by the implementation. The values have the following meanings:

YES	The state of the object, including objects it acts on, are in the same state as they would be if the operation completed normally. An error was detected after the operation's termination. Implementations are discouraged from returning this value. Requests that return this value should not be retried.
NO	The state of the object, including objects it acts on, are in a state that is identical to its state prior to execution of the operation. This may mean that the operation was never started, that the operation was started but did not change the object state, or that the implementation restored the object to the state it had before the operation began. Requests that return this value can be retried.
MAYBE	The state of the object, including objects it acts on, is not known. Implementations are discouraged from returning this value.

The standard exceptions are defined below:

```
#define ex_body {unsigned long minor;
    completion_status completed;}
enum completion_status {COMPLETED_YES, COMPLETED_NO,
    COMPLETED_MAYBE};
enum exception_type {NO_EXCEPTION, USER_EXCEPTION,
    SYSTEM_EXCEPTION};
exception UNKNOWN ex_body; // the unknown exception
exception BAD_PARAM ex_body; // an invalid parameter was
    passed
exception NO_MEMORY ex_body; // dynamic memory allocation
     failure
exception IMP_LIMIT ex_body; // violated implementation limit
exception COMM_FAILURE ex_body; // communication failure
exception INV_OBJREF ex_body; // invalid object reference
exception NO_PERMISSION ex_body; // no permission for
    attempted op.
exception INTERNAL ex_body; // ORB internal error
exception MARSHAL ex_body; // error marshalling param/result
exception INIITIALIZE ex_body; // ORB initialization failure
exception NO_IMPLEMENT ex_body; // operation implementation
    unavailable
exception BAD_TYPECODE ex_body; // bad typecode
exception BAD_OPERATION ex_body; // invalid operation
exception NO_RESOURCES ex_body; // insufficient resources
    for req.
exception NO_RESPONSE ex_body; // response to req. not
    yet available
exception PERSIST_STORE ex_body; // persistent storage failure
exception BAD_INV_ORDER ex_body; // routine invocations
    out of order
exception TRANSIENT ex body; // transient failure - reissue
    request
exception FREE_MEM ex_body; // cannot free memory
exception INV_IDENT ex_body; // invalid identifier syntax
exception INV_FLAG ex_body; // invalid flag was specified
exception INTF_REPOS ex_body; // error accessing interface
    repository
exception BAD_CONTEXT ex_body; // error processing context
    object
exception OBJ_ADAPTER ex_body; // failure detected by object
    adapter
exception DATA_CONVERSION ex_body; // data conversion error
```

Declaring Attributes

An interface can have attributes that are within the interface definition.

> **Note:** A derived interface (see Inheritance) automatically supports any attributes in the interface(s) it inherits from, and can add its own attributes. However, a derived interface cannot re-declare an attribute as a different type, but it can re-declare it as readonly.

Declaring an attribute is logically equivalent to declaring a pair of accessor functions??—?one to retrieve the value of the attribute and one to set the value of the attribute.

> **Note:** The actual accessor function names are language-mapping specific. Only the attribute name is subject to IDL's name scoping rules. The accessor function names are guaranteed not to collide with any legal operation names that can be specified in IDL.

The syntax of an attribute declaration is:

```
[readonly] attribute simple_type_specifier declarator[[,declarator]…];
```

The optional readonly keyword indicates that only the implementation can set its value; that is, that there is only a single accessor function?—?the retrieve value function. You can, for example, declare an operation in IDL and the implementation of that operation would set the value of a readonly attribute.

Example

```
readonly attribute AStoreId store_id;
readonly attribute float store_total;
readonly attribute float store_tax_total;
```

The simple_type_specifier can be a:

- Base data type (see Base Data Types)
- Template type (see Template Types)
- Scoped name (see <Undefined Cross-Reference>)

An identifier is the type name of the attribute.

Declaring an attribute in IDL is similar to defining a pair of public methods to get and set the value of a private data member. You can also define a readonly attribute, which prevents the client from setting the attribute value:

```
interface Stack
{
    readonly attribute long size;

    long pop();
    void push(in long n);
    boolean is_empty();
};
```

In this example, Stack includes a readonly attribute, size. Although the client can determine the size of the stack from the attribute, it cannot set it.

Declaring an attribute is different from declaring “get” or “set” operations because attributes, unlike operations, cannot “raise” user-defined exceptions.

Attribute operations return errors by means of standard exceptions.

Note: Although attributes may appear to be a data item or member (the value of which does not change), the implementation can be written to recompute the value on each access. This can be the case even if the readonly attribute is specified.

Inheritance

An interface can inherit from (that is, be derived from) one or more interfaces. An inheritance specification, which declares that an interface is derived from one or more interfaces, takes the following form:

```
interface identifier : scoped_name[,scoped_name[…]]
{
    [interface_definition;
    […]]
};
```

The identifier (name) of an interface can be used as a type name (once the interface has been declared). For example, it can be used as a parameter or member that uses that name is the same as a

reference to the object supporting the interface. Any object whose type is an interface identifier is expected to support the operations in that interface. For example, if a parameter of type interface Stack, it would be expected to support the Stack operations, pop, push, and is_empty (see for the stack interface definition).

> **Note:** An interface that inherits elements from other interfaces is called a derived interface; the interface from which elements are inherited is called a base interface. Furthermore, an interface is called a direct base interface if it is specified directly in the inheritance specification; it is called an indirect base interface if it is, in turn, a base interface of another direct base interfaces specified in the inheritance specification.

Elements of a base interface can be referred to as if they were elements of the derived interface. A derived interface can redefine inherited types, constants, and exceptions, as well as declare operations and attributes.

Multiple inheritance means that an interface is derived from more than one direct base interface. In these situations, the order of derivation (that is, the order in which the base interfaces are specified) is not significant. However, since multiple inheritance may cause ambiguity, you should use the resolution operator (that is, ::) to explicitly identify the desired element (see Names and Scopes).

An interface_definition, which can declare new elements, as well as redefine elements in base interfaces, can include:

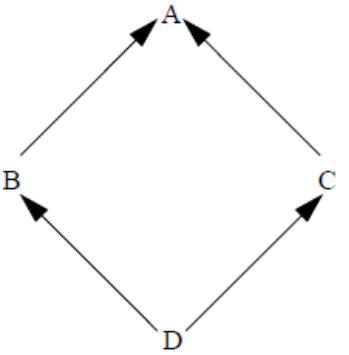
- Type declarations (see Declaring Data Types)
- Constant declarations (see Declaring Constants)
- Exception declarations (see Declaring Exceptions)
- Operation declarations (see Declaring Operations)
- Attribute declarations (see Declaring Attributes)

The rules for scoping these names are described in .

A base interface cannot be specified as a direct base interface of a derived interface more than once; however, it can be an indirect base interface any number of times. For example, the inheritance illustrated in can be declared as follows:

```
interface A {…};
interface B:A {…};
interface C:A {…};
interface D:B,C {…}
```

Illustration of Interfaces Inheritance



References to types, constants and exceptions are bound to an interface when it is defined (that is, when it is replaced with the equivalent global scoped name). This guarantees that the syntax and semantics of an interface are not changed when the interface is a base class for a derived class. Consider this example:

```
const long L=3;

interface A
{
   void f(in float s[L]);// s has 3 floats
};

interface B
{
   const long L=4;
};

interface C:B,A {};// what is f()'s signature?
```

In the example above, the early binding of types, constants, and exceptions at interface definition guarantees that the signature of operation f in interface C is:

```
void f(in float s[3]);
```

which is identical to that in interface A. This rule also prevents the redefinition of a type, constant, or exception in a derived interface from affecting the operations and attributes inherited from a base interface.

Interface inheritance causes all identifiers in the closure of the inheritance tree to be imported into the current naming scope. A type name, constant name, enumeration value name, or exception name from an enclosing scope can be redefined in the current scope. An attempt to use an ambiguous name without qualification will cause an IDL compilation error.

In addition to using the elements defined in the base interface(s), a derived interface can declare new elements (for example, constants) and/or redefine the elements defined in the base interface. A derived interface that redefines any of the inherited type, constant, or exception names must satisfy the scope rules described in .

Note: A derived interface cannot inherit from multiple interfaces (that is, from either direct base or indirect base interfaces) that provide the same operation or attribute name. An implementation of an interface, however, can redefine the implementation of those operations and attributes.

Note: The implementation of the operation can be redefined, not the interface.

A derived interface has an “is a” relationship with its base interfaces (that is, it is the same kind of whatever the base interface describes). For example, a DroppableObject interface is a specific kind of Document interface; therefore, the DroppableObject could inherit from the Document:

```
interface DroppableObject : Document
{
   IDL statements describing DroppableObject
};
```

DroppableObject, in this example, inherits every element of the Document interface. That is, if DroppableObject is declared as shown above, but includes no IDL statements of its own, its interface is identical to that of Document.

The body of the DroppableObject interface contains any needed definitions that are not already defined in the Document interface. It also can include redefinitions of type, constant, or exception names already defined in Document.

Multiple inheritance allows you to derive an interface from more than one base interface. If the derived interface inherits from multiple interfaces, the order in which the interfaces are inherited is not significant.

For example, assume there are three interfaces: Queue, Directory, and Mailbox. The Queue interface stores a sequence of arbitrary type; a Directory interface provides access to objects by name; and a Mailbox interface behaves like a Queue and a Directory, as well as a Mailbox. Thus, if a Mailbox inherits from both Queue and Directory, a browsing tool that works on directories can work on mailboxes, and a mail filter can use the Queue interface allowing various filters to be composed in a Mailbox:

```
interface Mailbox : Queue,Directory
{
    IDL statements describing Mailbox
};
```

You can specify the base interfaces (in this example, Queue and Directory) in any order since the order is not significant.

IDL Preprocessing

IDL preprocessing is based on ANSI C++ preprocessing and provides macro substitution, conditional compilation, and source file inclusion. The preprocessing facilities are used to include definitions from other IDL specifications.

For a comprehensive discussion of C++ preprocessing, refer to the “Preprocessing” chapter in The Annotated C++ Reference Manual.

Directives (that is, lines beginning with #) communicate with the preprocessor. These lines, which may include white space before the #, have a syntax that is independent of IDL. Except for the IDL-specific pragmas, which are semantically constrained, they may appear anywhere, and remain in effect until the end of the translation unit. Furthermore, a preprocessing directive can continue on another line; to continue a line, place a backslash (\) immediately before the new line at the end of the line to be continued.

Note: A backslash (\) character cannot be the last character in a source file.

#include

You can include definitions from other IDL specifications with #include. If the #include appears in a global scope, text from any included file is treated as if it appeared in the including file (that is, the types, constants, modules, and interfaces are declared and available), although no additional code is generated by the IDL compiler as a result of the inclusion. It simply allows you to resolve external IDL references within the IDL file.

Note: #include should be used only in global scopes because including scopes modify the names of all included constructs.

CORBAModule

In order to prevent names defined within the CORBA specification from clashing with names in programming languages and other software systems, all names defined by CORBA are treated as if they were defined within a module named CORBA. Within an IDL specification, however, IDL keywords such as Object must not be preceded by a CORBA:: prefix. Other interface names are not IDL keywords and so must be referred to by their fully scoped names within an IDL specification.

Names and Scopes

An entire IDL file forms a naming scope. Each time you use one of the following kinds of declarations, you form a nested scope:

- Module
- Interface
- Structure
- Union
- Operation
- Exception

The names of declarations reflect the naming scope in which they reside. The names you use when declaring any of the following are scoped:

- Types
- Constants
- Enumeration values
- Exceptions
- Interfaces
- Attributes
- Operations

The syntax of a scoped_name is:

[*scoped_name*][::]*identifier*

The optional scoped_name is the name of a scope. The identifier is an element or member declared in the scope. It can be referenced explicitly by using a scope resolution operator (that is, ::), as illustrated in the following examples of valid references to scoped names:

```
A::except1
::except1
except1
```

Note: You cannot define an identifier more than once in a scope, although you can redefine identifiers in nested scopes.

Since the IDL compiler is not case sensitive, respelling an identifier (in terms of case) is considered to be reuse of the name in its scope. For example, Test in the following sample, is a re-declaration of test and, therefore, is not allowed:

```
interface check_segment
{
   exception test {};
   void Test();
      // ILLEGAL: this is a re-declaration of test!
};
```

Type names defined in a scope are available for immediate use within that scope. Specifically, although it is syntactically possible to generate recursive type specifications in IDL, such recursion is

semantically constrained. The only permissible form of recursive type specification is through the use of the sequence template type. For example, the following is a valid form of recursive type specification

```
struct foo
{
   long value;
   sequence<foo> chain;
};
```

An unqualified name can be used in a particular scope. However, once it is used in a scope, it cannot be redefined in that scope; such redefinitions cause compilation errors.

Note: An unqualified name used in a particular scope is resolved by successively searching farther out in enclosing scopes. Thus, if you use a name defined in an enclosing scope in the current scope, you cannot redefine a version of that name in the current scope.

When a qualified name begins with the scope resolution operator (for example, ::identifier), the resolution process starts at file scope. A qualified name is resolved by first resolving the qualifier (scoped_name), then locating the definition of the identifier within that scope.

Note: The identifier must be directly defined in the scope (or, in the case of an interface, inherited into the scope). The identifier is not searched for in enclosing scopes.

It is sometimes useful for interfaces to refer to exceptions, types, and constants that are declared in other interfaces or modules. You make this reference by using the scope resolution operator (that is, ::) as illustrated in the following example. In this example, an operation in interface B raises an exception declared in interface A:

```
interface A
{
   exception general_error {};
   …
};

interface B
{
   void op1()
      raises(A::general_error);
}:
```

Every IDL definition in a file has a global name within that file. The global name is the concatenation of the current root, the current scope, the scope resolution operator (that is, ::), and the local name for the definition.

Inheritance produces shadow copies of inherited identifiers, but these are semantically the same as the original definition. Therefore, as shown in the following example, you can refer to the inherited except1 exception as either A::except1 or B::except1:

```
interface A
{
   exception except1 {};
};

interface B : A {};

interface C
{
   void op1()
      raises(A::except1);
   void op2()
      raises(B::except1);
            //op1() and op2() raise the same
            //exception.
};
```

Ambiguity can occur in specifications due to the nested naming scopes. For example, in:

```
interface A
{
    typedef string<128> string_t;
};

interface B
{
    typedef string<256> string_t;
};

interface C:A,B
{
    attribute string_t Title;// AMBIGUOUS!!!
};
```

the attribute declaration in interface C is ambiguous because the IDL compiler cannot determine which string_t is desired.

IDL Traps

These are some of the more common problems developers encounter when defining IDL interfaces for Smalltalk classes.

Magnitude Mismatches

The standard IDL numeric quantities do not match the sizes of the standard Smalltalk Magnitude subclasses. An IDL long (-231 to 231-1) may be represented as a Smalltalk SmallInteger (-229 to 229-1), LargeNegativeInteger, or LargePositiveInteger, depending on its size and sign. Conversely, some valid LargePositiveIntegers cannot be represented as IDL longs.

The marshalling engines, which translate objects from their Smalltalk representation to transmission format and back again, do not check the magnitudes of numbers when marshalling. If you define an IDL interface to return a short value, then return the SmallInteger 2 raisedTo: 28, the number that arrives at the receiver will not be interpreted as 228. It is the developer's responsibility to check magnitudes before transmitting them in remote messages.

Mismatched IDL Interfaces and Smalltalk Selectors

When you change a message selector in Smalltalk, you must remember to change the corresponding IDL definitions. If you change the type of an argument, this will not cause Smalltalk errors, but may make the IDL invalid, causing marshalling exception.

Inheritance and Overriding Operations

Unlike Smalltalk, IDL forbids interfaces to override operations defined in their superclass. If the superclass definition specifies an operation, the subclass must use that operation definition.

Passing Values and References: Interfaces and Structures

You use interfaces and structures in your operation definitions to control whether an object is passed by value or by reference. Use the name of an interface as a type in your operation declaration when you want to pass an instance by reference. Use the name of a struct in your operation declaration when you want to pass an instance by value. This works for either the type of the return value or the type of one or more of the parameters.

For example, building on the Person example above, you may have these definitions:

```
module PersonModule {

    #pragma class PersonStruct Person
    struct PersonStruct {
        string name;
        short age;
    };
    interface PersonInterface {

        string name();
        #pragma selector set_name name:
        void set_name (in string s);

        short age();
        #pragma selector set_age age:
        void set_age (in short s);

        PersonStruct personCopyWithName (in string n);
        PersonInterface personReferenceWithName (in string n);
    };
};
```

In this case, the method personCopyWithName: will answer a local copy of a Person (pass by value), but the method personReferenceWithName: will answer a reference to a remote instance of Person (pass by reference).

SmalltalkTypes

It is important to look at what is in SmalltalkTypes in DSTRepository. There you will find a series of typedefs that were useful to the developers of DST. These typedefs arrange it so that instances of the following classes, for example, are passed by value:

Symbol	ByteArray	ByteString	OrderedCollection
Set	Bag	Association	Dictionary
Point	Rectangle	Date	Time

IDL void and Smalltalk nil

There is no Smalltalk equivalent of void, just as there is no IDL equivalent of nil. Thus, it is important to to be aware of the following:

- A remote object, when sent an operation whose signature specifies a void return value, will answer a local nil. The same object, sent the same message locally, could answer self. (For consistency, you can make the methods answer nil locally as well.)
- A remote object, sent an operation whose signature specifies a base or defined type as a return value, will generate a marshalling error if the remote object answers nil. (This is common if you fail to initialize instance variables with an object of the appropriate kind.)
- A remote object, sent an operation whose signature specifies an interface as a return value, may answer an object reference to a remote nil.

9

Mapping of IDL to Smalltalk

This chapter describes the mapping of OMG IDL constructs to Smalltalk constructs. You must use IDL to define the interfaces for an application's remotely-accessible objects. In these interfaces, you define the externally-visible functionality of each object (but you implement this functionality elsewhere in Distributed Smalltalk Smalltalk).

A critical part of the ORB's activities is the translation service (via a language binding) between the local language (such as Smalltalk) and IDL, the language-neutral Interface Definition Language that all ORBs speak as their common language. This chapter describes the IDL semantics, gives the syntax for IDL grammatical constructs and the Smalltalk-to-IDL language binding implemented in Distributed Smalltalk, and explains how to use it.

Constraints on Smalltalk Mappings

- Whenever possible, IDL types are mapped directly to existing, portable Smalltalk classes.
- The Smalltalk mapping only describes the public (client) interface to Smalltalk classes and objects supporting IDL. Individual IDL compilers or CORBA implementations might define additional private interfaces.
- The implementation of IDL interfaces is left unspecified. Implementations may choose to:
    - Map each IDL interface to a separate Smalltalk class

  - Provide one Smalltalk class to map all IDL interfaces
  - Allow arbitrary Smalltalk classes to map IDL interfaces
- Because of the dynamic nature of Smalltalk, the mapping of the any and union types is such that an explicit mapping is unnecessary. Instead, the value of the any and union types can be passed directly. In the case of the any type, the Smalltalk mapping will derive a TypeCode which can be used to represent the value. In the case of the union type, the Smalltalk mapping will derive a discriminator which can be used to represent the value.
- The explicit passing of environment and context values on operations is not required.
- Except in the case of object references, no memory management is required for data parameters and return results from operations. All such Smalltalk objects reside within Smalltalk memory, and so garbage collection will reclaim their storage when they are no longer used.

Default Mapping for IDL to Smalltalk

The use of underscore characters in IDL identifiers is not allowed in all Smalltalk language implementations. Thus, a conversion algorithm is required to convert names used in IDL to valid Smalltalk identifiers.

To convert an IDL identifier to a Smalltalk identifier, remove each underscore and capitalize the following letter (if it exists). For example:

add_to_copy_map becomes addToCopyMap

describe_contents becomes describeContents

Smalltalk implementations generally require that class names and global variables have an uppercase first letter, while other names have a lowercase first letter.

One aspect of the language mapping can cause an IDL compiler to map incorrectly to Smalltalk code resulting in name space collisions. Because Smalltalk implementations generally only support a global name space, and disallow underscore characters in identifiers, the

mapping of identifiers used in IDL to Smalltalk identifiers can result in a name collision. As an example of name collision, consider the following IDL declaration:

```
interface Example {
    void sample_op () ;
    void sampleOp () ;
};
```

Both of these operations map to the Smalltalk selector sampleOp. In order to prevent name collision problems, each implementation of the IDL language binding must support an explicit naming mechanism, which can be used to map an IDL identifier into an arbitrary Smalltalk identifier. Distributed Smalltalk uses #pragma as the mechanism.

Handling Return Values

IDL and Smalltalk message syntaxes both allow zero or more input parameters to be supplied in a request. For return values, Smalltalk methods yield a single result object, whereas IDL allows an optional result and zero or more out or inout parameters to be returned from an invocation. In this binding, the non-void result of an operation is returned as the result of the corresponding Smalltalk method, whereas out and inout parameters are to be communicated back to the call via instances of a class conforming to the CORBAParameter protocol, passed as explicit parameters.

To create an object that supports the CORBAParameter protocol, the message asCORBAParameter can be sent to any Smalltalk object. This will return a Smalltalk object conforming to the CORBAParameter protocol, whose value will be the object it was created from. The value of that CORBAParameter object can be subsequently changed with the value: message. asCORBAParameter is implemented in Object and returns a ValueHolder, which latter is used to represent inout and out parameters that are present in addition to the return value.

Limitations

The proposed language mapping places limitations on the use of certain types defined in IDL.

For the any and union types, specific integral and floating point types may not be able to be specified as values. The implementation will map such values into an appropriate type, but if the value can be represented by multiple types, the one actually used cannot be determined. For example, consider the union definition below:

```
union Foo switch (long) {
    case 1: long x;
    case 2: short y;
} ;
```

When a Smalltalk object corresponding to this union type has a value that fits in both a long and a short, the Smalltalk mapping can derive discriminator 1 or 2, and map the integral value into either a long or short value (corresponding to the value of the discriminator determined).

This limitation can be overcome in some cases by a careful ordering of the union types, and in all cases by use of DSTUnion, which allow explicit specification of the value and the discriminator for parameters.

Mapping of IDL Elements to Smalltalk

The following overview provides a brief description of the mapping of IDL elements to the Smalltalk language.

IDL Element	Smalltalk Language
object references	Smalltalk objects which represent CORBA objects. The Smalltalk objects must respond to all messages defined by the CORBA objects' interface.
interfaces	A set of messages that Smalltalk objects which represent object references must respond to. The set of messages corresponds to the attributes and operations defined in the interface and inherited interfaces.
operations	Smalltalk messages.
attributes	Smalltalk messages.
constants	Smalltalk objects available in CORBAConstants dictionary.
integral types	Smalltalk objects which conform to the Integer class.
floating point type	Smalltalk objects which conform to the Float class.

IDL Element	Smalltalk Language
boolean type	Smalltalk true or false objects.
enumeration types	Smalltalk objects which conform to the CORBAEnum protocol.
any type	Smalltalk objects that can be mapped into an IDL type.
structure types	Smalltalk objects which conform to the Dictionary class.
union types	Smalltalk objects which map to the possible value types of the IDL union, or which conform to the CORBAUnion protocol.
sequence type	Smalltalk objects which conform to the OrderedCollection class.
string type	Smalltalk objects which conform to the String class.
array type	Smalltalk objects which conform to the Array class.
exception type	Smalltalk objects which conform to the Dictionary class.

SmalltalkTypes

A large number of special mappings used in DST are defined in the SmalltalkTypes module in DSTRepository. It is helpful to become familiar with these default mappings between IDL and Smalltalk types in DST.

Of particular interest are the *OrNil types, which handle many cases of translating between IDL void and Smalltalk nil. Note that if you are not going to use *OrNil unions in specifying return values, it is very important that you carefully and fully initialize classes that will be accessed remotely. Refer to IDL void and Smalltalk nil in Chapter 8, “Defining IDL Interfaces” for details.

Mapping for Interface

Each IDL interface defines the operations that object references with that interface must support. In Smalltalk, each IDL interface defines the methods that object references with that interface must respond to.

Implementations are free to map each IDL interface to a separate Smalltalk class, map all IDL interfaces to a single Smalltalk class, or map arbitrary Smalltalk classes to IDL interfaces.

CORBAName Method

In Distributed Smalltalk, the CORBAName is the tie between an interface and its corresponding implementation. That is, any object that has an interface (that is, a CORBA object), must implement the CORBAName, which specifies the interface name. When the ORB receives an incoming request, it locates the interface in the Interface Repository, and the Smalltalk class by this CORBAName.

Thus, in the Smalltalk class Depot, repository>>CORBAName would map the class Depot to the IDL interface Depot as follows:

```
CORBAName
    ^#'::CentralOffice::Depot'
```

The CORBAName method is usually implemented on the instance side of a class definition and provides the link to the interface for instances of the class, but it may also be implemented on the class side, in which case the CORBAName method provides the link to the interface for the class.

Getting Information About an Interface

Object references to both local and remote objects supporting IDL interfaces are via the normal Smalltalk object reference mechanism. To obtain the interface associated with the object reference, invoke the getInterface method; this returns the actual interface meta object which models its type information.

In addition, and when the programmer knows she is dealing with a surrogate object reference, the interface will return the local repository's meta object for that type. Access to local meta objects is considerably faster, of course.

Mapping for Objects

A CORBA object is represented in Smalltalk as a Smalltalk object called an object reference. The object reference must respond to all messages defined by that CORBA object's interface.

An object reference can have a value which indicates that it does not represent a CORBA object. This value is the standard Smalltalk value nil.

Invocation of Operations

IDL and Smalltalk message syntaxes both allow zero or more input parameters to be supplied in a request. For return values, Smalltalk methods yield a single result object, whereas IDL allows an optional result and zero or more out or inout parameters to be returned from an invocation. In this binding, the non-void result of an operation is returned as the result of the corresponding Smalltalk method, whereas out and inout parameters are to be communicated back to the caller via instances of a class conforming to the CORBAParameter protocol, passed as explicit parameters.

For example, the following operations:

```
boolean definesProperty(in string key);
void defines_property(
    in string key,
    out boolean is_defined);
```

are used as follows:

```
aBool := self definesProperty: aString.
self
    definesProperty: aString
    isDefined: (aBool := nil asCORBAParameter).
```

As another example, the operations:

```
boolean has_property_protection(
    in string key,
    out Protection pval);

ORBStatus create_request (in Context ctx,
    in Identifier operation,
    in NVList arg_list,
    inout DynamicInvocation::NamedValue result,
    out Request request,
    in Flags reg_flags);
```

would be invoked as:

```
aBool := self
    hasPropertyProtection: aString
    pval: (protection := nil asCORBAParameter).
aStatus := ORBObject
    createRequest: aContext
    operation: anIdentifier
    argList: anNVList
    result: (result := aNamedValue asCORBAParameter)
    request: (request := nil asCORBAParameter)
    reqFlags: aFlags.
```

The return value of IDL operations that are specified with a void return type is undefined.

Mapping for Attributes

IDL attribute declarations are a shorthand mechanism to define pairs of simple accessing operations: one to get the value of the attribute and one to set it. Such accessing methods are common in Smalltalk programs as well, so attribute declarations are mapped to standard methods to get and set the named attribute value, respectively.

For example:

```
attribute string title;
readonly attribute string my_name;
```

means that Smalltalk programmers can expect to use title and title: methods to get and set the title attribute of the CORBA object, and the myName method to retrieve the my_name attribute.

Although attributes provide a shorthand for setters and getters, the syntax for attributes does not allow you to specify the exceptions that might be returned, as does an ordinary operation declaration.

Readonly Attributes for Security

By default, attributes are read-write. However, you can declare read-only attributes to keep clients from changing what they should not. For example, the CompoundLifecycle::LinkRead module declares a variety of attributes including these read-only attributes:

```
readonly attribute LinkSet head;
readonly attribute boolean is_existence_ensuring;
```

An IDL operation can set the value of a read-only attribute in its implementation.

Mapping for Constants

IDL allows constant expressions to be declared globally as well as in interface and module definitions. IDL constant values are stored in a dictionary named CORBAConstants under the fully qualified name of the constant, not subject to the name conversion algorithm. The constants are accessed by sending the at: message to the dictionary with an instance of a String whose value is the fully qualified name.

For example, given the following IDL specification:

```
module ApplicationBasics {
   const CopyDepth shallow_cpy = 4;
};
```

the ApplicationBasics::shallow_cpy constant can be accessed with the following Smalltalk code:

```
value := CORBAConstants at: '::ApplicationBasics::shallow_cpy'.
```

After this call, the value variable will contain the integral value 4.

Here is another example where constant declarations map Smalltalk names to IDL:

```
const LinkType containment_link = 1;
```

Tells the compiler to substitute link type 1 whenever the identifier containment_link is used.

```
const LinkType reference_link = 3;
```

Substitute link type 3 when reference_link is used.

```
const LinkType designation_link = 5;
```

Substitute link type 5 when designation_link is used.

```
const LinkType weak_link = 7;
```

Substitute link type 7 when weak_link is used.

Getting More Information About a Constant

IDL constant values are stored in the global dictionary CORBAConstants under the fully qualified name of the constant.

Mapping for Basic Data Types

Each of the parameters of an IDL operation definition has an associated data type which must be declared in advance, since IDL is a statically-typed definition language. This means that some

operations that can be implemented in Smalltalk cannot be declared in IDL at all. It is also complicated by the fact that, all Smalltalk values are instances of a Smalltalk class. In order to be able to construct valid calls on IDL operations, however, a mapping must be devised. Fortunately, the following type-to-class mapping works well enough and useful distributed systems can be constructed.

Base Type Mapping

Since Smalltalk is not a typed language, various classes in the Magnitude categories are used to map Smalltalk objects to IDL data types.

- Smalltalk Magnitude classes map directly onto the required IDL basic datatypes, and the subclasses of this abstract class are concerned with their representation in all situations.
- Boolean values TRUE and FALSE are used by the Smalltalk programmer to represent IDL boolean types.
- Character values are used by the Smalltalk programmer to represent IDL char types.
- Float and Double values are used by the Smalltalk programmer to represent IDL float and double types.
- Integer values are used by the Smalltalk programmer to represent IDL long and short integer types.
- Character and SmallInteger values may be used by the Smalltalk programmer to represent IDL octet types.

The following basic datatypes are mapped into existing Smalltalk classes. In the case of short, unsigned short, long, unsigned long, float, double, and octet, the actual class used is left up to the implementation, for the following reasons:

- There is no standard for Smalltalk that specifics integral and floating point classes and the valid ranges of their instances.
- The classes themselves are rarely used in Smalltalk. Instances of the classes are made available as constants included in code, or as the result of computation.

The basic datatypes are mapped as follows:

short

An IDL short integer falls in the range [-2l5, 2l5-l]. In Smalltalk, a short is represented as an instance of an appropriate integral class.

long

An IDL long integer falls in the range [-231,231-l]. In Smalltalk, a long is represented as an instance of an appropriate integral class.

long long

An IDL long long integer falls in the range [-263 ,263-1]. In Smalltalk, a long long is represented as an instance of an appropriate integral class.

unsigned short

An IDL unsigned short integer falls in the range [0,216-l]. In Smalltalk, an unsigned short is represented as an instance of an appropriate integral class.

unsigned long

An IDL unsigned long integer falls in the range [0,232-l]. In Smalltalk, an unsigned long is represented as an instance of an appropriate integral class.

unsigned long long

An IDL unsigned long long integer falls in the range [0,264-1]. In Smalltalk, an unsigned long long is represented as an instance of an appropriate integral class.

float

An IDL float type represents IEEE single-precision (32-bit) floating point numbers. In Smalltalk, a float is represented as an instance of an appropriate floating point class.

fixed

An IDL fixed is represented as an instance of an appropriate fractional class with a fixed denominator (see Mapping for Fixed Type).

double

An IDL **double** type represents IEEE single-precision 64-bit) floating point numbers. In Smalltalk, a double is represented as an instance of an appropriate floating point class.

long double

An IDL long double conforms to the IEEE double extended (a mantissa of at least 64 bits, a sign bit, and an exponent of at least 15 bits) floating point standard (ANSI/IEEE Std 754-1985). In Smalltalk, a long double is represented as an instance of an appropriate floating point class.

char

An IDL char holds an 8-bit quantity mapping to the ISO Latin-1 8859.1 character set. In Smalltalk, a char is represented as an instance of Character.

wchar

An IDL wchar defines a wide character from any character set. A wide character is represented as an instance of the Character class.

boolean

An IDL boolean may hold one of two values: TRUE or FALSE. In Smalltalk, a boolean is represented by the values true or false, respectively.

octet

An IDL octet is an 8-bit quantity that undergoes no conversion during transmission. In Smalltalk, an octet is represented as an instance of an appropriate integral class with a value in the range [1,255].

Mapping for Fixed Type

An IDL fixed is represented as an instance of an appropriate fractional class with a fixed denominator.

Smalltalk class FixedPoint is the only Smalltalk class with an explicit, default mapping to the IDL fixed type.

Mapping for the Any Type

Due to the dynamic nature of Smalltalk, where the class of objects can be determined at runtime, an explicit mapping of the any type to a particular Smalltalk class is not required. Instead, wherever an any is required, the user may pass any Smalltalk object which can be mapped into an IDL type. For instance, if an IDL structure type is defined in an interface, a Dictionary for that structure type will be mapped. Instances of this class can be used wherever an any is expected, since that Smalltalk object can be mapped to the IDL structure.

Likewise, when an any is returned as the result of an operation, the actual Smalltalk object which represents the value of the any data structure will be returned.

Any Smalltalk class may be mapped to an instance of an IDL type any in an operation invocation parameter list. By default, type any output parameters and results are returned as the value of the object.

However, type any should not be used indiscriminately, because it has additional overhead. The ORB has to marshal information about exactly which type of object is coming across as an any in addition to the value itself.

CORBAType Method

The CORBAType method specifies how an object is to be marshaled when it is passed under the umbrella of type any. By default, we pass by reference. If you want to pass an object by value when it is passed as an any, you must override CORBAType.

The default implementation of CORBAType is in class Object. It returns a meta object for the object's interface, which marshals it as an object reference, not an IDL data type. This object reference corresponds to the CORBAName method associated with this object (a fully qualified interface name). Browse implementors of CORBAType to see other implementations.

As a rule, you should implement the CORBAType method in any class that uses the CLASS pragma in its IDL interface definition. For example, see the CosNaming module in DSTRepository, where pragmas are defined for classes DSTNameComponent and DSTName.

Mapping for Enum

IDL enumerators are stored in a dictionary named CORBAConstants under the fully qualified name of the enumerator, not subject to the name conversion algorithm. The enumerators are accessed by sending the at: message to the dictionary with an instance of a String whose value is the fully qualified name.

These enumerator Smalltalk objects must support the aCORBAEnum protocol, to allow enumerators of the same type to be compared. The order in which the enumerators are named in the specification of an enumeration defines the relative order of the enumerators. The protocol must support the following instance methods:

```
< aCORBAEnum
```

Answers true if the receiver is less than aCORBAEnum, otherwise answers false.

```
<= aCORBAEnum
```

Answers true if the receiver is less than or equal to aCORBAEnum, otherwise answers false.

```
= aCORBAEnum
```

Answers true if the receiver is equal to aCORBAEnum, otherwise answers false.

```
> aCORBAEnum
```

Answers true if the receiver is greater than aCORBAEnum, otherwise answers false.

```
>= aCORBAEnum
```

Answers true if the receiver is greater than or equal to aCORBAEnum, otherwise answers false.

For example, given the following IDL specification:

```
module Graphics {
    enum ChartStyle
        {lineChart, barChart, stackedBarChart, pieChart};
};
```

the Graphics::lineChart enumeration value can be accessed with the following Smalltalk code:

```
value := CORBAConstants at: '::Graphics::lineChart'.
```

After this call, the value variable is assigned to a Smalltalk object that can be compared with other enumeration values.

Mapping for Struct Types

An IDL struct is mapped to an instance of the Dictionary class. The key for each IDL struct member is an instance of Symbol whose value is the name of the element converted according to the algorithm given earlier.

For example, given the following IDL declaration:

```
struct  Binding {
    Name binding_name;
    BindingType binding_type;
};
```

the binding_name element can be accessed as follows:

```
aBindingStruct at: #bindingName
```

and set as follows:

```
aBindingStruct at: #bindingName put: aName
```

Mapping for Union Types

For IDL union types, two binding mechanisms are provided: an implicit binding and an explicit binding. Although not required, implementations may choose to provide both implicit and explicit mappings for other IDL types, such as structs and sequences. In the explicit mapping, the IDL type is mapped to a user-specified Smalltalk class. The implicit binding takes maximum advantage of the dynamic nature of Smalltalk and is the least intrusive binding for the Smalltalk programmer. The explicit binding retains the value of the discriminator and provides greater control for the programmer.

Although the particular mechanism for choosing implicit vs. explicit binding semantics is implementation specific, all implementations must provide both mechanisms. Binding semantics is expected to be specifiable on a per-union declaration basis, for example using #pragmas.

Implicit Binding

Wherever a union is required, the user may pass any Smalltalk object that can be mapped to an IDL type, and whose type matches one of the types of the values in the union. Consider the following example:

```
structure S { long x; long y; };
union U switch (short) {
    case 1: S s;
    case 2: long 1;
    default: char c;
};
```

In the example above, a Dictionary for structure S will be mapped. Instances of Dictionary with runtime elements as defined in structure S, integral numbers, or characters can be used wherever a union of type U is expected. In this example, instances of these classes can be mapped into one of the S, long, or char types, and an appropriate discriminator value can be determined at runtime.

Likewise, when a union is returned as the result of an operation, the actual Smalltalk object which represents the value of the union will be returned.

Explicit Binding

Use of the explicit binding will result in specific Smalltalk classes being accepted and returned by the ORB. Each union object must conform to the CORBAUnIon protocol. This protocol must support the following instance methods:

discriminator

Answers the discriminator associated with the instance

discriminator: anObject

Sets the discriminator associated with the instance

value

Answers the value associated with the instance

value: anObject

Sets the value associated with the instance

To create an object that supports the CORBAUnIon protocol, the instance method asCORBAUnIon: aDiscrImInator can be invoked by any Smalltalk object. This method will return a Smalltalk object

conforming to the CORBAUnIon protocol, whose discriminator will be set to aDiscrimInator and whose value will be set to the receiver of the message.

Mapping for Sequence Types

Instances of the OrderedCollectIon class are used to represent IDL elements with the sequence type.

A sequence is a one-dimensional array with two characteristics: a subtype, and an optional maximum size. Use a "< >" combination to specify the type of data that belongs in a sequence, and optionally, the upper limit of elements.For example:

Example		Comment
sequence<string>	elements;	The sequence elements' members will be of type string.
sequence <NameComponent>	Name;	The sequence Name's members will be of the type NameComponent.
sequence<char , 2048 >	Text Buffer;	The sequence TextBuffer will have a maximum number of 2048 members all of which will be characters.

Mapping for String Types

Instances of the Smalltalk String class are used to represent IDL elements with the string type.

Strings

Smalltalk strings and their subclasses may be passed and will be returned by IDL operations involving string arguments. A string can be unbounded or can have a maximum size (specified via the "< >" combination). For example:

Example		Comment
string	username;	The string username is unbounded.
string<25>	ChartLabel;	The string ChartLabel may be no longer than 25 characters.

An IDL wide string is represented as an instance of an appropriate Smalltalk String class.

Mapping for Array Types

Instances of the Smalltalk array class are used to represent IDL elements with the array type.

Mapping for Exception Types

Each defined exception type is mapped to an instance of Dictionary.

Exception handling is implemented using the Distributed Smalltalk Signal exception handling mechanisms. Thus to raise an exception, the program can simply invoke #error:.

Since IDL exceptions are allowed to have arbitrary structured values returned with the exception, the programmer needs a way to specify this information as well. Fortunately, Smalltalk is up to the task. Consider the example Smalltalk fragment, which raises the BAD_INV_ORDER exception (one of the standard exceptions defined in interface Object):

```
^ErrorSignal
    raiseWith: (Array
        with: #'BAD_INV_ORDER'
        with: (Array
        with: minor
        with: #NO))
    errorString: 'routine invocations out of order'
```

In order to allow the ORB to correctly return the error result structure to the sender of the method, an array must be returned as the parameter of the error. Here, the symbolic name of the event is provided in an array along with the type-structure representation of the required error result values. These values will be marshalled by the ORB to ensure that the same exception can be raised in the context of the client of the remote operation.

As with normal Signal exceptions, a handle:do: recovery block may be used to catch and recover from these exceptions. The main difference is that the ORB call context will have already unwound to the site of the remote call before the exception is raised. This greatly limits the extent to which recovery can be accomplished.

For example, the NamingContext interface in the CosNaming module declares these exceptions:

```
interface NamingContext {
…
enum NotFoundReason {missing_node, not_context, not_object};

exception NotFound {NotFoundReason why; Name rest_of_name; };
exception CannotProceed {NamingContext cxt; Name
   rest_of_name; };
exception InvalidName {};
exception AlreadyBound {};
exception NotEmpty {};
…
};
```

For exceptions declared with empty braces, no additional information is available to the client code when the exception is raised.

Exceptions can be declared anywhere within an IDL module. Exceptions declared at the beginning of the module apply to the module as a whole; exceptions declared within an interface apply to that interface only.

Note, however, that [1] you cannot specify what exceptions an operation declared as an attribute might return, and [2] if you do not specify what exceptions might be returned by an operation, you will, when an exception is returned, get the UNKNOWN exception.

Getting More Information on Exceptions

The Object interface (in DSTRepository>>core IFs>>CORBA) declares all the standard exceptions.

Each DSTexception meta object is also an instance of the ExceptionDef interface in the Repository, and may be accessed accordingly.

IDL attribute names containing an underscore (_) character are automatically converted to conventional Smalltalk using the capitalization rule.

Mapping for Operations

IDL operations having zero parameters map directly to Smalltalk unary messages, while IDL operations having one or more parameters correspond to Smalltalk keyword messages. To determine the default selector for such an operation, begin with the

IDL operation identifier and concatenate the parameter name of each parameter followed by a colon, ignoring the first parameter. The selector name is subject to the identifier conversion algorithm.

For example, the following IDL operations:

```
void add_to_copy_map(
   in CORBA::ORBId id,
   in LinkSet link_set);

void connect push_supplier(
   in EventComm::PushSupplier push_supplier);

void add_to_delete_map(
   in CORBA::ORBId id,
   in LinkSet link_set);
```

become selectors:

```
addToCopyMap:linkSet:
connectPushSupplier:
addToDeleteMap:linkSet:
```

Implicit Arguments to Operations

Unlike the C mapping, where an object reference, environment, and optional context must be passed as parameters to each operation, the Smalltalk mapping does not require these parameters to be passed to each operation.

The object reference is provided in the client code as the receiver of a message. So although it is not a parameter on the operation, it is a required part of the operation invocation.

This mapping defines the CORBAExceptionEvent protocol to convey exception information in place of the environment used in the C mapping. This protocol can either be mapped into native Smalltalk exceptions or used in cases where native Smalltalk exception handling is unavailable.

A context expression can be associated with the current Smalltalk process by sending the message corbaContext: to the current process, along with a valid context parameter. The current context can be retrieved by sending the corbaContext message to the current process.

The current process may be obtained by sending the message activeProcess to the Smalltalk global variable named Processor.

Argument-Passing Considerations

All parameters passed into and returned from the Smalltalk methods used to invoke operations are allocated in memory maintained by the Smalltalk virtual machine. Thus, explicit free( ) ing of the memory is not required. The memory will be garbage-collected when it is no longer referenced.

The only exception is object references. Since object references may contain pointers to memory allocated by the operating system, it is necessary for the user to explicitly free them when no longer needed. This is accomplished by using the operation release of the CORBA::Object interface.

Unmapped Interfaces

It is sometimes convenient or necessary to define an interface without providing an implementation. For example, DST defines an interface,

```
interfaceNamingContextExt : NamingContext
```

in CosNaming, to support ORBs that are ahead of DST in CORBA compliance. Browse this interface definition for an example.

Handling Exceptions

IDL allows each operation definition to include information about the kinds of run-time errors which may be encountered. These are specified in an exception definition which declares an optional error structure which will be returned by the operation should an error be detected. Since Smalltalk exception handling classes are not yet standardized between existing implementations, a generalized mapping is provided.

In this binding, the IDL compiler creates exception objects and populates the CORBAConstants dictionary. These exception objects are accessed from the CORBAConstants dictionary by sending the at: message with an instance of a String whose value is the fully qualified name. Each exception object must conform to the CORBAExceptionEvent protocol. This protocol must support the following instance methods:

```
corbaHandle: aHandlerBlock do: aBlock
```

Exceptions may be handled by sending an exception object the message corbaHandh:do: with appropriate handler and scoping blocks as parameters. The aBlock parameter is the Smalltalk block to evaluate. It is passed no parameters. The aHandlerBlock parameter is a block to evaluate when an exception occurs. It has one parameter: a Smalltalk object which conforms to theCORBAExceptionValue protocol.

```
corbaRaise
```

Exceptions may be raised by sending an exception object the message corbaRaise.

```
corbaRaiseWith: aDictionary
```

Exceptions may be raised by sending an exception object the message corbaRaiseWith:. The parameter is expected to be an instance of the Smalltalk Dictionary class, as described below.

For example, given the following IDL specification:

```
interface NamingContext {
    ...
    exception NotEmpty {};
    void destroy ()
        raises (NotEmpty);
    ...
};
```

the NamingContext::NotEmpty exception can be raised as follows:

```
(CORBAConstants at: '::NamingContext::NotEmpty')
    corbaRaise.
```

The exception can be handled as follows:

```
(CORBAConstants at: '::NamingContext::NotEmpty')
    corbaHandle: [:ev I "error handling logic here" ]
    do: [aNamingContext destroy].
```

Exception Values

CORBA IDL allows values to be returned as part of the exception. Exception values are constructed using instances of the Smalltalk Dictionary class. The keys of the dictionary are the names of the

elements of the exception, the names of which are converted using the name conversion algorithm. The following example, which illustrates how exception values are used:

```
interface NamingContext {
   ...
   exception CannotProceed {
      NamingContext cxt;
      Name rest_of_name;
   };
   Object resolve (in Name n)
      raises (CannotProceed);
   ...
};
```

would be raised as follows:

```
(CORBAConstants at: '::NamingContext::CannotProceed')
   corbaRaiseWith: (Dictionary
      with: (Association key: #cxt value: aNamingContext)
      with: (Association key: #restOfName value: aName)).
```

The CORBAExceptionValue Protocol

When an exception is raised, the exception block is evaluated, passing it one argument which conforms to the CORBAExceptIonValue protocol. This protocol must support the following instance message:

```
corbaExceptionValue
```

It answers the Dictionary with which the exception was raised.

Given the NamingContext interface defined above, the following code illustrates how exceptions are handled:

```
(CORBAConstants at: '::NamingContext::NotEmpty')
   corbaHandle: [:ev |
      cxt := ev corbaExceptionValue at: #cxt.
      restOfName := ev corbaExceptionValue at: #restOfName]
   do: [aNamingContext destroy].
```

In this example, the cxt and restOfName variables will be set to the respective values from the exception structure, if the exception is raised.

Pragmas

Pragmas are implementation-dependent messages to the IDL compiler that can be ignored by another compiler without harm. There are two categories of pragmas:

- RepositoryId pragmas: ID. version. prefix
- VisualWorks specific pragmas: selector, class, and access.

IDL-specific pragmas may appear anywhere in a specification.

Pragma	IDL Type
id	module, interface, attribute, operation, typedef, constant, exception
prefix	anywhere (no restrictions)
version	module, interface, attribute, operation, typedef, constant, exception
selector	operation
class	struct, enum, union, typedef
access	operation

RepositoryIds

RepositoryIds are globally unique values that can be used to establish the identity of information in the repository. A RepositoryId is represented as a string, allowing programs to store, copy, and compare them without regard to the structure of the value. It does not matter what format is used for any particular RepositoryId. However, conventions are used to manage the name space created by these IDs. All repository objects will have RepositoryIds (module, interface, attribute, operation, typedef, constant, exception).

RepositoryIds may be associated with IDL definitions in a variety of ways: Installation tools might generate them, they might be defined with pragma's in IDL source, or they might be supplied with the package to be installed.

The format of the ID is a short format name followed by a colon (:) followed by characters according to the format. The three formats are:

- IDL format derived from IDL names

If no RepositoryId is specified, the system will generate an IDL format RepositoryId.

- DCE format
- Local format that is intended for short-term use, e.g., in a development environment.

> **Note:** IDL format is the recommended type. In general, it is preferred to let the system allocate the RepositoryId.

IDL Format

The IDL format for RepositoryIds primarily utilizes IDL-scoped names to distinguish between definitions. It also includes an optional unique prefix, and major and minor version numbers.

IDL format RepositoryIDs consist of three components, separated by colons (:).

The first component is the format name:

```
IDL
```

The second component is a list of identifiers, separated by slashes (/). These identifiers are arbitrarily long sequences of alphabetic, digit, underscore (_), hyphen (-), and period (.) characters. Typically, the first identifier is a unique prefix, and the rest are the IDL Identifiers that make up the scoped name of the definition.

The third component is made up of major and minor version numbers, in decimal format, separated by a period (.). When two interfaces have RepositoryIds differing only in minor version number, it can be assumed that the definition with the higher version number is upwardly compatible with (i.e., can be treated as derived from) the one with the lower minor version number.

For example, the RepositoryId for the initial version of interface Printer defined on module Office by an organization known as “ABCCo” might be:

```
IDL:ABCCo/Office/Printer:1.0
```

This format makes it convenient to generate and manage a set of IDs for a collection of IDL definitions. The person creating the definitions sets a prefix (“ABCCo”), and the IDL compiler or other tool can synthesize all the needed IDs.

Because RepositoryIds may be used in many different computing environments and ORBs, as well as over a long period of time, care must be taken in choosing them. Prefixes that are known to be distinct for other reasons (e.g., trademarked names, domain names, UUIDs, etc.) are preferable to generic ones (e.g., Document).

DCE Format

DCE format RepositoryIds start with the characters DCE: and are followed by the printable form of the UUID, a colon, and a single digit decimal minor version number, for example:

```
DCE:700dc518-0110-11ce-ac8f-0800090bSd3e:l
```

Local Format

Local format RepositoryIds start with the characters LOCAL: and are followed by an arbitrary string. Local format IDs are not intended for use outside a particular repository, and thus do not need to conform to any particular convention. Local IDs that are just consecutive integers might be used within a development environment to have a very cheap way to manufacture the IDs while avoiding conflicts with well-known interfaces.

Note: DCE and Local formats are not recommended.

RepositoryId Pragmas

A mechanism is provided to include RepositoryIds with published IDL specifications. A convention is specified for using #pragma directives to annotate IDL specifications with these IDs. Whether an IDL compiler uses these annotations directly, or some other tool is involved, is implementation defined.

Three IDL pragmas are specified in order to support arbitrary RepositoryId formats while supporting the IDL RepositoryId format with minimal annotation. An IDL compiler must either interpret these annotations as specified, or ignore them completely.

ID Pragma

An IDL pragma of the format:

```
#pragma ID <name> "<id>"
```

associates an arbitrary RepositoryId string with a specific IDL name. The <name> can be a fully or partially scoped name or a simple identifier, interpreted according to the usual IDL name lookup rules relative to the scope within which the pragma is contained.

The use of an ID pragma is discouraged because the system will generate it for you.

Prefix Pragma

An IDL pragma of the format:

```
#pragma prefix "<string>"
```

sets the current prefix used in generating IDL format RepositoryIds. The specified prefix applies to RepositoryIds generated after the pragma until the end of the current scope is reached or another prefix pragma is encountered.

Version Pragma

A VERSION pragma is optional for interface, module, attribute, constant, exception, operation, and typedef declarations. An IDL pragma of the format:

```
#pragma version <name> <major>.<minor>
```

provides the version specification used in generating an IDL format RepositoryId for a specific IDL name. The <name> can be a fully or partially scoped name or a simple identifier, interpreted according to the usual IDL name lookup rules relative to the scope within which the pragma is contained. The <major> and <minor> components are decimal unsigned shorts. If no version pragma is supplied for a definition, version 1.0 is assumed.

Interfaces and Version Control

When a remote object reference is received by a client and the client wishes to send a message to that object, the client side ORB checks to determine if the interface is contained in the local repository. If the local repository contains the correct interface (identified by its RepositoryId) compatibility is assumed and the operation continues normally. If the local repository holds the correct interface, but the version fields of the RepositoryIds mismatch, then an exception is raised.

If you are using a shared repository, such an exceptions suggests that a new version of the interface should be brought into the repository.

A higher version of an interface must support all the operations of previous versions. Only one version of an interface is accessible (and stored) in the DSTRepository.

When you create a new version of an existing interface and assign (or reassign) it a version number:

- Do not change existing operation signatures.
- Only add new operations at the lexical end of the interface definition. (That is, do not insert a new operation between existing operation declarations.)
- If appropriate, add additional types for the new operations after the lexical end of the previously existing interface.

Generating Repository IDs

If no ID pragma is specified, a definition is globally identified by an IDL format RepositoryId.

The ID string is generated by starting with the string IDL:. Then, if any prefix pragma applies, it is appended, followed by a slash (/). Next, the components of the scoped name of the definition, relative to the scope in which any prefix that applies was encountered, are appended, separated by slashes. Finally, a colon (:) and the version specification are appended.

For example, the following IDL:

```
module M1 1
    typedef long T1;
    typedef long T2;
    #pragma ID T2 "DCE:d62207a2-011e-11ce-88b4-
        0800090b5d3e:3"
};
#pragma prefix "P1"
module M2 {
    module M3 {
        #pragma prefix "P2"
        typedef long T3;
    };
    typedef long T4;
    #pragma version T4 2.4
};
```

specifies types with the following scoped names and RepositoryIds:

Scope Name	RepositoryId
::MI::TI	IDL:MI/TI:1.0
::MI::T2	DCE:d62207a2-O11e11ce-88b4-0800090b5d3e:3
::M2::M3::T3	IDL:P2/T3: 1.0
::M2::T4	IDL:PI/M2/T4:2.4

For this scheme to provide reliable global identity, the prefixes used must be unique. Two non-colliding options are suggested: Internet domain names and DCE UUIDs.

Furthermore, in a distributed world, where different entities independently evolve types, a convention must be followed to avoid the same RepositoryId being used for two different types. Only the entity that created the prefix has authority to create new IDs by simply incrementing the version number. Other entities must use a new prefix, even if they are only making a minor change to an existing type.

Prefix pragmas can be used to preserve the existing IDs when a module or other container is renamed or moved.

```
module M4 {
   #pragma prefix P1/M2
   module M3 {
      #pragma prefix P2
      typedef long T3;
   };
   typedef long T4;
   #pragma version T4 2.4
};
```

This IDL declares types with the same global identities as those declared in module M2 above.

Distributed Smalltalk Pragmas

In a Distributed Smalltalk Interface Repository, the most commonly used pragmas are class and selector.

Class Pragma

A class pragma is recommended for new data type declarations. It maps the declared data type to a Smalltalk class.

```
#pragma class <idl type> <Smalltalk class>
```

For example:

```
#pragma  class NameComponent DSTNameComponent
   struct  NameComponent {Istring id; Istring kind; };
```

Selector Pragma

A selector pragma is recommended, but not required due to the default mapping rules for each operation declaration. It maps the declared operation to its Smalltalk implementation method.

```
#pragma selector <idl operation> <Smalltalk method>
```

For example:

```
#pragma  selector rebind contextReBind:to:
   void rebind (in Name n, in Object obj);
```

Access Pragma

An access pragma is optional for operation declarations; it is used to check specified level(s) of access for authorized users to this operation. Classes that inherit from ORBObject and DSTPresenter can specify access control for any operation in their interfaces. To set access control for an operation in an interface, include the following line at the beginning of an operation definition (in the Interface Repository):

```
#pragma access <idl operation> nameOfAccessValue
```

For example:

```
#pragma  access set admin
void set (in AccessList access,
   in SymbolOrORBId user);
```

where the nameOfAccessValue is a string, such as read or admin (as specified in AccessSymbols). To see examples of how the access pragma is used, see class DSTRepository, module Security.

About IDL and DSTRepository

IDL is represented in the system in two ways:

- the text of the IDL is represented in the several methods of DSTRepository, and
- the marshaling machinery produced from the text is present as a privileged instance of class DSTmoduleRepository.

With one exception, all the code you write in Distributed Smalltalk is standard Smalltalk code. The exception is in the Interface Repository (IR), which appears as class DSTRepository. Methods in this class are written in IDL. IDL is used here because this is the public access registry of objects available to all CORBA-compliant applications, regardless of language.

The class DSTRepository is used as a container of IDL code. An instance of DSTmoduleRepository is the marshalling engine that converts messages sent to objRefs, and the return values from such calls, to and from the on-the-wire encodings defined in the CORBA specification. All messages that can be sent between images are registered here.

Editing the Interface Repository

You can edit the Interface Repository, DSTRepository, using any system browser. Note that there is no attempt to prevent simultaneous editing by multiple users.

IDL Mapping to Smalltalk

The DSTMetaObject class, in conjunction with its subclasses and the immediate subclasses of ORBObject, implements the IDL mapping to the Smalltalk programming language. These classes provide the Smalltalk programmer with mechanisms for expressing the following IDL concepts:

Classes	Concept
DSTtypeBase, subclasses	All IDL basic datatypes
DSTtypeConstr, DSTtypeTemplate	All IDL constructed datatypes
DSTconstant	References to constants defined in IDL

Classes	Concept
DSTObjRef	References to objects defined in IDL
DSToperation, DSTparameter, DSTsignature	Invocations of operations, including passing parameters and receiving results
DSTexception	Exceptions, including what happens when an operation raises an exception and how the exception parameters are accessed
DSTattribute	Access to attributes
ORBObject	Signatures for the operations defined by the ORB, such as the dynamic invocation interface, and the object adapters

In addition to defining the language mapping from IDL to Smalltalk, these meta objects are themselves remotely accessible and provide the Interface Repository behavior which is defined for all CORBA implementations.

10

Working with Object Interfaces

Before an application can run in a distributed environment, its object interfaces must be available to remote calls via the ORB. To do this, you must add hooks in both the Smalltalk class definitions and in the IDL interface definitions, so when an interface is invoked it can be found.

Specifically, you need to:

- Identify classes as “factories,” which create instances of objects.
- Define interfaces, which specify what services an object can provide, and register them in the *Interface Repository*.

This chapter explains how to make a class a factory and register it with the interface repository. It also describes ways for working and maintaining interfaces in the repository.

Making a Class a Factory

According to the CORBA specification, an object that can be instantiated to create another object is a *factory*. Thus, all non-abstract Smalltalk classes are potentially factories.

In order for a class to be identified as a factory, it must be registered with the ORB as a factory. To do so, the class must define this instance method:

abstractClassId

This method returns an abstract class identifier (a UUID) for the class, which the ORB uses to locate the class, and in turn to instantiate the desired object.

The method typically looks like this:

```
abstractClassId

    ^'c815c088-4901-0000-02d8-2421ae000000' asUUID
```

The trick is that the UUID *must be unique for this class* in the image. To generate a unique identifier for a class, evaluate the following in a workspace, using **PrintIt** :

```
ORBObject newId
```

Then copy the resulting string into the method body, in place of the string in the above example.

> **Note:** *DO NOT* copy the UUID from the body of any existing abstractClassId method. This number must be unique for this class in the image.

With this method defined, the ORB recognizes and registers the class as a factory when it initializes. An ORB initializes its factories registry when it starts. You can also force initialization in these ways:

- In the **DST** menu, choose **Initialize Factories**.
- Evaluate the expression:

```
ORBObject initializeFactories
```

Adding an Interface to the Interface Repository

The class DSTRepository is used as a container of IDL code. An instance of DSTmoduleRepository is the marshalling engine that converts messages sent to objRefs, and the return values from such calls, to and from the on-the-wire encodings defined in the CORBA specification. All messages that can be sent between images are registered here.

When a remote object (client) requests a service from a local object, the local ORB's Interface Repository is used to identify the local object, which services it can perform, and which messages are sent to provide these services. The association between an interface and its supporting class is made with the CORBAName message, which supplies the interface name.

To add an interface to the repository, do the following:

1 Create the CORBAName method.

Every class that implements an interface registered in the Interface Repository must implement the CORBAName instance method. This identifies a specific module and interface in the Interface Repository. Code for this method (usually in the message category repository) looks something like this:

```
CORBAName
"Answer the name of the receiver's CORBA interface in the IDL
repository."

^#'::DSTSampleComputeService::DSTSampleComputeServiceInterfa
ce'
```

The two words in the CORBAName method code correspond to the name of the *module* and the name of the *interface* as specified in DSTRepository.

2 Generate an IDL interface definition.

Send the message asIDLDefinition to your interface class, to create a first draft of the interfaces for a Smalltalk class:

```
yourClassName asIDLDefinition
```

The interface definition created will include an operation for every method in the class, many of which will be inappropriate for distributed access and can thus be removed. asIDLDefinition also makes best guesses at return types and parameters, but you will probably need to edit these as well.

Once generated, the definition is displayed in a text window.

3 Edit the definition, as required.

You need to:

- Verify that the interface name is correct, and corresponds to the name you supplied in the CORBAName method for the class.
- Add parent interfaces, as needed.
- Delete operation definitions that correspond to messages that should not be available to remote clients (including but not limited to messages in private protocols).
- For the remaining operation definitions, edit the result types, parameters, and operation names.
- Edit definitions for types, constants, attributes, exceptions (for the module as a whole or for specific interfaces).

- Delete unnecessary pragmas. For example selector pragmas are not needed for any unary messages, as the mapping between the Smalltalk message and IDL operation is clear.
- Add access pragmas for access controlled operations.

4 Browse DSTRepository to add these interfaces to a new module.

- Copy the text from the workspace and paste it into the module you are creating.
- Add module comment and name at the beginning of the module.
- Add a final " };" at the end of the module.
- Verify that each interface ends properly with a brace and a semicolon: "};" .

For specifics on IDL syntax and Smalltalk language bindings, see Chapter 8, "Defining IDL Interfaces".

Importing IDL files

Distributed Smalltalk provides a mechanism to import IDL files generated outside of Distributed Smalltalk. These external IDL files can have preprocessing directives. The important steps are listed below.

Setup for Preprocessing

Distributed Smalltalk *does not* include a preprocessor. You can use one of the following approaches:

- Use an ANSI C++ preprocessor to preprocess the IDL file.

  a Preprocess the IDL using the ANSI C++ preprocessor that is available on your system.

  b Import the IDL file into VisualWorks using the IDLCompiler importIDLFile:category: class method.

- Use the VisualWorks DLL and C Connect preprocessor (CPreprocessor)

  The first argument is the name of the preprocessed IDL file. .

  You can use the C preprocessor that comes with DLL and C Connect, included with Distributed Smalltalk. Even though this

preprocessor is not ANSI C++ compliant, it will work in most cases. Load the DLLCC parcel, then do the following:

a Modify the IDLCompiler preprocess: class method to work with CPreprocessor. As described in the method comment, change the method to

```
^CPreprocessor preprocess: aStream
```

Other preprocess messages are defined in CPreprocessor that you may need to use instead. Put whatever statement meets your needs as the method body.

b Send an importIDLFile:category: to the IDLCompiler class.

This message sends the (modified) preprocess: message to the input stream. The arguments are a FileName specifying the IDL file, and a symbol specifying the DSTRepository method category.

Annotate the IDL with Pragmas Where Necessary

Use a System Browser to add any necessary pragmas to the imported IDL. See *Chapter 8, "Defining IDL Interfaces"* for details on pragmas.

Avoiding Interface Problems

Keeping Interface Repositories Updated

Each Distributed Smalltalk image contains its own interface repository, unless you are using a shared repository. Changes you make to interfaces in one image do *not* propagate automatically to others. When interface repositories are not in sync with each other, you can get communication failures.

One way to facilitate interface repository maintenance is with a shared repository. To share a repository, open the DST Settings tool (**DST > Settings**). On the **Interface Repository** page, select the **Hostname** radio button and enter the host IP address or name. Do this in all images that will be sharing this repository, except the one hosting the repository, which will be configured to **Local**.

11

Initialization Service

ORB initialization defines the way in which an application can initialize itself in a CORBA environment. There are three aspects to ORB initialization as specified by the OMG:

- ORB initialization

  Initialize an application into the ORB and Object Adapter environments. Return ORB and OA pseudo object references to the application for use in future ORB and OA operations.

- Object Adaptor (OA) initialization

  Obtain a reference to an object adaptor pseudo-object so that object implementations have access to the ORB functionality.

- Obtaining initial object references

  Obtain initial object references for an application.

Distributed Smalltalk does not implement the ORB and OA initialization interfaces. These interfaces are not necessary because of the combination of Smalltalk's dynamic nature and Distributed Smalltalk's architecture. These interfaces are intended for support of objects generated with static languages like C/C++.

Programmatically Initializing, Starting, and Stopping the ORB

The ORB can be initialized, started, and stopped using the **DST** menu in the Launcher. In many cases, however, it is desirable to do so programmatically, either with a custom tool or without any tool at all.

To initialize an ORB, send an initializeORBAtHost:nodeId: message to the ORBObject class:

```
ORBObject initializeORBAtHost: aHostName nodeId: aHostAddress
```

where aHostName is the host name and aHostAddress is the host IP address, as defined for IPSocketAddress. Given a host name only, you can get the address and initialize the ORB like this:

```
ORBObject
    initializeORBAtHost: aHostName
    nodeId: ( IPSocketAddress hostAddressByName: aHostName).
```

To initialize the ORB on the local machine, simply evaluate:

```
|host|

    host := SocketAccessor getHostname.
    ORBObject initializeORBAtHost: host
    nodeId: (IPSocketAddress
        hostAddressByName: host).
    ORBDaemon startUpCoordinator startRequestBroker
```

Once initialized, you can start the ORB.

Starting and stopping the ORB is managed by an instance of ORBStartUpCoordinator that is held by ORBDaemon. To start or stop the ORB, send one of these messages to the coordinator:

startRequestBroker

Starts the request broker.

shutDown: minutes

Shuts down the ORB in minutes, an integer value. To shutdown immediately, specify 0.

You get the coordinator from the ORBDaemon by sending the startUpCoordinator message, so you can start or stop the ORB as follows:

```
ORBDaemon startUpCoordinator startRequestBroker
```

or

```
ORBDaemon startUpCoordinator shutDown: 3
```

Getting Remote ORB References

Message sends to class OrbResolver are used to generate references to remote ORBs. Several methods are provided.

Given the ORB hostname and port number, use:

```
OrbResolver
    generateOrbProxy: hostname
    transport: ORBDaemon configurationManager
    configurationOf: #IIOP
    port: portNumber
```

If you already have an ObjRef to an object on the remote ORB, you can get a reference to the ORB using:

```
OrbResolver generateOrbProxyOnReference: aCoLocatedReference
```

Browse OrbResolver for other options, and search the system for senders for examples.

Initial Object References

The initial object reference service logically is a simplified local version of the naming service which an application can use to obtain a small defined set of object references which are essential to the application's operation.

Because only a small well defined set of objects are expected to be available via the initial object reference mechanism the naming context is flattened to a single level namespace. Only two operations are defined for the initial object reference mechanism. The pseudo IDL for these operations is:

```
module CORBA {
    \interface ORB {
        typedef string ObjectId;
        typedef sequence <ObjectId> ObjectIdList;
        exception InvalidName {};
        ObjectIdList list_initial_services ();
        Object resolve_initial_references (in ObjectId
            identifier) raises (InvalidName) ;
    };
};
```

In order to allow an application to determine which objects have references available via the initial references mechanism the list_initial_services operation is provided. It returns a sequence of strings. Each string represents an object which is available through this mechanism.

The resolve_initial_references operation returns the object reference associated with its argument. Arguments can be any of the strings returned by the list_initial_services operation.

Distributed Smalltalk Implementation

The list_initial_services operation is implemented by:

ORBObject class>>listInitialServices

When invoked it will return an IdentitySet of symbols representing objects which have references available via the initial references mechanism.

ORBObject class>>resolveInitialReferences:

The argument to this method is one of the symbols returned by listInitialServices. This method returns the object reference associated with the argument.

Currently there are four objects whose references are available via the initial references mechanism:

- InterfaceRepository
- NameService
- FactoryFinder
- UserSecurityDatabase

ORB Utility Methods

There are a variety of utility methods available in ORBObject for retrieving information about the ORB or various

hostName

You often need to get the local host name, for example, in the process of initializing an ORB. This is the easiest way to do it.

namingService

This is the quickest way to get the naming service. It usually will be either a DSTNameContext or a DSTObjRefRemote, depending on whether the DST image has been configured to use a local or a remote naming service.

factoryFinder

This is the quickest way to get the factory finder, which is a directory used by the Lifecycle Service.

repository

This is the quickest way to get the interface repository. You will get either a privileged instance of DSTmoduleRepository or a reference to a one, depending on whether the image is configured to use a local or a remote repository.

referenceToFile: aString object: anObject

This message returns what is known as a “stringified object reference.” A reference, in the form of a hexadecimal string, to anObject is written to the file name aString. Such files are a usual way of providing clients, at startup, with initial references to an remote object.

referenceFromFile: aString

This method produces an object reference from a stringified object reference contained in the file aString.

explainIOR:

Provides a detailed description of an IOR. This is useful in debugging when it is found that the object reference obtained from a stringified object reference cannot be resolved.

Browse the class side of ORBObject for additional utility methods.

12

Naming Service

The Naming Service is part of the Common Object Services specification published by OMG. It specifies what CORBA object names should consist of and how names can be set and accessed, so that local and remote objects in any CORBA implementation can be correctly identified. Clients can use the naming service to locate and identify objects in both local and remote systems.

Distributed Smalltalk implements this service by providing a simple mapping between the specified name structure, and a ation of this includes support both for standard naming policies, You use the naming service directly to obtain initial access to an object programmatically (see “Initial Object References”).

Note that the ORB does not use the naming service, but identifies objects by the unique identifiers or the objects themselves (if local) or of their object references (if remote). The Naming Service is a service provided for developers, so that they can make certain privileged objects publicly available.

What Constitutes a Name?

A name is an ordered sequence of components that is *bound* to a specific object. A name binding is a name-to-object association.

Name components are the parts that make up a name. A name is comprised of one or more components. A component is the name of either the bound object or a naming context. There can be more than one naming context in a compound name.

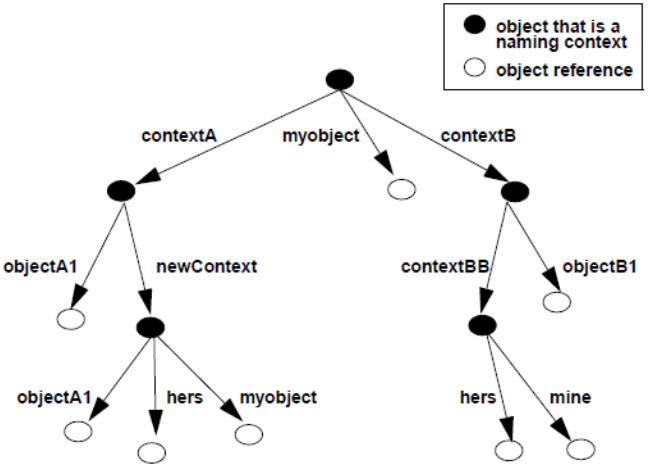
A simple name is a name with a single component (an object). Simple names are guaranteed unique only within a context.

A compound name is made up of an ordered sequence of contexts and the name of the bound object. In a compound name, each component except the last is used to name a context; the last component names an object. Compound names are guaranteed to be unique system-wide.

A naming context is an object that contains a set of name bindings in which each name is unique. A name binding is always defined relative to a naming context. Different names can be bound to an object in the same or different contexts at the same time. Since a name context is itself an object, it may be bound to a name in another name context.

A naming graph is a directed graph with contexts (nodes) and labeled edges. A naming graph is created by binding contexts in other contexts. A naming graph is similar to a file system's directory structure, with contexts that are similar to directories, and objects similar to file names.

Example of a Naming Graph



Naming Service Operations

The classes that implement the naming service are in the class category COS-Naming. You can browse those classes and the following examples to learn more about naming policies and services.

Creating Names

To create an instance of a name, class DSTName implements these class methods:

- To create a new name given the name components, use on: For example:

```
DSTName on: (Array with:
    (DSTNameComponent id: 'simple' kind: 'text') ).
```

  or:

```
DSTName on: (Array
    with: (DSTNameComponent id: 'example' kind: 'dir')
    with: (DSTNameComponent id: 'myImage' kind: 'im') ).
```

- To return a new name on a given name string, use onString: or asDSTName. For example:

```
DSTName onString: 'simple' or 'simple' asDSTName
```

- To return a new compound name, use onStrings: or the shortcut method asDSTName: For example:

```
DSTName onStrings: #('component1' 'component2' 'component3')
```

  or

```
#('component1' 'component2' 'component3') asDSTName.
```

Binding and Unbinding

The naming policy establishes how to *bind* each object to a unique name within a given context. *A* name binding is a name-to-object association. Only one object can be bound to a particular name in a context.

Class DSTNameContext implements methods for the following binding operations:

- You can bind both objects and other contexts to contexts (bindNewContext:, contextBind:to:, contextBindContext:to:).
- If a context does not exist, you can create it, or create it and bind an object to it (newContext, bindNewContext:).
- If an object or context is already bound, it can be rebound (contextReBind:to:, contextReBindContext:to:)
- If rebinding is not strong enough, you can unbind or destroy a context (contextUnBind, destroyContext).

For example:

```
| cxt |
cxt := DSTNameContext new.
cxt contextBind:('foo' asDSTName) to: 7.
cxt contextReBind:('foo' asDSTName) to: 8.
cxt contextBindContext:(DSTName onString:'aContext')
                to: DSTNameContext new.
cxt contextBind:(DSTName onStrings: #('aContext' 'fee'))
                to: #fum.
cxt contextUnBind: (DSTName onStrings:
                #('aContext' 'fee')).
```

Resolving and Listing Contexts

A name can be *resolved* to determine which object it represents. *A* name resolution uses a name to identify an object. Because names can have multiple components, name resolution can traverse multiple contexts.

Class DSTNameContext implements these methods resolving names and listing contexts:

- To resolve a name, use contextResolve:.
- To return a given number of bindings contained in the specified naming context, you can use listContext:. (Use with DSTBindingIterator to iterate through the list.)

For example:

```
| cxt |
cxt := DSTNameContext new.
cxt contextBind: (DSTName onString: 'foo') to: 7.
cxt contextResolve: (DSTName onString: 'foo').
cxt bindNewContext: (DSTName on:
   (Array with: (DSTNameComponent id: 'foo' kind: 'cxt') ) ).
cxt newContext.
cxt destroyContext.
```

Syntax-Independent Kinds and Identifiers

To avoid issues of differing name syntax, the naming service always deals with names in their structural form, which consists of two attributes: the identifier attribute and the kind attribute. Both the identifier attribute and the kind attribute are represented as IDL strings.

The kind attribute adds descriptive information to names independent of their syntax. For example, suffixes such as (for C language in Unix) ".c" or ".o" would be replaced with "c_source" or "object_code". Applications like the C compiler depend on these syntactic conventions to make name transformations such as from foo.c to foo.o. Such syntactic convention is not explicit; software that does not depend on the syntactic conventions for names does not have to be changed to adapt to new conventions.

An empty string indicates *no* kind. The naming service does not interpret, assign or manage these values in any way. Higher levels of software may make policies about the use and management of these values.

Exceptions

Class DSTNameContext implements these exceptions for the naming service:

notFoundError:restOfName:

The name does not identify a binding.

cannotProceedError:nameComponent:

The implementation has given up for some reason. (For example, when there is a network problem during a resolve operation that involves several systems.) The client, however, may be able to continue operation at the returned naming context.

invalidNameError

The name is invalid.

alreadyBoundError

A name binding using this name already exists.

notEmptyError

The context cannot be destroyed because it is not empty.

Interfaces

The CosNaming module in DSTRepository defines the NamingContext and BindingIterator interfaces for object naming. Browse these interfaces for details.

Implementation

Four classes interact to provide the primary support for the naming service. Browse these classes for variables and methods. Their positions in the class hierarchy are:

Object
  DSTNameComponent
  Collection
    SequenceableCollection
      OrderedCollection
        DSTNameModel
    ORBObject
      DSTPersistentObject
        DSTNameContext
          DSTfactoryFinder
          SessionContext
            DSTDesktopSessionContext
  Stream
    PeekableStream
      PositionableStream
        InternalStream
          ReadStream
            DSTBindingIterator

13

Event Notification

The event notification service enables objects to notify one another of interesting occurrences using an agreed protocol and set of objects. As designed, it provides optimal communication between objects in a distributed computing environment.

Overview

The event notification service supports decoupled, asynchronous communication between objects. Objects that generate events (event suppliers) place the event information in an event channel. From the event channel, event information is either pushed to event consumers (objects that wish to receive the event information), or pulled by the event consumers from the event channel at the consumer's convenience.

There can be more than one event channel. Each event channel can have one or more event suppliers and one or more event consumers.

Need for Event Notification in a Distributed System

In a distributed object system, objects that interact may "live" in various images and machines, both local and remote. By decoupling communication, the event channel provides support for object interaction when objects are unavailable temporarily because the network or a remote system is "down."

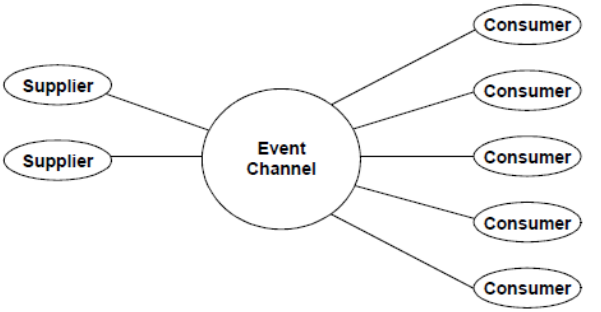
The CORBA2.0 architecture specifies a synchronous notification mechanism (RPC) between a single client and single server, both of which must be available when the service request is made. The need for asynchronous communication prompted OMG to include the event service in the Common Object Services Specification.

Terminology

event	An occurrence within an object that may be of interest to other objects. For example, when a model object changes, it generates an event to inform its view-controller pairs in both local and distributed images.
event consumer	An object that receives and processesevent data.
event supplier	An object that produces event data for distribution to consumers.
event channel	An object that holds event information until consumers are ready to receive it.

Event Channel

An event channel stores event information, thus allowing objects to communicate asynchronously. Although consumers and suppliers communicate with the event channel using standard CORBA requests, the event channel need not supply the event data to its consumer at the same time it consumes the data from its supplier.



- An event channel can have any number of consumers and suppliers.
- Consumers and suppliers must register with the event channel in order to participate in it.
- The event channel is a consumer of event information from its suppliers, and a supplier of event information to its consumers.

Multiple Event Channels

Usually, each group of related objects and activities should have its own event channel. Channels can be used to handle multiple sources and sinks irrespective of their function. Typically you would organize it around specifically related objects and activities.

However, the same channel can be allowed to handle both data changed and data deleted event information.

Event Channel Administration

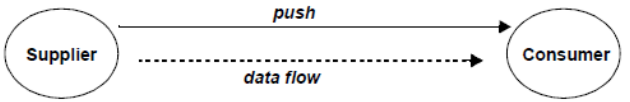
An event channel is built up incrementally. When an event channel is created, there are no suppliers and no consumers associated with it. Upon creation of the channel, the factory returns an object reference supporting the EventChannel interface. The ConsumerAdmin and SupplierAdmin interfaces allow consumers and suppliers to be added to the event channel. (That is, the ConsumerAdmin and SupplierAdmin interfaces provide client access to the services implemented in class DSTEventChannel's message categories Consumer Admin and Supplier Admin.)

Push and Pull Models

The event notification service supports two models of communication: push (the default) and pull. When adding a consumer or supplier to an event channel, you specify it as either pull or push type.

Push

The push model is similar to an interrupt: when an event occurs, the supplier initiates the notification of the event to the consumer immediately.

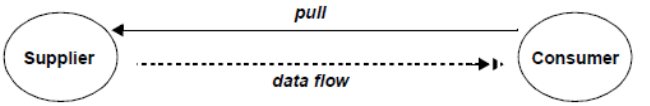


For example, the push model would be the best choice for a disk (an event supplier) that needs to notify a system administration tool (an event consumer) immediately if the disk runs out of space. When the

disk is full, it pushes event information to announce the space problem; any connected consumer, in this case the system administration tool, is notified immediately of the event.

Pull

The pull model is similar to polling: a consumer initiates a request for event data when it is convenient for the consumer to do so, regardless of when (or if) the event occurs.



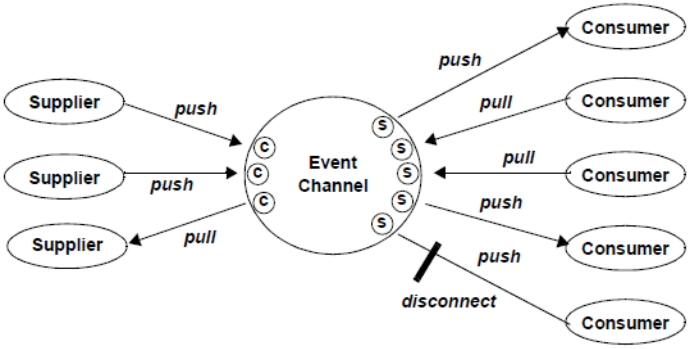
For example, the pull model would be a good choice for an event notification relationship between a document (event consumer) that needs to know about changes to an embedded table (event supplier). If the document is closed when the table changes, notification of the change can wait until the document is next opened or accessed. If a user is editing the document, the editing process should probably not be interrupted to update the table; this can also wait until there is a pause in editing. That is, if you set up the document as a pull consumer, it can request update information at its convenience (for example, at start up, or when open but idle).

Disconnect to Terminate Communications

The disconnect operations allow either a consumer, supplier, or channel to terminate communications by severing its ties with the supplier or consumer. These operations are useful when an object should not be interrupted with event information. The disconnect operations are:

DSTPullConsumer	disconnectPullConsumer
DSTPullSupplier	disconnectPullSupplier
DSTPushConsumer	disconnectPushConsumer
DSTPushSupplier	disconnectPushSupplier

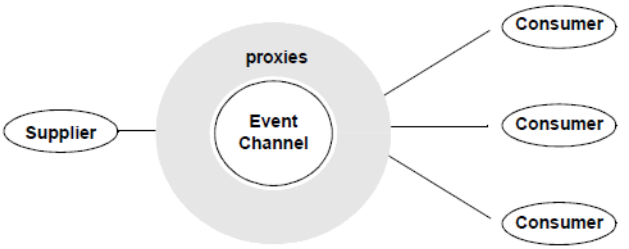
Consumers and Suppliers



- Any of the event channel's relationships with either suppliers or consumers can use either the push or pull model.
- Any supplier or consumer can be disconnected from the event channel (in order to avoid inconvenient event notification).

Proxies

Proxy consumers and suppliers (classes DSTProxyConsumer and DSTProxySupplier) are system-level classes that are used to establish communication with an event channel. Application programmers should never work directly with proxy objects. As an example of push and pull, consider the following diagram:



Event Data

The push and pull operations of the consumer and supplier interfaces communicate event data as type any. This allows generic services, such as an event channel, to consume, store, and supply event data without understanding the type of the event data.

Using type any for event data does not mean that the data is untyped. Suppliers and consumers of event data need to agree on the type of the event data. Consumers of the event data need to interpret the data according to the agreed upon type.

However, using type any has a higher overhead and does not provide type checking; you can use explicitly typed events if you want to lower messaging overhead and check types (see Using Typed Events).

Using Events

If you wish to consume events from an EventChannel, you need to implement an class which will handle messages from the consumer (DSTPushConsumer or DSTPullConsumer). An instance of this class is held by the consumer in an attribute named host. Upon receiving a disconnect message, for instance, the consumer notify the host by sending the message:

```
host removeConsumer: self.
```

A host to a DSTPushConsumer must also implement a method which will get called when an event is received by the consumer. This method is designated upon setup as the aspect. It should be noted that the Symbol that is passed to the consumer is converted to a setter method.

You must also implement two messages for supplier hosts that wish to participate as supplier to event channels. Upon receiving a disconnect message, the supplier will notify the host by sending the message:

```
host removeSupplier: self.
```

A host to a DSTPullConsumer will additionally need to implement the method supplierNeedsEvent. This message gets sent when the pullConsumer has requested an event and no events are left in the queue for the supplier.

This gives the host a chance to process any outstanding events before the pull supplier responds to the pull consumer.

Example Code for Events

The examples below require that an EventChannel be created, for example:

```
anEventChannel := DSTEventChannel new asRemotable
```

and that the appropriate hosts are constructed as described in above.

Example: Connecting a Push Consumer to a Channel

1 Create a new push consumer. For example:

```
consumer := DSTPushConsumer new.
```

2 Get a proxy supplier. For example:

```
proxySupplier := anEventChannel forConsumers
    obtainPushSupplier.
```

3 Connect the consumer to the supplier. For example:

```
proxySupplier connectPushConsumer: consumer.
```

4 Initialize the consumer. For example:

```
consumer host: aHost supplier: proxySupplier aspect:
    #displayEvent
```

Note: The host is expected to have implemented the displayEvent: method.

Example: Connecting a Pull Consumer to an Event Channel

1 Create a new pull consumer. For example:

```
consumer := DSTPullConsumer new.
```

2 Get a proxy supplier. For example:

```
proxySupplier := anEventChannel forConsumers obtainPullSupplier.
```

3 Connect the consumer to the supplier. For example:

```
proxySupplier connectPullConsumer: consumer.
```

4 Initialize the consumer. For example:

```
consumer host: aHost supplier: proxySupplier.
```

Example: Connecting a Push Supplier to a Channel

1 Create a new push supplier. For example:

```
supplier := DSTPushSupplier new.
```

2 Get a proxy consumer. For example:

```
proxyConsumer := anEventChannel forSuppliers
    obtainPushConsumer.
```

3 Connect the supplier to the consumer. For example:

```
proxyConsumer connectPushSupplier: supplier.
```

4 Initialize the supplier. For example:

```
supplier host: s1_supplier consumer: proxyConsumer.
```

Example: Testing the Event Example

```
supplier processEvent: 'hello'.
supplier processEvent: 'hello again'.
Transcript cr; show: 'Pull  Consumer tryPull event  >  ', consumer
   pullEventData ;cr.
Transcript  cr; show: 'Pull Consumer pull event  > ', consumer
   pullEventData ;cr.
```

Using Typed Events

The typed event service extends basic event notification, allowing you to determine:

- Specific event types

  By default, event channels pass data of type. However, it can be more efficient if you type an event channel to pass only strings, or tables, or a specific type of structure that you have defined, as appropriate.

- Quality of service

  Using the typed event service, you can specify the quality of service for each channel or consumer-supplier pair. That is, you can set the channel to retry at certain interval over a given time period, or you can set it to retry once only, or not to retry at all.

By default, a push supplier sends event notification to a consumer when the event channel receives the event data. If the consumer is unavailable for the original notification, the event data is held in the channel until another event occurs, at which time notification of both

events is sent together. The event channel will continue to attempt to push the event data each time a new event occurs, until it is successful or the channel is destroyed.

Example: Connecting to a Channel

To connect to a channel, at a minimum, you must:

1 Create a new consumer. For example:

```
consumer := DSTPushConsumer new.
```

2 Get a supplier. For example:

```
supplier := anEventChannel forConsumers obtainPushSupplier.
```

3 Connect the consumer to the supplier. For example:

```
supplier connectPushConsumer: consumer.
```

4 Initialize the consumer. For example:

```
consumer
    'host: self
    supplier: supplier
    aspect: #linkAdded
```

Example: Implementing a Typed Push Connection

If you wish to allow a supplier-to-consumer push connection that is typed, you should implement both a typed push supplier and a typed push consumer, as well as their corresponding interfaces.

Typed Push Supplier and Interface

If you want to create a push supplier that only generates event data of type String or type Point (a structured type with two elements: x and y), you can do this:

1 Subclass from DSTTypedPushSupplier.

2 Create the class repository methods abstractClassId and CORBAName.

3 Create the private method pushToConsumer: anEvent, which might be defined like this:

```
pushToConsumer: anEvent
    "push the event to the consumer"
    (anEvent isKindOf: String)
        ifTrue: [^consumer pushString: anEvent].
    (anEvent isKindOf: Point)
        ifTrue: [^consumer pushPoint: anEvent].
consumer pushEventData: anEvent
```

4 Create an IDL interface which might look something like this:

```
// This interface defines the behavior of my new typed push supplier.
//
interface TypedPushSupplierExample : CosEventComm::PushSupplier
{};
```

Notice that the interface can be simple (no operations) but it must be listed in the interface repository so that a typed event channel can create one using the CORBAName as the key. Also, it must inherit from an interface (such as PushSupplier) that defines or inherits the appropriate behavior.

5 Set up a typed supplier (subtly different from setting up a non-typed supplier):

```
"create a new event channel"
    aTypedEventChannel := DSTTypedEventChannel new.

"create a new supplier"
    supplier := MyTypedPushSupplier new.

"hook the supplier to the event channel"
    supplierAdmin := aTypedEventChannel forSuppliers.
    proxyConsumer := supplierAdmin obtain TypedPushConsumer:
        MyTypedPushConsumer new CORBAName.
    proxyConsumer connectPushSupplier: supplier.

"initialize the supplier"
    supplier host: self
        consumer: proxyConsumer getTypedConsumer.
```

Corresponding Typed Push Consumer and Interface

To implement a consumer that interacts with the supplier you just created:

1 Subclass from DSTTypedPushConsumer.

2 Create the class repository methods abstractClassId and CORBAName.

3 Create the host messages methods pushString: and pushPoint:, which might be defined like this:

```
pushString: aString
    "pass this event to the host"

    self pushEventData: aString

pushPoint: aPoint
    "pass this event to the host"
    self pushEventData: aPoint
```

4 Create an IDL interface which might look something like this:

```
// This interface defines behavior of my new typed push consumer
//
        interface TypedPushConsumerExample :
                CosTypedEventComm::TypedPushConsumer
    {

        void pushString (in string str)
                raises (Disconnected);
        void pushPoint (in Point pt)
                raises (Disconnected);
    };
```

5 Set up a typed consumer:

```
"create a new consumer"
    consumer := MyTypedPushConsumer new.

"hook the consumer to the event channel"
    consumerAdmin := aTypedEventChannel forConsumers.
    proxySupplier := consumerAdmin obtainTypedPushSupplier:
        MyTypedPushSupplier new CORBAName.
    proxySupplier connectPushConsumer: consumer.

"initialize the consumer"
    consumer host: self
        supplier: proxySupplier
        aspect: #handleMyEvent.
```

Example: Implementing a Typed Pull Connection

This example shows how you might implement typed pull supplier and consumer objects and their interfaces. Like the previous example, they will pass objects of types String and Point.

Typed Pull Supplier and Interface

1 Subclass from DSTypedPullSupplier.

2 Give the class repository methods abstractClassId and CORBAName.

3 Give it the private methods pullString and tryPullString, which might be defined like this:

```
pullString
    "return the next event that is a kind of String"
    ^self pullTypedEvent: String

tryPullString
    "return the next event that is a kind of String, returning no data if
    necessary"
    ^self tryPullTypedEvent: String
```

4 Create an IDL interface, which might look something like this:

```
// This interface defines the abstract behavior my typed pull
    supplier example
    //
interface TypedPullSupplierExample :
    CosTypedEventComm::TypedPullSupplier {

        string pullString ()
                raises (Disconnected);
        string tryPullString (out boolean has_event)
                raises (Disconnected);
        Point pullPoint ()
                raises (Disconnected);
        Point tryPullPoint (out boolean has_event)
                raises (Disconnected);
    };
```

Corresponding Typed Pull Consumer and Interface

1 Subclass from DSTPullConsumer.

2 Write the class repository methods abstractClassId and CORBAName.

3 Write the host messages methods pullTypedEvent: and tryPullTypedEvent:, which might be defined like this:

```
pullTypedEvent: aClass
    "try to pull event data from the supplier"

    connected
        ifTrue:
            [(aClass isKindOf: String)
                ifTrue: [^supplier pullString].
            (aClass isKindOf: Point)
                ifTrue: [^supplier pullPoint].
            ^supplier pull]
        ifFalse: [^self disconnectedError]

tryPullTypedEvent: aClass
    "try to pull event data from the supplier"

    connected
        ifTrue:
            [(aClass isKindOf: String)
                ifTrue: [^supplier tryPullString].
            (aClass isKindOf: Point)
                ifTrue: [^supplier tryPullPoint].
            ^supplier tryPull]
        ifFalse: [^self disconnectedError]
```

4 Create an IDL interface which might look something like this:

```
interface TypedPullConsumerExample :
    CosEventComm::PullConsumer {}
```

Example: Determining Quality of Service

If you want to change the quality of service from the default (retry at every new event until successful), you can override the processEvent: method in a subclass of DSTPushSupplier.

For example, you might write:

```
processEvent: anAny
    "process an event by sending it to the consumer.  Discard the
     event if an error occurs"

    | evt |
    (self checkEvent: anAny)
        ifFalse: [^nil].
    events nextPut: anAny.
    connected ifTrue: [[events isEmpty]
            whileFalse:
                [evt := events next.
                self errorSignal handle: [:err | err signal == ORBObject
                    invObjrefSignal
                        ifTrue:
                            [(host asLocal isKindOf: DSTEventChannel)
                                ifTrue: [host removeSupplier: self].
                            self connected: false]
                        ifFalse: [Dialog onDebugNotify:
                             'EventSupplier>>pushEvent
                            error: ' , err errorString]]
                    do: [self pushToConsumer: evt]]]
```

Interfaces

Four modules in DSTRepository define interfaces for the event notification service: CosEventComm, CosTypedEventComm, CosEventChannelAdmin and CosTypedEventChannelAdmin. Browse these interfaces for details.

The IDL hierarchy is as follows:

PushConsumer
- **TypedPushConsumer**
- **ProxyPushConsumer**
  - **TypedProxyPushConsumer**ProxyPushConsumer, TypedPushConsumer DSTProxyConsumer:TypedProxyPushConsumer, ProxyPullConsumer

PushSupplier
- **TypedPushSupplier**
- **ProxyPushSupplier**
  - **DSTProxySupplier** : ProxyPushSupplier, TypedProxyPullSupplier

PullConsumer
- **ProxyPullConsumer**
  - **DSTProxyConsumer** : ProxyPullConsumer, TypedProxyPushConsumer

PullSupplier
- **TypedPullSupplier**
- **ProxyPullSupplier**
  - **TypedProxyPullSupplier** : ProxyPullSupplier, TypedPullSupplier

ConsumerAdmin
- **TypedConsumerAdmin**

SupplierAdmin
- **TypedSupplierAdmin**

EventChannel

TypedEventChannel
- **DSTEventChannel** : TypedEventChannel, TypedSupplierAdmin, TypedConsumerAdmin

Implementation

The following classes interact to support the event notification service. Browse these classes for variables and methods. Their positions in the class hierarchy are:

Object
  Model
    ORBObject
      DSTProxyConsumer
      DSTProxySupplier
      DSTPersistentObject
        DSTEventChannel
          DSTTypedEventChannel
          DSTPullConsumer
            TypedPullConsumerExample
          DSTPullSupplier
            DSTTypedPullSupplier
            TypedPullSupplierExample
          DSTPushConsumer
            DSTTypedPushConsumer
            TypedPushConsumerExample
          DSTPushSupplier
            TypedPushSupplierExample

Note: Application developers should not use classes DSTProxyConsumer and DSTProxySupplier directly. No variables and messages appear here.

14

Basic Lifecycle

OMG's Common Object Services specification defines basic lifecycle services for creating, deleting, copying and moving objects both locally and remotely. While standard Smalltalk handles most basic lifecycle implementation within a local image, Distributed Smalltalk adds lifecycle interfaces to support distribution and interoperability.

Lifecycle services are an extension to the core services provided in an ORB. Core services include activation, request delivery, principal authentication, and method dispatch, as well as the creation and destruction of object registration information. Any facilities required for object population control and migration are part of the lifecycle services.

basic lifecycle	Services that govern simple objects, such as create, delete, and move.
factory object	An object that creates objects in response to client service requests. In Distributed Smalltalk, a factory is any class that can be instantiated and has interfaces registered for creating objects in the Interface Repository. Any object that creates another object in response to some request is technically a factory; factory implementations are not special. The polymorphic createObject: method is available in ORBObject and DSTPresenter for Distributed Smalltalk.Factory objects are registered during the Initialize Factories phase of the ORB initialization. For a class to be registered as a factory, it must have an instance method abstractClassID (which returns the appropriate UUID value for the class as a symbol).
factory finder	An object at a specific location that helps clients obtain references to factories of a particular class. A factory registered with a factory finder represents an implementation at an abstract location; thus, factory finders permit clients to query a location for an implementation.

Lifecycle Operations

Create

An external client uses the local factory finder object to find the correct abstract class, which then creates the new object. For an example of using a factory finder to create an object, see Examples: With and Without the Factory Representative .

Resource allocation during object creation includes one or more Object Adapter object references, and persistent storage for the object's persistent state.

Copy and Deep Copy

Copy makes a copy of the initial object, its children (containees and linked objects), their children and so forth. All non-containment links in the copy continue to refer to the same objects as the corresponding links in the original.

Deep copy is same as copy except that objects linked by non-containment links may be copied along with their children. A link's `deepCopyWith` setting controls which referenced objects are copied,

and which continue to be shared between the original and the copied objects. You set linked objects to be shared or copied when you create the links. By default, they are shared.

Move

Moving an object means removing it from one container and putting it into another. In essence, a copy of the object is made at the destination, the original is removed, and the copy is renamed such that existing references to the original continue to refer to the copy.

> **Note:** If the new container is at a different location, a move also relocates the object and any children.

Destroy

Destroy deletes an object and removes it from the system's registry. Nominally this also deletes the object's descendants, if any. However, if any of the components are referenced by reference links from outside the compound object, the delete does not occur, or the protected objects are moved to the orphanage so the delete can continue.

Throw Away

The throw away operation prepares an object for deletion by moving the object to a wastebasket (or similar service). Since this is potentially the last manual step before a subsequent automatic deletion, it prechecks for any constraints that would prevent the deletion.

Externalize and Internalize

Moving or copying objects between locations requires the objects to be externalized and subsequently internalized at the new location. In Distributed Smalltalk, the marshall operation converts a Smalltalk object into a byte stream for externalization (transmission to a remote server). To internalize, the unmarshall operation creates a Smalltalk object from a marshalled byte stream.

Creating Objects

COS on Factories and Factory Finders

COS specifies factories as the objects that create objects in response to a client request. It further specifies factory finders as the objects that help locate factories at a given location.

- Factory object—An object that creates an object(s) in response to a client service request. In Distributed Smalltalk, a factory is any class that can be instantiated and has interfaces registered for creating objects in the Interface Repository.

  When a client wishes to request a service of an object, the server object must first be created. Thus the client makes a request to a factory to create the server object.

- Factory finder—An object at a specific location that helps clients obtain references to factories of a particular class. A factory registered with a factory finder represents an implementation at an abstract location; thus, factory finders permit clients to query a location for an implementation.

  In order for a client to create a remote object, the client must have an object reference to the factory where the remote object will be created. Clients can use the naming service to get such object references.

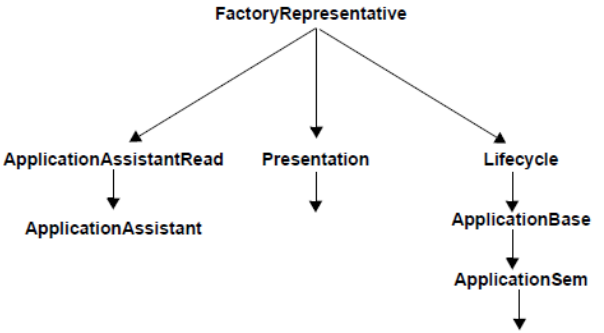
VisualWorks's Implementation

Any classes that inherit from ORBObject can be instantiated in response to a remote client's request. Factory objects are registered during the **Initialize Factories** phase of the ORB initialization. For a class to be registered as a factory, it must have an instance method abstractClassId (which returns the appropriate UUID value for the class).

The interface FactoryRepresentative is an Distributed Smalltalk extension to the COS specification that improves performance in remote object creation. Most interfaces in the Interface Repository inherit from FactoryRepresentative, which implements the IDL create_object operation (mapped to the createObject: Smalltalk method). The create_object operation can be used as a short cut to create an instance of a particular class that is registered with the receiver. (If

the create_object operation fails, you can use a more explicit interaction with the factory finder instead.) Examples of this follow next.

The interfaces that inherit from the FactoryRepresentative interface can be diagramed as follows:



Examples: With and Without the Factory Representative

The following examples show how to create an instance of ShapeSO on a remote machine called worldly.

The purpose of these examples is to show how to minimize the number of RPCs needed to create a remote object. However, in order to create a remote object, one must have an initial object reference to the remote image. Of the many ways to obtain this initial reference. Two examples are show below.

Example 1: Stringified Object Reference

This example uses the CORBA standard objectToString method to produce a “stringified” object reference which can be written to a file. This file is made available to client systems which uses the CORBA standard stringToObject method to read in the “stringified” object reference.

The following example code uses the DST convenience methods:

```
ORBObject class>>referenceToFile:
```

This stringifies the object reference and stores it to a file.

```
ORBObject class>>referenceFromFile:
```

This unstringifies the object reference and extracts it from a file.

On worldly execute:

```
ORBObject
    referenceToFile:'myffinder'
    object: (ORBObject resolveInitialReferences: #FactoryFinder)
```

which creates a “stringified” reference to worldly’s factory finder and stores it in the file myffinder.

The client executes:

```
|ff|
ff := ORBObject referenceFromFile: 'myffinder'
```

which returns an object reference to worldly’s factory finder.

Example 2: Naming Service as Registry

This approach uses the naming service to help locate an initial object reference to worldly’s factory finder.

On worldly execute:

```
|ns|
ns := ORBObject resolveInitialReferences: #NameService.
ns contextBind: ('factoryFinder' asDSTName) to: (ORBObject
    resolveInitialReferences: #FactoryFinder)
```

This associates worldly’s factory finder with the name ‘factoryFinder’ and binds this association in the top level context of worldly’s naming service.

The client then configures its naming service to use worldly’s naming service. An object reference to worldly’s factoryFinder is then obtained by:

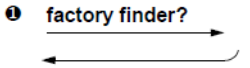
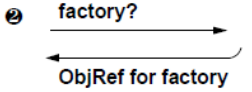
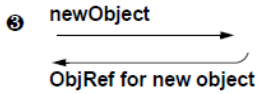
```
| ns ff |
ns := ORBObject resolveInitialReferences: #NameService.
ff := ns contextResolve: (DSTName onString: 'factoryFinder')
```

Since the client is configured to use worldly’s naming service the first line returns a reference to worldly’s naming service. The second line extracts object reference from the top level context of the naming service.

> Note: All of the examples in this chapter will use the approach of example 1 to obtain the factory finder object reference.

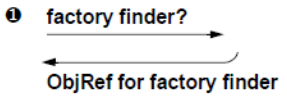
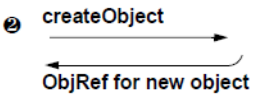
Using FactoryFinder Directly

By using the FactoryFinder directly, it requires 3 RPCs to get the object reference.

1	 Locate the factory finder for the remote location where you will create the object.	ffinder := ORBObject referenceFromFile: 'myffinder'
2	 Query the factory finder for a reference to a factory to create the object.	shapeFactory := ffinder contextResolve: 'ShapeSO' asDSTName.
3	 Create the remote object that will return an object reference.	shapeFactory createObjectKey: 'ShapeSO' asDSTName criteria: #().

Using the Factory Representative—Option #1

By using the FactoryRepresentative interface, you can optimize communications (saving 1 of the original 3 RPCs).

1	 Locate the factory finder for the remote location where you will create the object.	ffinder := ORBObject referenceFromFile: 'myffinder'
2	 Create the object through a request to the factory finder.	shapeObject := ffinder createObject: ShapeSO getInstanceACL.

Using the Factory Representative—Option #2

If you already have a reference to a factory representative, it takes one RPC.

1	❶ createObject → ← ObjRef for new object This creates shape on the same host as that of aRemoteObjRef (a previously created remote object).	| shapeObject |shapeObject := aRemoteObjRef createObject: ShapeSO getInstanceACL.

Note: Since most interfaces in Distributed Smalltalk inherit from FactoryRepresentative, this shortcut can be used with almost any object reference. In other words, most objects can be used to create other objects at a given location.

Example: Copying an Object

The following example shows how to locate a factory finder on a machine called worldly, create an instance of ShapeSO there, manipulate it, then copy it.

```
| ffinder worldlyShape localShape|
❶ ffinder := ORBObject referenceFromFile: 'myffinder'
❷ worldlyShape := ffinder createObject: ShapeSO getInstanceACL.
❸ worldlyShape setShape: #triangle by: nil.
❹ worldlyShape inspect.
❺ localShape := worldlyShape copyFactoryFinder:ORBObject factoryFinder
                    criteria: #()
localShape inspect.
```

Commentary

1 Get worldly's factory finder.

2 Tell the factory finder to create an object.

3 Change the shape of the remote shape object.

4 Inspect the remote shape object.

5 Create (using the local factory finder) and inspect a local copy of the remote object.

Interfaces

DSTRepository's COSLifecycle module includes the basic factory and lifecycle object interfaces. Browse these interfaces for details. The IDL hierarchy is as follows:

FactoryRepensentative

FactoryFinder

LifecycleObject

GenericFactory

The SmalltalkTypes module includes interfaces that support externalization and internalization.

StreamRead
Stream

Implementation

The class that is primarily responsible for basic lifecycle is DSTFactoryFinder. Browse this class for variables and methods. Browse these classes for variables and methods. Its position in the class hierarchy is:

Object
Model
ORBObject
DSTPersistentObject
DSTNameContext
DSTfactoryFinder

15

Concurrency Control Service

The concurrency control service defines how an object mediates simultaneous access by one or more clients such that the consistency of the object is not compromised when accessed by concurrently executing processes. It is an implementation of the *Object Management Group's Common Object Services Specification*.

The concurrency control service interface can be used in two ways:

1 Acquiring locks on behalf of the current thread (that must be executing outside the scope of a transaction).

2 Acquiring locks on behalf of a transaction, or

The principal difference between these transactional and non-transactional modes of operation is that when operating in a transactional mode, the transaction service drives the release of the locks as the transaction commits or aborts. In non-transactional mode, the responsibility for dropping locks at the appropriate time lies with the user of the concurrency control service.

The basic notion is that the concurrency control service provides a mechanism for a resource to be associated with a lock. In reality, because of the lock semantics, this turns out to be a collection of locks, or a lock set. The meaning of a resource is not defined by the concurrency control service but by some object implementation which uses the service. The concurrency control service coordinates concurrent use of a resource using locks.

lock	A lock represents the ability of a specific client to access a specific resource in a particular way. Each lock is associated with a single resource and a single client. Coordination is achieved by preventing multiple clients from simultaneously possessing locks for the same resource if the activities of those clients might conflict. To achieve coordination, a client must obtain an appropriate lock before accessing a shared resource.
lock set	A collection of locks associated with a single resource.
lock modes	Lock modes correspond to different categories of access.
lock granularity	Typically, if an object is a resource, the object would internally create and retain a lock set. However, the mapping between objects and resources (and lock sets) is up to the object implementation; the mapping could be one to one, but it could also be one to many, many to many, or many to one.
conflict resolution	The service will grant a lock to a client only if no other client holds a lock on the resource that would conflict with the intended access to the resource. The decision to grant a lock depends upon the modes of the lock held or requested. For example, a read lock conflicts with a write lock. If a write lock is held on a resource by one client, a read lock will not be granted to another client.
lock duration	Typically, a transaction will retain all of its locks until the transaction is completed (either committed or aborted). This policy supports serializability of transactional operations. Using the two phase commit protocol, locks held by a transaction are dropped when the transaction completes.
transaction duration locking	This a special case of strict two-phase locking. In the first phase (the growing phase), a transaction obtains locks that are kept until the second phase (the shrinking phase), at which point they are released. A transaction must not release locks during the first phase, and must not obtain new locks during the second phase, otherwise concurrent computations may be able to view intermediate results of the transaction.

Lock Modes

The concurrency control service defines five types of lock modes which implement conventional multiple readers, one writer semantics.

read (R)

Read locks conflict with write locks.

write (W)

Write locks conflict with other write locks.

upgrade (U)

An upgrade mode lock is a read lock that conflicts with itself. It is useful for avoiding a common form of deadlock that occurs when two or more clients attempt to read and then update the same resource. If more than one client holds a read lock on the resource, a deadlock will occur as soon as one of the clients requests a write lock on the resource. If each client requests a single upgrade lock followed by a write lock, this deadlock will not occur.

intention read (IR)

intention write (IW)

Both intention read and intention write support variable granularity locking and are used to exploit the natural hierarchical relationship between locks of different granularity. For example, consider the hierarchical relationship inherent in a database: a database consists of a collection of files, with each file holding multiple records. To access a record, a coarse grain lock may be set on the database, but at the cost of restricting other clients from accessing the database. Clearly, this level of locking is unsuitable. However, only setting a lock on the record is also inappropriate, because another client might set a lock on the file holding the record and delete or modify the file.

Using variable granularity locking, a client first obtains intention locks on the ancestor(s) of the required resource. To read a record in the database, for example, the client obtains an intention read lock (IR) on the database and the file (in this order) before obtaining the read lock (R) on the record. Intention read locks (IR) conflict with write locks (W), and intention write locks (IW) conflict with read (R) and write (W) locks.

The granularity of the resources locked by an application determines the concurrency within the application. Coarse granularity locks incur low overhead (since there are fewer locks to manage) but reduce concurrency since conflicts are more likely to occur. Fine granularity locks improve concurrency but result in a higher locking overhead since more locks are requested. Selecting a suitable lock granularity is a balance between the lock overhead and the degree of concurrency required.

Lock Mode Compatibility

Granted Mode	Requested Mode				
	IR	R	U	IW	W
Intention Read (IR)					*
Read (R)				*	*
Upgrade (U)			*	*	*
Intention Write (IW)		*	*		*
Write (W)	*	*	*	*	*

This table defines the compatibility between the various locking modes (the symbol * is used to indicate when locks conflict). When a client requests a lock on a resource that cannot be granted because another client holds a lock on the resource in a conflicting mode, the client must wait until the holding client releases its lock. The service enforces a queueing policy such that all clients waiting for a new lock are serviced in a first in, first out order. Subsequent requests are blocked by the first request waiting to be granted the lock, unless the requesting client is a transaction that is a member of the same transaction family as an existing holder of the lock. For a description of transaction families, see Chapter 16, “Transaction Service”.

Multiple Lock Semantics

In this model, a client can hold multiple locks on the same resource simultaneously and the locks can be of different modes. In addition, a client can hold multiple locks of the same mode on the same resource; effectively, a count is kept of the number of locks of a given mode that have been granted to the client. When a client holds locks on a resource in more than one mode, the other clients will not be granted a lock on the resource unless the requested lock mode is compatible with all of the modes of the existing locks. A user can hold a lock multiple times; it must be released as many times as it was acquired in order to free the resource.

Locks and LockSets

Locks are implemented in the class Lock. Since multiple possession semantics are supported, locks must maintain a count. Locks also hold on to the context of the lock's owner for validation of requests. In the general case, is associated with a distributed thread of control (ORB context), for Transactional Locks, it is the Transaction Context

Locksets are implemented in the Smalltalk Class LockSet. A Lockset is an object that manages the locks on some resource. In general, a lockset is associated with a single resource and may hold many locks. This object provides methods to acquire and release locks.

The various lock modes are described as enumerations (browse DSTTypeEnumerator) that have symbol values corresponding to the lock modes defined in the service. The symbols and their corresponding lock modes are, in descending order of precedence:

Symbol	Lock Mode
#write	Write
#intentionWrite	Intention Write
#upgrade	Upgrade
#read	Read
#intentionRead	Intention Read

When a lock is requested, the request is validated according to the compatibility rules defined in . During validation a check is made to insure that the requested lock mode does not conflict with the strongest lock mode granted. If it does the lock request will be not be granted at that time. For example, if a write lock is held, any requests for a lock on that resource by a different owner will not be granted.

The COS specification defines a LockSet coordinator interface, in order to provide an administrative interface and avoid potential deadlocks, The coordinator interface is implemented in the separate class DSTLockSetCoordinator.

Interfaces

The CosConcurrencyControl module in DSTRepository defines interfaces for concurrency. Browse these interfaces for details. The IDL hierarchy is as follows:

LockSet
  DSTCoordinatingLockSet: LockSet, LockCoordinator
  DSTLockSet:LockSet, LifeCycleObject, FactoryRepresentative
TransactionalLockSet
DSTTransactionalLockSet:TransactionalLockSet,
      FactoryRepresentative, LifeCycleObject,
LockSetFactory
LockCoordinator

Implementation

In Distributed Smalltalk, the classes for concurrency and it subclasses take these positions in the class hierarchy. Browse these classes for variables and methods. Their positions in the class hierarchy are:

Object
  DSTLock
  DSTLockCoordinator
  Model
    ORBObject
      DSTPersistentObject
        DSTLockSet
          DSTTransactionalLockSet
  DSTServiceContext
    DSTConcurrencyContext

Using Distributed Smalltalk Concurrency Service

The concurrency service is a general service that may be used to manage access on any distributed resource. In Distributed Smalltalk, there are two examples of the use of the concurrency service. They are as follows:

- DSTRecoverableObject (part of transaction service)
- DSTResourceManager

Using the Class DSTResourceManager

Instances of this class manage resources that are shared by locks between several owners. Lock ownership is implicitly defined on the distributed thread of control. (This can be overwritten in DSTResourceManager>>setContext).

The resources are identified by name, which is a string or symbol. The resource owners have to agree on a name for each resource they want to share. The class DSTResourceManager is used by DSTSemantic objects. It is also used to synchronize access to the interface repository. This class can be used directly, or as an example for using the concurrency service. The following code example can be browsed under the category of CORBA-CORE, in the class DSTResourceManager.

Creating Locks

The following method returns the lockset for the resource key, and creates one if necessary. The factory creation method, create, must be used to instantiate a lockset.

The hint is any user defined string that will be associated with the lock.

```
findOrCreateLockFor: key hint: aHint
    ^locksets at: key ifAbsent:
    [hints at: key put: aHint.
    locksets at: key put: DSTLockSet create]
```

Acquiring Locks

The following method acquires a lock on the named resource and gets the LockSet for the named resource first. Locksets manage ownership implicitly through the concurrency context which is propagated along the thread of control in the ORB context. Therefore, we need to set the context before attempting to acquire the lock.

In the following method, aLockModeEnum is an enumerator which identifies the strength of the desired lock. Browse senders of this method using an enumerator object. DSTLockSet has class side methods which return the enumerators which correspond to the defined lock modes. For example, DSTLockSet class > read will return the enumerator defined in the CORBAConstants dictionary as:

```
::CosConcurrencyControl::lock_mode::read.
```

If the lock is granted and the granted level is the highest for the lockset, then the hint is updated. This is because multiple holders are allowed for a lockset and multiple levels of locks are allowed for each

owner. The method returns a boolean that will be true if the lock was successful. The hint is a value holder whose value will contain information about the current owner of the highest, most recently granted lock.

This code example illustrates acquiring locks:

acquire: aResourceName mode: aLockModeEnum with: aHint

```
| key lock acquired |
DSTLockSet setContext.
key := aResourceName asSymbol.
lock := self findOrCreateLockFor: key hint: aHint value.
(acquired := lock tryLock: aLockModeEnum)
    ifTrue: [lock granted == aLockModeEnum
        ifTrue: [hints at: key put: aHint value]]
    ifFalse: [aHint value: (self hintOf: key)].
^acquired
```

Releasing Locks

The following method deals with releasing locks:

```
release: aResourceName mode: aLockModeEnum
```

If the named resource (by string or symbol) is locked by the owner for the specified mode, then the lock count in the lockset is decreased by 1 and the resource is released when the lock count reaches 0. If the lock count was decreased, then true is returned.

```
| key lockset |
key := aResourceName asSymbol.
lockset := locksets at: key ifAbsent: [^false].
Object errorSignal
    handle: [:ex | ^false]
    do:
        [lockset unlock: aLockModeEnum.
        ^true]
```

Destroying Locks

Since the class DSTLockSet is a subclass of ORBObject and created using factory methods, it must be explicitly destroyed. The following method destroys the receiver and any locksets that it may hold.

```
destroy
locksets values do: [ : lockset | lockset destroy ].
super destroy.
```

Using Transactional Locksets

A transactional lockset is a kind of lockset intended to be used within the scope of a transaction. It is used by clients of the transaction service, generally by DSTRecoverableObjects.

The only difference between locksets and transactional locksets is that with a transactional lockset, the transaction context is used for validation.

16

Transaction Service

The concept of transactions is an important programming paradigm for simplifying the construction of reliable and available applications, especially those that require concurrent access to shared data. The transaction concept was first deployed in commercial operational applications where it was used to protect data in centralized databases. More recently, the transaction concept has been extended to the broader context of distributed computation. Today it is widely accepted that transactions are the key to constructing reliable distributed applications.

The transaction service supports transactions that have the following ACID characteristics:

- Atomicity—This ensures that the set of computations is either completely done or completely undone. A transaction whose work completes is said to commit. A transaction whose work is completely undone is said to rollback. A transaction may rollback due to system failures (for example, processor failure or a deadlock), or because a= programmer chose to execute an rollback call.
- Consistency—The effects of a transaction preserves invariant properties. A transaction leaves the collection of objects in a consistent state. There may be integrity rules that must be checked before commit.
- Isolation—Transactions are allowed to execute concurrently, but the results will be the same as if the transactions executed serially. Isolation ensures that concurrently executing transactions cannot observe inconsistencies. Programmers are therefore free to cause temporary inconsistencies during the

execution of a transaction knowing that their partial modifications will never be visible.

- Durability—If a transaction completes successfully, the results of its operations will never be lost, except in the event of catastrophes. Systems can be designed to reduce the risk of catastrophes.

A transaction can be terminated in two ways: the transaction is either committed or rolled back. When a transaction is committed, all changes made by the associated requests are made permanent. When a transaction is rolled back, all changes made by the associated requests are undone.

The transaction service defines interfaces that allow multiple, distributed objects to cooperate to provide atomicity. These interfaces enable the objects to either commit all changes together or to rollback all changes together, even in the presence of (noncatastrophic) failure. No requirements are placed on the objects other than those defined by the transaction service interfaces.

Examples are OODBMS, and persistent objects. The value of a separate transaction service is that it allows:

- Transactions to include multiple, separately defined, ACID objects.
- The possibility of transactions which include objects and resources from the non-object world.

Distributed Smalltalk's Implementation of Transactions

The Distributed Smalltalk implementation of the transaction service provides:

- A transactional infrastructure for coordination among transactional objects.
- Classes that implement transactional object and recoverable object behavior.
- A framework for the class implementor to develop specific kinds of transactional and recoverable objects based upon their persistence requirements.

The infrastructure is implemented as a set of services that allow the threads executing operations on objects within a transaction to work together harmoniously to provide the ACID properties. This infrastructure consists of:

- Operations for begin, commit, and rollback of a transaction.
- Operations for associating transactions with threads and mechanisms for propagating transactions to other objects whose behavior is affected by a transaction.
- Operations for objects with recoverable state to participate in transaction completion.
- A protocol engine which implements the two-phase commit protocol with presumed abort optimization to ensure that all participants within a transaction commit or rollback together.
- An enhancement to CORBA to permit transaction context to be passed between cooperating implementations of the Transaction Service.

In addition to the transactional infrastructure, a class implementor needs tools in order to develop objects that have the requisite atomicity, durability, and isolation properties. The concurrency control service augmented with the transaction service provides this support. The transaction service support for the class implementor is a mechanism that coordinates the use of concurrency and persistence by an object as transactions are created, rolled back, and committed. For example, the concurrency control service supports transactional locking which ensures that locks acquired on objects during that transaction will be released at transaction termination.

In Distributed Smalltalk, support for this mechanism is built into the class DSTRecoverableObject. These objects hold transactional locksets that are used during the two phase commit process. Subclasses of DSTRecoverableObject need only implement the methods to save and recover their persistent state according to the underlying persistent store that is in place.

Two types of transactions are supported:

- *Flat transactions?*—?A flat transaction groups all operations within its scope into a single transactional entity.
- *Nested transactions*?—?A nested transaction is a transaction embedded within another transaction.

Nested transactions rollback independently from their parent transaction and can be used within concurrently executing threads to increase system performance while maintaining consistency (since the nested transactions serialize with respect to each other). The results of a nested transaction only become permanent when its top-level transaction is committed. Nested transactions are especially valuable for encapsulating an object's transactional behavior, and enable transactions to become a general programming mechanism for constructing reusable building blocks for reliable distributed applications.

A client can make requests to multiple objects that may be located on different nodes in the network within the scope of a transaction.

For compatibility with X/Open, implementations of the Object Transaction Service may track the "spread" of the transaction so that all participants in the transaction see the same outcome. Similarly, these OTS implementations track the spread when the implementation of an object in turns act as the client of other remotely-located objects.

Supporting these distributed transactions requires support from the ORB so that the "transactional-context" is passed transparently with each request.

Terminology

active	The state of a transaction when processing is in progress and completion of the transaction has not yet commenced.
atomicity	A transaction property that ensures that if work is interrupted by failure, any partially completed results will be undone. A transaction whose work completes is said to commit. A transaction whose work is completely undone is said to rollback (abort).
begin	An operation on the Transaction Service which establishes the initial boundary of a transaction.
commit	Commit has two definitions as follows:An operation in the Current and Terminator interfaces that a program uses to request that the current transaction terminate normally and that the effects of that transaction be made permanent.An operation in the Resource interface which causes the effects of a transaction to be made permanent.

committed	The property of a transaction or a transactional object, when it has successfully performed the commit protocol.
completion	The processing required (either by commit or abort) to obtain the durable outcome of a transaction.
coordinator	A object involves Resource objects in a transaction when they are registered. A coordinator is responsible for driving the two-phase commit protocol.
concurrency control service	See Chapter 15, "Concurrency Control Service"
direct context management	An application manipulates the Control object and the other objects associated with the transaction.
flat Transaction	A transaction that has no subtransactions, and that cannot have subtransactions.
indirect context management	An application uses the Current pseudo object, provided by the Transaction Service, to associate the transaction context with the application thread of control. See DSTTransactionalObject.
nested transaction	A transaction that either has a subtransaction or is a subtransaction on some other transaction.
prepared	The state that a transaction is in when phase one of a two-phase commit has completed.
Propagation	A function of the transaction service that allows the Transaction context of a client to be associated with a transactional operation on a server object. The Transaction Service supports both implicit and explicit propagation of transaction context.
recoverable object	An object whose data is affected by committing or rolling back a transaction. See DSTRecoverableObject.
recoverable server	An object that registers a Resource (not necessarily itself) with a Transaction Coordinator to participate in transaction completion.
recovery service	An object service used by resource managers for restoring the state of objects to a prior state of consistency
resource	An object in the transaction service that is registered for involvement in two-phase commit. An object that supports the Resource interface. See DSTRecoverableObject.

rollback	Rollback (also known as Abort) has two definition as follows:An operation in the Current and Terminator interfaces used to indicate that the current transaction has terminated abnormally and its effects should be discarded.An operation in the Resource interface which causes all state changes in the transaction to be undone.
thread	The entity that is currently in control of the processor.
TP (Transaction Process) monitor	A system component that accepts input work requests and associates resources with the programs that act upon these requests to provide a run-time environment for program execution.
transaction	A collection of operations on the physical and abstract application state.
transaction client	An arbitrary program that can invoke operations of many transactional objects in a single transaction. Not necessarily the Transaction originator.
transaction context	The transaction information associated with a specific thread. See Propagation.
transaction operation	An operation on an object that participates in the propagation of the current transaction.
transaction originator	An arbitrary program?— typically, a transactional client, but not necessarily an object — that begins a transaction.
transaction object	An object that offers at least one transactional operation, thus requiring the ORB and the transaction service to propagate a Transaction Context, usually used to refer to an object, none of whose operations are affected by being involved within the scope of a transaction. See DSTTransactionalObject.
transaction server	A collection of one or more objects whose behavior is affected by the transaction, but have no recoverable states of their own.
two-phase commit	A transaction manager protocol for ensuring that all changes to recoverable resources occur atomically and furthermore, the failure of any resource to complete will cause all other resource to undo changes.

Transactional Applications

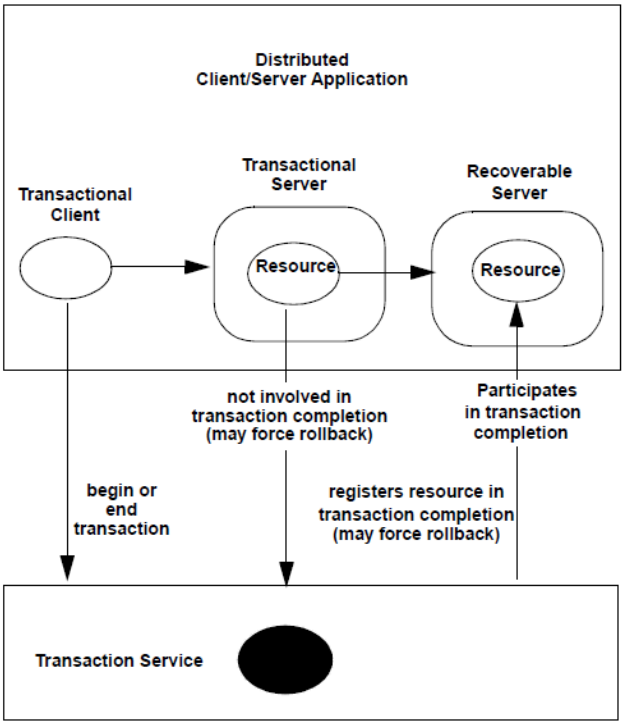
The transaction service provides transaction synchronization across the elements of a distributed client/server application.

A transaction can involve multiple objects performing multiple requests. The scope of a transaction is defined by a transaction context that is shared by the participating objects. The transaction service places no constraints on the number of objects involved, the topology of the application or the way in which the application is distributed across a network. In this scenario, the transaction context is transmitted implicitly to the objects, without direct client intervention.

In a typical scenario, a client first begins a transaction (by issuing a request to an object defined by the transaction service), which establishes a transaction context associated with the client thread. The client then issues requests. These requests are implicitly associated with the client's transaction; they share the client's transaction context. Eventually, the client decides to end the transaction (by issuing another request). If there were no failures, the changes produced as a consequence of the client's requests would then be committed; otherwise, the changes would be rolled back.

The transaction service also supports scenarios where the client directly controls the propagation of the transaction context. For example, a client can pass the transaction context to an object as an explicit parameter in a request.

The transaction service does not require that all requests be performed within the scope of a transaction. A request issued outside the scope of a transaction has no associated transaction context. It is up to each object to determine its behavior when invoked outside the scope of a transaction; an object that requires a transaction context can raise a standard exception.



This diagram show a simple application that includes these basic elements: Transactional Client, Transactional Objects. Recoverable Objects, and Transactional Servers. The discussion of these follows.

Transactional Client

A transactional client is an arbitrary program that can invoke operations of many transactional objects in a single transaction. The program that begins a transaction is called the transaction originator. The originator may be the same object as the client. In fact, often the transaction may be implicitly originated by invoking an operation on a recoverable object.

Transactional Object

We use the term transactional object to refer to an object whose behavior is affected by being involved within the scope of a transaction. A transactional object typically contains or indirectly refers to persistent data that can be modified by requests.

In Distributed Smalltalk this term refers to objects that implement the Current pseudo object interface. See DSTTransactionalObject.

The transaction service does not require that all requests have transactional behavior, even when issued within the scope of a transaction. An object can choose to not support transactional behavior, or to support transactional behavior for some requests but not others.

We use the term nontransactional object to refer to an object none of whose operations are affected by being involved within the scope of a transaction. If an object does not support transactional behavior for a request, then the changes produced by the request might not survive a failure and the changes will not be undone if the transaction associated with the request is rolled back.

An object can also choose to support transactional behavior for some requests but not others. This choice can be exercised by both the client and the server of the request.

The transaction service permits an interface to have both transactional and nontransactional implementations. No IDL extensions are introduced to specify whether or not an operation has transactional behavior. When objects use implicit context propagation transactional behavior can be a quality of service that differs in different implementations.

Transactional objects are used to implement two types of application servers:

1 Transactional Server

2 Recoverable Server

Recoverable Objects and Resource Objects

To implement transactional behavior, an object must participate in certain protocols defined by the transaction service. These protocols are used to ensure that all participants in the transaction agree on the outcome (commit or rollback), and to recover from failures.

To be more precise, an object is required to participate in these protocols only if it directly manages data whose state is subject to change within a transaction. An object whose data is affected by committing or rolling back a transaction is called a recoverable object.

A recoverable object is by definition a transactional object. However, an object can be transactional but not recoverable by implementing its state using some other (recoverable) object. A client is concerned only that an object is transactional; a client cannot tell whether a transactional object is or is not a recoverable object.

A recoverable object must participate in the transaction service protocols. It does so by registering an object that implements the Resource interface. The transaction service drives the commit protocol by issuing requests to the resources registered for a transaction.

A recoverable object typically involves itself in a transaction because it is required to retain in stable storage certain information at critical times in its processing. When a recoverable object restarts after a failure, it participates in a recovery protocol based on the contents (or lack of contents) of its stable storage.

A transaction can be used to coordinate non-durable activities which do not require permanent changes to storage.

Transactional Server

A transactional server is a collection of one or more objects whose behavior is affected by the transaction, but have no recoverable states of their own. Instead, it implements transactional changes using other recoverable objects. A transactional server does not participate in the completion of the transaction, but it can force the transaction to be rolled back.

Recoverable Server

A recoverable server is a collection of objects, at least one of which is recoverable.

A recoverable server participates in the protocols by registering one or more Resource objects with the transaction service. The transaction service drives the commit protocol by issuing requests to the resources registered for a transaction.

Transaction Service Functionality

The transaction service provides operations to:

- Control the scope and duration of a transaction

- Allow multiple objects to be involved in a single, atomic transaction
- Allow objects to associate changes in their internal state with a transaction
- Coordinate the completion of transactions

Transaction Models

Two distributed transaction models are supported: flat transactions and nested transactions.

Flat Transactions

The definition of the functionality provided, and the commitment protocols used, is modelled on the X/OpenDTP transaction model definition.

A flat transaction is considered to be a top-level transaction (see the next section) that cannot have a child transaction. In Distributed Smalltalk there is nothing to restrict a top-level transaction from having child transactions.

Nested Transactions

The transaction service also defines a nested transaction model. Nested transactions provide for a finer granularity of recovery than flat transactions. The effect of failures that require rollback can be limited so that unaffected parts of the transaction need not rollback.

Nested transactions allow an application to create a transaction that is embedded in an existing transaction. The existing transaction is called the parent of the subtransaction; the subtransaction is called a child of the parent transaction.

Multiple subtransactions can be embedded in the same parent transaction. The children of one parent are called siblings.

Subtransactions can be embedded in other subtransactions to any level of nesting. The ancestors of a transaction are the parent of the subtransaction and (recursively) the parents of its ancestors. The descendants of a transaction are the children of the transaction and (recursively) the children of its descendants.

A top-level transaction is one with no parent. A top-level transaction and all of its descendants are called a transaction family.

A subtransaction is similar to a top-level transaction in that the changes made on behalf of a subtransaction are either committed in their entirety or rolled back. However, when a subtransaction is committed, the changes remain contingent upon commitment of all of the transaction's ancestors.

Subtransactions are strictly nested. A transaction cannot commit unless all of its children have completed. When a transaction is rolled back, all of its children are rolled back.

Objects that participate in transactions must support isolation of transactions. The concept of isolation applies to subtransactions as well as to top level transactions. When a transaction has multiple children, the children appear to other transactions to execute serially, even if they are performed concurrently.

Subtransactions can be used to isolate failures. If an operation performed within a subtransaction fails, only the subtransaction is rolled back. The parent transaction has the opportunity to correct or compensate for the problem and complete its operation. Subtransactions can also be used to perform suboperations of a transaction in parallel, without the risk of inconsistent results.

Transaction Termination

A transaction is terminated by issuing a request to commit or rollback the transaction. Typically, a transaction is terminated by the client that originated the transaction — the transaction originator. Some implementations of the transaction service may allow transactions to be terminated by transaction service clients other than the one which created the transaction.

Any participant in a transaction can force the transaction to be rolled back (eventually). If a transaction is rolled back, all participants rollback their changes. Typically, a participant may request the rollback of the current transaction after encountering a failure.

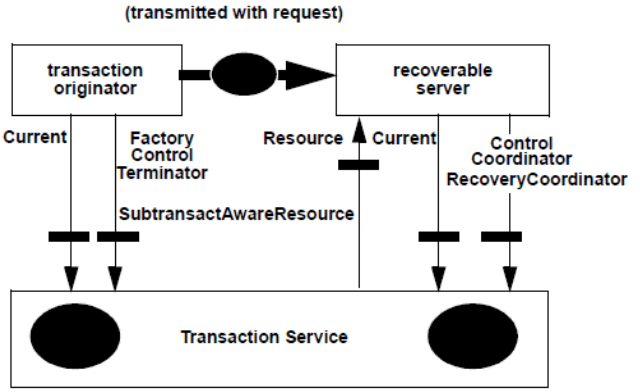
Transaction Context

As part of the environment of each ORB-aware thread, the ORB maintains a transaction context. The transaction context associated with a thread is either nil (indicating that the thread has no associated transaction) or it refers to a specific transaction. It is permitted for multiple threads to be associated with the same transaction at the same time, in the same execution environment or in multiple execution environments.

The transaction context is implicitly transmitted to transactional objects as part of a transactional operation invocation. The transaction service also allows programmers to pass a transaction context as an explicit parameter of a request.

Service Architecture

The figure below illustrates the major components and interfaces defined by the transaction service. The transaction originator is an arbitrary program that begins a transaction.



The transaction originator creates a transaction using a Factory (DSTTransaction class>>create:); a Control is returned that provides access to a Terminator and a Coordinator. The transaction originator uses the Terminator to commit or rollback the transaction. The Coordinator is made available to recoverable servers, either explicitly or implicitly (by implicitly propagating a transaction context with a request). Control, Coordinator and Terminator are IDL interfaces that are all implemented in the class DSTTransaction.

A recoverable server registers a Resource with the Coordinator. The Resource implements the two-phase commit protocol which is driven by the transaction service. A recoverable server can also register a specia1ized resource called a SubtransactionAwareResource to track the completion of subtransactions. DSTRecoverableObject supports both the Resource and SubtransactionAware interfaces.

To simplify coding, most applications use the Current pseudo object interface, which provides access to an implicit per-thread transaction context. DSTTransactionalObject implements the Current interface. DSTRecoverableObject is a subclass of DSTTransactionalObject and inherits from this implementation.

Typical Usage

A typical transaction originator uses the Current pseudo object to begin a transaction, which becomes associated with the transaction originator's thread.

The transaction originator then issues requests. Some of these requests involve transactional objects. When a request is issued to a transactional object, the transaction context associated with the invoking thread is automatically propagated to the thread executing the method of the target object. No explicit operation parameter or context declaration is required to transmit the transaction context. Propagation of the transaction context can extend to multiple levels if a transactional object issues a request to a transactional object.

```
| current |
current = DSTTransactionalObject new.
current begin
. . .
```

Using the pseudo object, the transactional object can unilaterally rollback the transaction and can inquire about the current state of the transaction. Using the pseudo object, the transactional object also can obtain a Coordinator for the current transaction. Using the Coordinator, a transactional object can determine the relationship between two transactions, to implement isolation among multiple transactions.

By implementing the Current interface in DSTTransactionalObject, we allow all Transactional and Recoverable objects an interface that allows operations to be sent that effect the entire Transaction and not just the particular Resource object. (DSTRecoverableObject is a subclass of DSTTransactionalObject.)

Some transactional objects are also recoverable objects. A recoverable object has persistent data that must be managed as part of the transaction. A recoverable object uses the Coordinator to register a Resource object as a participant in the transaction. The resource represents the recoverable object's participation in the

transaction; each resource is implicitly associated with a single transaction. The Coordinator uses the resource to perform the two-phase commit protocol on the recoverable object's data.

After the computations involved in the transaction have been completed, the transaction originator uses the pseudo object to request that the changes be committed. The transaction service commits the transaction using a two-phase commit protocol, wherein a series of requests are issued to the registered resources.

Transaction Context

A transaction context can be associated with each ORB-aware thread. The transaction context associated with a thread is either **nil** (indicating that the thread has no associated transaction), or it refers to a specific transaction. It is permitted for multiple threads to be associated with the same transaction at the same time.

When a thread in an object server is used by an object adapter to perform a request on a transactional object, the object adapter initializes the transaction context associated with that thread by effectively copying the transaction context of the thread that issued the request.

The transaction context is used to determine ownership of the resources involved in a transaction. DSTTransactionalObjects use DSTTransactionalLockSets to control access to resources, and the transactional locksets use information in the transaction context to determine ownership.

Context Management

The transaction service supports management and propagation of transaction context - using objects provided by service. Using this approach, the transaction originator issues a request to a Factory to begin a new top-level transaction. The factory returns a Control object specific to the new transaction that allows an application to terminate the transaction or to become a participant in the transaction (by registering a resource). An application can propagate a transaction context by passing the Control as an explicit request parameter.

The Control interface does not directly support management of the transaction. Instead, it supports operations that return two other objects, a Terminator and a Coordinator. The Terminator is used to commit or rollback the transaction. The Coordinator is used to enable

transactional objects to participate in the transaction. These two objects can be propagated independently, allowing finer granulatity control over propagation.

In VisualWorks, the Control, Terminator and Coordinator interfaces are all implemented in DSTTransaction. However, the implementation does not preclude the use of external or specialized Coordinators and Terminators. For this reason, it is strongly recommended that users of the service acquire and use the Control, Coordinator and Terminator interfaces as defined.

Interfaces

The CosTransactions module in DSTRepository's defines interfaces for transactions. Browse these interfaces for details. The IDL hierarchy is as follows:

Factory
  DSTTransactionFactory: Factory, ClassObject
Control
  DSTControl
Terminator
Coordinator
  DSTCoordinator
    DSTTransaction: DSTCoordinator, DSTControl, Terminator
RecoveryCoordinator
  DSTRecoveryCoordinator: RecoveryCoordinator, LifeCycleObject, FactoryRepresentive
Resource
  SubtransactionAwareResource
TransactionalObject
  DSTTransactionalObject: TransactionalObject, LifeCycleObject, FactoryRepresentive
    DSTRecoverableObject: DSTTransactionalObject, SubtransactionAwareResource

Use of Transaction Service Functionality for Interfaces

Function	Used by	Context Management	
		Direct	Indirect[1]
Create a transaction	Transaction originator	Factory::create Control::get_terminator Control::get_coordinator	begin set_timeout
Terminate a transaction	Transaction originator-*implicit*All-*explicit*	Terminator::commit Terminator::rollback	commit rollback
Rollback a transaction	Server	Terminator::rollback_only	rollback_only
Control propagation of transaction to a server	Server	Declaration of method parameter	TransactionalObject interface
Control by client of transaction propagation to a server	All	Request parameters	get_control suspend resume
Become a participant in a transaction	Recoverable Server	Coordinator::register_resource	Not applicable
Miscellaneous	All	Coordinator::get_status Coordinator::get_transaction_name Coordinator::is_same_transaction Coordinator::hash_transaction	get_status get_transaction_name Not applicable Not applicable

1.All indirect context management operations are on the Current pseudo-object interface.

Implementation

In Distributed Smalltalk, the classes for transactions take these positions in the class hierarchy. Browse these classes for variables and methods. Their positions in the class hierarchy are:

Object
  Model
    ORBObject
      DSTPersistentObject
        DSTTransactionalObject
          DSTRecoverableObject
            DSTSampleRecoverableObject
        DSTRecoveryCoordinator
  DSTTransaction
  DSTServiceContext
    DSTTransactionContext
  DSTTransactionIdentifier
  DSTTransactionIdentity

Using the Distributed Smalltalk Transaction Service

The classes that implement the transaction service are in the class category COS-Transactions. You can browse those classes to learn more about transaction policies and services.

Implementing a Recoverable Object

The Recoverable Object framework in Distributed Smalltalk is designed to be extended for specific kinds of persistent objects, or objects which are stored in particular kinds of data stores (DBMS).

As an implementor of a Recoverable Object, you will subclass from DSTRecoverableObject and add behavior specific to that subclass. DSTTransactionalObject and DSTRecoverableObject are both abstract classes.

Example

An example of a concrete Recoverable Object can be seen in the class DSTSampleRecoverableObject. This object implements a simple persistence mechanism based upon the externalization and internalization mechanism in one of its parent classes, DSTPersistentObject. This example shows the minimum work a subclass of DSTRecoverableObject needs to do to participate as a Resource within a distributed transaction.

In this example, five methods are overwritten in the concrete class:

1 commitData

This message is sent by the recoverable object framework when an object's data should be committed.

2 prepareState

This message is sent by the recoverable object framework in the first phase of a two phase commit.

3 rollbackState

This message is sent by the recoverable object framework when an object's state should be rolled back within a transaction.

The first three messages are sent during the two phase commit process. In the first phase, the prepareState message will be sent. At this time an object must prepare itself to either rollback or commit its state. It must return either true or false.

4 commitSubtransaction:

This message is sent when a resource has been registered with a subtransaction and the subtransaction has been committed.

5 rollbackSubtransaction

This message is sent when a resource has been registered with a subtransaction and the subtransaction has been rolled back.

When the commitData or rollbackState message is sent, the object is responsible for performing the appropriate action.

For specific data bases, this is the point where you will perform the actual database commit or rollback operations.

You will also need to determine when the actual starting of the database transaction should be performed.

One convenient method is to override the beginTransaction operation in DSTTransactionalObject to perform the operation at this time.

In practice, many persistent stores do not implement a full two-phase commit.

In this case, implementors of Recoverable Objects will need to override additional operations to insure consistency.

For example, you may be using a persistent store that only supports a single database transaction per image. In this case you may want to implement a scheme to maintain a single database transaction within a set of logical distributed transactions.

Example

You may create a notion of a root transaction within your Recoverable Object and when you begin a transaction, first check to see if you are operating within a transaction. If not, create one, if so, create a subtransaction within the current context:

```
beginTransaction
    "Create a new transaction within the current thread. If
     I am in a transaction already, create this transaction
     as a subtransaction in order to operate within a single
     database transaction. Note: beginDatabaseTransaction will
     begin the actual transaction on the DBMS."

    self transaction isNil
        ifTrue:
        [self transaction: (DSTTransaction create: 0).
        rootTransaction := self transaction.
        self transaction getCoordinator registerResource: self.
        self beginDatabaseTransaction]
        ifFalse: [self beginSubTransaction]
```

Creating a Transaction

Transactions may be created using either:

- The Current pseudo object interface (implemented on DSTTransactionalObject)
- The explicit factory methods on DSTTransaction

If you use the Current interface, a transaction will be created on your behalf. The Current interface is intended to be used by transactional objects so that they do not need to directly manage the transaction.

A Recoverable Object may create a transaction by sending the beginTransaction message to itself. This will both create the transaction and register the object as a resource with the transaction. For example:

```
| resource |
resource := DSTSampleRecoverableObject new initialize.
resource beginTransaction.
```

In the above code fragment the method beginTransaction is the Smalltalk implementation of the operation begin on the Current pseudo object.

This is equivalent to the following code fragment which explicitly creates a transaction and registers a resource with it:

```
| resource control coord |
resource := DSTSampleRecoverableObject new initialize.
control := DSTTransaction create: 0.
coord := control getCoordinator.
coord registerResource: resource.
```

Creating a transaction will set the transaction context within the current (distributed) thread of control. This context information is implicitly passed along the thread of control until the transaction is terminated. Once started the transaction must be terminated by either rolling back or committing the transaction. At this point, the context information which is implicitly passed along the thread of control will be destroyed.

Completing a Transaction

While a transaction is in effect, messages may be sent to a Recoverable Object which effect the state of the object. During the first phase of the two phase commit, an object will be sent the *prepare* message by the transaction terminator. The Recoverable Object must reply with a vote which tells the terminator whether the object can commit or should be rolled back. The appropriate vote responses are defined as enumerations and can be accessed via accessors on DSTTransaction class.

If an object votes to rollback during the prepare (first) phase, all objects which are part of the transaction and have voted to commit will then be asked to rollback during the second phase. If no objects vote to roll back during the prepare phase, then all of the objects which voted to commit, will be asked to commit.

An object will generally maintain its state in such a way that when asked to prepare for a commit, its instance variable vote will be in an appropriate state. For example, an object may have started an operation which could leave it in an inconsistent state until completed. During that window, the object may choose to set its vote to rollback. Upon successful completion it may set its vote to commit.

Example

A subclass of DSTRecoverableObject which implements a distributed cache of inventory items may have an operation such as:

```
cacheAll
    "Get all the inventory objects from the database and cache
    them into local objects in my image."

    lockset lock: self coordinator mode: lockset class read
    self vote: DSTTransaction voteRollback.
    itemCache := InventoryItem new allObjects.
    self vote: DSTTransaction voteCommit.
    lockset unlock: self coordinator mode: lockset class read.
```

In the above example, notice that the Recoverable Object uses an object named lockset to manage concurrent access to its resources. Instances of DSTRecoverableObject have their own Transactional Locksets which should be used by the Recoverable Object when appropriate. For more information on locksets, see Chapter 15, “Concurrency Control Service”.

If the transaction were to be prepared during the period when the cache was being established, this object would vote to rollback and the transaction would be rolled back.

Transactions may be completed in either one of two ways:

- By explicitly using the transaction terminator
- By invoking methods which map to the Current pseudo object interface

A transaction may be rolled back by a Recoverable Object using the Current pseudo object as follows:

```
| resource |
resource := DSTSampleRecoverableObject new initialize.
resource beginTransaction.
. . .
resource commitTransaction: false
```

This is equivalent to the following code fragment which explicitly creates a transaction and registers a resource with it:

```
| resource control coord terminator |
resource := DSTSampleRecoverableObject new initialize.
control := DSTTransaction create: 0.
coord := control getCoordinator.
coord registerResource: resource.
. . .
terminator := control getTerminator.
terminator commit: false
```

Create a Transaction Example

This example can be browsed on the class side of DSTSampleRecoverableObject and demonstrates the use a recoverable object with indirect context.

```
"This example demonstrates the use of a recoverable object
   with indirect context management (the Current pseudoObject)"
"Processor activeProcess orbContext transactionContext: nil."
"self example1: ORBObject factoryFinder"

| suspended resource |
resource := self create.
resource beginTransaction.
suspended := resource suspendTransaction.
DSTTransaction noTransactionSignal handle:
   [ :x | "This should  raise an exception" ]
   do:
      [ resource commitTransaction: false.
      self error: 'testCurrentInterfaceNear: suspend failed'; cr ].
resource resumeTransaction: suspended.
Object errorSignal handle:
   [ :x | self error: 'example1: resume  failed'; cr ]
   do: [resource commitTransaction: false].
resource beginTransaction.
resource vote: DSTTransaction voteCommit.
resource commitTransaction: false.
resource getTransactionStatus == DSTTransaction statusCommitted
   ifFalse: [ self error: 'example1: Failure, transaction status ' ,
      resource getTransactionStatus printString; cr ].
resource beginTransaction.
resource vote: DSTTransaction voteRollback.
resource rollbackTransaction.
^resource
```

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Debugging and Tuning

Debugging and tuning is somewhat more complicated for distributed applications than for local applications. This chapter introduces the tools provided with DST for debugging and performance tuning. It also provides hints for optimizing performance.

The steps you should follow in troubleshooting and tuning are:

1 Get the application running in a local image.

2 Test in a simulated distributed environment (Local RPC).

3 Test in a distributed environment.

4 Optimize and tune for performance.

Debugging and Tuning Tools

The DST Settings tool (or the DST page in the VW Settings tool) is the primary user interface to Distributed Smalltalk, Specifically, it sets options for testing and debugging facilities in DST.

Debugging

Checking the **Debugging** checkbox enables logging errors to the Transcript window. A dialog gives you the option to **Abort** or **Proceed**.

Local Testing

Checking the **Local Testing** checkbox causes the local image to simulate a distributed object environment by using the full IDL marshaling and unmarshaling machinery.

Local RPC Testing

It is typical to use I3 for early prototyping of a distributed application, before expressing the interfaces in IDL. Once you have translated the interfaces, but before distributing the application, you should test them locally. During this stage of development, you can debug an application more easily using a single image with local objects simulating remote objects. DST provides Local RPC Testing to do this.

Local Testing simulates remote execution by wrapping a local object in a special proxy—an instance of DSTObjRefLocal—that invokes the lower-level marshalling and unmarshalling machinery typical of a remote call.

To enable local testing, you do two things:

1 Check **Local Testing** on the DST Settings page, and

2 Sending asRemotable to the objects under test.

Local Testing is object-specific; you must explicitly wrap one or more objects implement the interface you intend to test in a proxy, by sending them the message asRemotable. For example, to test the interface for the operation quantity of an instance of Order, you would turn on Local Testing and evaluate something like:

```
Order new asRemotable quantity.
```

The effect of asRemotable can be undone by sending a wrapped object the message asLocal. If, during Local Testing, you want to ensure that an object is local, you can send it the message mustBeLocal, which will raise an exception if an object proves not to be local after an attempt to make it so.

It is important to make all of the objects remoteable that need to be made remoteable, in order to completely test your interface(s).

If you do not turn local testing OFF when testing a remote execution, you may have local, simulated behavior where you intended none. If you do not turn local RPC testing ON when testing a partially remote execution, you may have true, distributed behavior where you intended local simulation.

Occasionally, you may notice an initially surprising number of DSTObjRefLocals. The principle cause is the creation of additional DSTObjRefLocals by the Basic Lifecyle service. If Local Testing is turned on, remote creation requests that utilize the Lifecycle Service will generate DSTObjRefLocals in order to simulate remote creation.

Performance Tuning and Optimization

As with any Smalltalk development project, you can redesign and optimize applications you write in Distributed Smalltalk.

- Tune the application to run well on slower or less reliable networks.
- Make the user interface more efficient and easy to use.
- Optimize for a greater number of users sharing objects.

Network Performance

While the function and interaction with local and remote objects is the same, performance may vary.

Symptoms

- Acceptable performance during local and Local RPC activity but sluggish performance over the network.

Possible Causes

- Slow network.
- Non-optimized message-passing with remote objects.
- Non-optimized distribution of local and remote object responsibilities.

Solutions

- To help isolate whether the problem is with the network or the local application, make sure that Local RPC testing is off, since Local RPC testing will impact performance.
- Rethink the presentation/semantic split. In general, presentation objects run locally, while semantic objects may run anywhere on the network. Thus, behaviors and attributes that involve heavy user interaction should be assigned to presentation objects, while less volatile behaviors and attributes should be assigned to semantic objects.

- Group messages to reduce overhead. The network performance cost for any message is about the same regardless of its size. Thus, you can refine your application to eliminate needless message sends, and group small messages wherever possible.
- Improve hardware and network configurations or use faster transfer media.

User Interface Organization

Distributed applications have the potential of providing users a large quantity and variety of objects. One of the biggest challenges in creating usable distributed applications is to provide an information structure and interface that lets users find what they need easily and rapidly.

With Distributed Smalltalk, an interface to information can be structured hierarchically, or as a network, or as a hybrid of the two. By building on the range of options, you can tune accessing schemes to your users' needs.

Symptoms

- Users spend too much time looking for objects, or they get frustrated and give up.
- Usability testing shows that objects are duplicated unnecessarily because users cannot find what they really want.

Possible Causes

- Excessively deep burying of objects in many levels of containers.
- Excessively shallow organization of objects, all at the top level.
- Objects organized into containers by some criteria other than projects or related tasks, or by no criteria at all.

Solutions

- Use the appropriate mix of containers and links to simplify information access. If the number of objects is small, organize them into containers (such as folders and file cabinets), letting users browse to find what they need. If the volume of information is large, browsing becomes inefficient and time-consuming. Other policies, such as hierarchical search, may be used in conjunction with the containment model to let users locate information more quickly.

Coding Style

As you develop applications using Distributed Smalltalk, you may wish to consider the following coding hints and guidelines.

Method Size

Since all remote calls require a certain minimum network overhead, you can reduce network traffic and optimize performance by grouping small methods into larger single calls.

Multiple Inheritance in DSTRepository

DSTRepository supports multiple inheritance for interfaces. Therefore, for corresponding Smalltalk classes, you may need to copy methods from more than one part of the class inheritance structure to achieve the effect of DSTRepository's multiple inheritance.

Blocks

The use of blocks in a distributed environment is different from their use in a local VisualWorks image. If you wish to pass blocks (by reference) across the network, you should define a corresponding interface in

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Creating a Deployment Image

In Distributed Smalltalk, runtime application creation is an extension of the VisualWorks runtime image-making process. This section assumes you are familiar with the VisualWorks process described in the VisualWorks *Application Developer's Guide*.

Design and Preparation

Before using the Image Maker to create a runtime application, there are several issues you may wish to resolve while you still have use of the full Distributed Smalltalk development environment.

Possible Runtime Configurations

Depending on the expected use of a runtime application, you can choose to create a single (ORB) runtime image, or multiple ORB runtime images. In runtime, as in development, an ORB image must be running on each system.

Each application is a separate ORB image. It is possible to configure a single ORB image to handle the naming service, the shared repository and security. This configured ORB runtime image can be reduced to an absolute minimum, so that it can run as a daemon process.

Runtime Request Broker Panel

Distributed Smalltalk provides a Request Broker panel that is used to start and stop the ORB in an image. You may include this default control panel in your application or runtime ORB image, or you may choose to modify the control panel, or even eliminate it if the ORB will be started programmatically.

If you want to start an ORB programmatically (without a control panel), do the following:

1 If the system is not initialized, initialize the system by executing:

```
ORBObject initializeORBAtHost: aHostname nodeId: aHostAddress.
```

for information on the appropriate arguments for hostName and hostAddress, see the class IPSocketAddress.

2 Start the request broker by executing:

```
ORBDaemon startUpCoordinator startRequestBroker.
```

Note: A session is an object that keeps the transient state of your environment and lets you keep track of objects you are working on. It is re-initialized at system initialization.

Providing a Desktop Icon

If you wish to use an icon other than the default desktop icon, you must format, name and position it in ways that Distributed Smalltalk expects, as follows:

- *File format* must be XPM, Common Desktop Environment format, or Smalltalk store format (using Smalltalk's internal screen capture fromUser:).

  Classes XPixmapCompiler and XPixmapDescription translate XPM format to an internal Smalltalk image. See the class comments for more information.

- *File name* must be the same as the application's semantic object (for example ShapeSO).

  If the class name is longer than allowed, the corresponding icon name must be truncated. (For example, some file systems have an 8-character limit.)

- *Path name* of the icon file must either be the default or you must make it explicit.

  The icons provided with Distributed Smalltalk are in the subdirectories /dst/icons/select or unselect.These icons are loaded when an image is built, and are stored in DSTPresenter class variables IconSMap and IconUMap (*s*elected and *un*selected versions).

To install an icon after the image is built, you must make its path explicit. To do this, you can use the DSTPresenter class method readIcon:path:.

Modifying File and Directory Path Names

If you develop on one platform and deliver on another, or if you deliver on the same platform but in a different directory tree, you should modify certain pathnames for your users. In addition to the standard VisualWorks files (visual.sou which is not needed for deployment, and the fonts directories), you may need to change the path names for the VisualWorks icons and pixmaps files. An easy way to make this change is to evaluate the following expression (substituting the correct path):

```
ORBObject installDir: 'pathname' asFilename
```

Creating a Deployment ORB Image

Candidate Classes for Removal

Category	Candidate for Removal	Comments
CORBA-Core	DSTPresenter	many dependencies in application presentations; remove with caution
CORBA-Contexts	(none)	removable if not using Request Broker panel interfaces
CORBA-MetaObjects	DSTMetaPO	many dependencies in application presentations; remove with caution
CORBA-Protocols-Core	(none)	
CORBA-Protocols-NCS	(none)	
CORBA-Protocol-IIOP	(none)	
CORBA-Compilers	all classes in category	remove IDLCompiler only if using shared repository

Category	Candidate for Removal	Comments
CORBA-Repository	DSTRepository (only class in category)	remove DSTRepository class only *if using shared repository the shared repository must be specified before the Image Maker is run*.unused interfaces can be removed *if using local repository*
CORBA-Tools	all classes in category except DSTClassFilter	
CORBA-Debugging	all classes in category	
COS-Events	all classes in category	many dependencies on these classes in the end-user environment; remove with caution
COS-Naming	(none)	do not remove!
COS-Lifecycle	(none)	do not remove!
COS-Concurrency	(none)	
COS-Transactions	all classes in category	provides transaction service
DST-ObjectServices	all classes in category	many dependencies on these classes in the end-user environment; remove with caution
DST-AccessControl	all classes in category except DSTUserAcct, DSTUserDB, DSTPrincipal	
DST-UserInterface	all classes in category	
DST-Policy	all classes in category	many dependencies on these classes in the end-user environment; remove with caution
DST-UserServices	all classes in category	

Category	Candidate for Removal	Comments
DST-Media	all classes in category	sample applications
DST-Collectors	all classes in category	sample applications
DST-Building	all classes in category	
DST-Containers	all classes in category	sample applications
DST-Office	all classes in category	
DST-Mapped Containers	all classes in category	sample applications
DST-AgentServices	all classes in category	required in default user interface; SessionContext may have other dependencies; many dependencies on these classes in the end-user environment — remove with caution
DST-Order Processing	all classes in category	sample applications
DST-Browser	all classes in category	provide services to standard applications
DST-Tools	all classes in category	development tools, not needed after deployment
DST-Testing	all classes in category	
DST-Integration	all classes in category	
DST-ORBLite-Examples	all classes in category	

Steps for Creating a Deployment Image

1 Stop the ORB

2 Save your image.

If you accidentally remove needed classes or have other problems during the deployment process, you will be able to start again from this saved image.

3 Open the Request Broker panel (or application).

- If you want the runtime application to have a Request Broker panel, it should be open now (but *not* started).
- If your application will not use a Request Broker panel, open the application.

4 Specify the shared interface repository, if appropriate.

If the deployment image will use a shared interface repository, you must set this up before running the Image Maker. That is, once the ORB is set to use a shared interface repository, you can safely remove classes DSTRepository and IDLCompiler.

You could also leave a settings window up (and not remove class DSTSystemSettings) to allow shared repository configuration during runtime. However, any image with DSTRepository removed must be a shared repository.

5 Load and run the Runtime Packager, as described in the VisualWorks Application Developer's Guide. Keep in mind the following special situations:

- The agent (AgentPO and AgentSO) uses the Smalltalk compiler; do not remove compiler classes if you wish to use the agent.
- Your application will need a way to initialize and start the ORB, so either your application must do this, or you need provide some functions of the DST menu in the Launcher.
- Your application must already be configured before you run the Rntime Packager, or you must provide access to the DST Settings Tool pages. Alternatively, your application may take responsibility for setting up the appropriate configuration.
- If DSTRepository is removed, the deployment image must use a shared repository. (See Step 4).

Optimizing Runtime Applications

Exception Handling

Your application should catch, handle, and recover from errors that are associated with distributed systems, including: unreliable networks, shared objects, remote systems that become unavailable, and so on. For troubleshooting information, see Chapter 19, “Troubleshooting”.

Be sure to:

- Provide graceful handling of exceptions.
- Complete testing before creating the deployment image, and save the development image. (Debugging can be very difficult in a deployment image because development tools are no longer available.)
- Test the deployment image, to verify that no needed code was removed.
- After deployment, you can use an Object Request Broker panel to monitor activity and start or stop the ORB on a remote image.

Minimizing Footprint

Frequently, a final runtime application needs to run on a platform with less memory and disk space, or a slower processor than your development platform. Some ideas for making a compact runtime application are:

- Remove all unnecessary classes during the Runtime Packager process.
- For the ORB image, remove all optional Distributed Smalltalk classes.
- Use a shared Interface Repository.

19

Troubleshooting

The most common issues that arise during development and operation are:

- Marshaling and unmarshaling errors
- Unavailable objects
- Synchronization errors
- Dangling references
- Interface access and editing errors
- Messages not understood
- Problems running multiple images
- Handling server-side transient errors

Marshaling and Unmarshaling Errors

Marshaling is the process of converting a Smalltalk message into a byte stream for transmission to a remote server. Unmarshaling creates a Smalltalk message from a marshaled byte stream. Marshaling and unmarshaling errors occur when the Interface Repository does not know how to deal with a given object.

Symptoms

- The application runs locally but not remotely.
- With Local RPC Testing turned on, or when running a distributed application, a marshallError or unmarshallError error notifier appears.

Possible Causes

- An object's interface has not been registered with the Interface Repository.
- The object's interface has changed since it was registered (repositories out of sync).
- A parameter or result value is inconsistent with the method's operation declaration.
- A legal Smalltalk construct may be illegal in IDL (IDL typing is more constrained than Smalltalk allows).

Solutions

- Use the IR Browser to check the object's interface.
- Edit the appropriate module in DSTRepository.
- Change the interface declaration in DSTRepository or change the value in the Smalltalk code.

Object Availability Exceptions

Since remote objects live in images over which the local image has no control, it is possible for remote objects to become unavailable. That is, when a local object sends a message to a remote object's surrogate, the surrogate tries to pass the message to the remote object but gets no response.

Symptoms

- The following exceptions are raised when a message is sent to an unavailable object:

commFailureError	Communication failure (the remote ORB is probably down)
invObjrefError:	Invalid object reference (most likely: the object no longer exists in the remote image)
noPermissionError:	No permission for attempted operation
noImplementError:	Operation implementation unavailable

noResponseError:	Response to request not yet available
transientError:	Transient failure?—?reissue request

Possible Causes

- Sockets, network, or other communications services are busy or unavailable.
- Remote image is closed or the system it runs on is unavailable (it may be turned off, or off the network).
- Remote ORB is stopped.
- Remote garbage collect reclaimed the object.

Solutions

- Wait for other ORB to be started, or for its image to come back on line.
- Strengthen the link. For more information refer to the discussion of links (page 79).
- If the problem is frequent, consider refining the application design to make the remote object local.
- When a communications failure occurs, in a Developer's system, you can debug or proceed, however in a Runtime system there is no option to debug. If you wish to let users attempt to retry after a communication failure, you can set class DSTObjRef's retrying flag to true (by default, it is set to false).
- For transient errors, consider using the transient error handler (see Handling Server-side Transient Errors).

Synchronization Problems

Synchronization problems are most likely to occur when multiple users share objects.

Symptoms

- Unreliable behavior.
- Non-deterministic errors.

Possible Causes

- Users' changes to a shared object conflict.
- Stale images access shared objects.

Solutions

- Use resource management to lock out multiple concurrent edits of shared resources. (Resource management is implemented in class DSTResourceManager and used by DSTSemantic.)
- Use semaphores to serialize critical parts of an application.
- Refine class DSTTraversal to provide tighter object locking and transaction control.
- Use an external database's object locking facilities.

Dangling References

Dangling references can occur when a method refers to an obsolete interface in the Interface Repository.

Symptoms

- "Dangling references" notifier.

Possible Causes

- A thread of control or context holds a reference to an interface object that has been removed from the Interface Repository. For example, you have open instances of an application that rely on an interface that you changed.

Solutions

- Close the offending application instances.

Remote Access to Overridden Methods

Objects that override methods in class Object cannot make these methods remotely available since the surrogates inherit from Object.

Symptoms

- You expect a remote message response but get a local one.

Possible Causes

- Instances of DSTObjRef and its subclasses function as surrogates for remote objects. Messages sent to instances of DSTObjRef that are not implemented in DSTObjRef or its superclass Object are assumed to be implemented in the remote object. However, if a method is defined both in the local class Object and the remote object that the DSTObjRef instance refers to, by default, Object's method will respond to the call; this is probably not the behavior you intended.

Solutions

- Define a method in DSTObjRef's message category override inheritance that overrides class Object's method of the same name. (See the other methods defined here for examples of the method definition.)

  For example, in order to have the message broadcast: aDSTObjRef call the remote object's broadcast: method, you must define broadcast: in DSTObjRef's override inheritance message category. Define it as:

```
broadcast: aSymbol
    "pass this operation to the referenced object"
    ^self perform: #broadcast on: (Array with: aSymbol).
```

Interface Repository Accessing Errors

The Interface Repository Browser uses resource management to protect against concurrent editing of the same interfaces and of interfaces that are in use. Thus, the system can deny your attempts to edit interfaces.

(Since the System Browser does not protect against concurrent edits, it can be dangerous place to edit an interface repository.)

Symptoms

- When using the Interface Repository Browser, if you choose Edit menu: Definition, an error message appears and the view does not change (that is, it remains a read-only iconic or text view).

Possible Causes

You are trying to edit:

- Fundamental interfaces that the IR Browser uses to present information (for example, the PSSplit module),
- An interface repository that someone else is currently editing, or
- An interface repository that someone was browsing when their system crashed (this problem does *not* occur when the ORB stops normally).

Solutions

- Use the View menu **as text** option to get read-only access.
- If locks should be released but were not because the system from which the interface repository was being edited crashed, you must reinitialize the repository. To do this, stop the ORB, then in the Distributed Smalltalk main window, select **DST>Initialize>Initialize Repository**.

Interface Incompatibilities

Objects in different images communicate via their interfaces which are stored in each ORB's interface repository. If the interfaces are not identical (or of compatible versions), you may see a badOperationError: or some other error.

Symptoms

- Errors (such as badOperationError:) occur during distributed execution that do not occur during Local RPC testing.

Possible Causes

- Interface definitions in the participating interface repositories are out of sync.
- Interface version numbers are out of sync. (The server interface's version number must be greater than or equal to the client's version.)
- If you are using a shared interface repository, the interfaces in the master repository may have changed since the local copy was cached.

Solutions

- If you are using a shared repository, stop the ORB, then in Distributed Smalltalk main window, select **DST>Initialize>Initialize Repository**.
- If you are using interface versioning, be sure that you use it correctly.

Other Exceptions

To support CORBA and object distribution, Distributed Smalltalk provides mechanisms for remote objects to send messages via surrogates and to access interfaces in the Interface Repository. As a result, there is an extra layer of complexity in pinpointing an error when a message to a distributed object is not understood.

Symptoms

The following exceptions are raised when a message sent to a remote object is not understood:

badInvOrderError	Routine invocations out of order
badOperationError:	Invalid operation, or interfaces out of sync
badParamError:	An invalid parameter was passed
badTypecodeError:	Bad typecode
contextError:	Error processing context object
dataConversionError:	Data conversion error
intfReposError:	Error accessing interface repository
invFlagError:	Invalid flag was specified
invIdentError:	Invalid identifier syntax
NotFound	Object not found (part of IDL interface)
SemanticError	(part of IDL interface)
UnknownID	Unknown object UUID (part of IDL interface)

Possible Causes

- Interface Repositories in the communicating images are out of sync. (The Interface Repository in each image is distinct; if you change one you must also change the others.)
- The message sent is not defined for the remote object.

Solutions

- In the remote image, determine whether the message being sent is actually implemented.

Problems Running Multiple Images

Cannot Start an ORB

- If an ORB already running on a system, you cannot start another.
- If you cannot start the ORB because there is no Request Broker panel, execute the statement DSTControlPanel open to reopen an Request Broker panel.

Cannot Determine Which Image You Are Using

- Use the Office's Action menu choice **Open Building**. Each office open on the current system will be shown here.

Handling Server-side Transient Errors

DST now has a customizable TransientErrorHandler for dealing with server side transient errors. To customize the handler, review the method comment of ORBDaemon class>>transientErrorHandler:.

Transients errors are usually raised when clients and servers are both overloaded, by the client spawning requests and the server receiving them. If the server is swamped with incoming requests, it spends all of its time spawning processes to respond to them, and those spawned processes never get a window in which to run. This can further entail that the requests will time out on the client side. When the server gets time to run its spawned, responding processes, and has return values to pass back, the client is too busy doing other things to listen, and this produces a transient error.

Transients are difficult to trap in user code, because they are generated on the server side, in a spawned process, created to respond to a remote request, initiated in another image. Because an unhandled transient will try to open a notifier, a user producing a headless server wants to trap them.

Before you decide to muffle notification of transients, using a handler block that throws them away, you really should find out exactly why and how the transients are occuring.

A

IDL Lexical Conventions

Overview

This chapter presents the lexical conventions of Distributed Smalltalk. It defines tokens in an Distributed Smalltalk specification and describes comments, identifiers, keywords, and literals (integer, character, floating point, and string).

File Processing

An Distributed Smalltalk specification logically consists of one or more files. A file is conceptually translated in several phases.

The first phase is preprocessing, which performs file inclusion and macro substitution. Preprocessing is controlled by directives introduced by lines having # as the first character other than white space. The result of preprocessing is a sequence of tokens. Such a sequence of tokens (that is, a file after preprocessing), is called a translation unit.

Comparison With C++ Lexical Conventions

IDL obeys the same lexical rules as C++, although new keywords are introduced to support distribution concepts. It also provides full support for standard C++ preprocessing features. The IDL specification is expected to track relevant changes to C++ introduced by the ANSI standardization effort.

Character Set

Distributed Smalltalk uses the ISO Latin-1 (8859.1) character set. This character set is divided into alphabetic characters (letters), digits, graphic characters, the space (blank) character and formatting

characters. The table below shows the Distributed Smalltalk alphabetic characters; upper- and lower-case equivalencies are paired.

Alphabetic Characters (Letter) (Continued)

Char.	Description	Char.	Description
Aa	Upper/Lower-case A	Àà	Upper/Lower-case A with grave accent
Bb	Upper/Lower-case B	Áá	Upper/Lower-case A with acute accent
Cc	Upper/Lower-case C	Ââ	Upper/Lower-case A with circumflex accent
Dd	Upper/Lower-case D	Ãã	Upper/Lower-case A with tilde
Ee	Upper/Lower-case E	Ää	Upper/Lower-case A with diaeresis
Ff	Upper/Lower-case F	Åå	Upper/Lower-case A with ring above
Gg	Upper/Lower-case G	Ææ	Upper/Lower-case dipthong A with E
Hh	Upper/Lower-case H	Çç	Upper/Lower-case C with cedilla
Ii	Upper/Lower-case I	Èè	Upper/Lower-case E with grave accent
Jj	Upper/Lower-case J	Éé	Upper/Lower-case E with acute accent
Kk	Upper/Lower-case K	Êê	Upper/Lower-case E with circumflex accent
Ll	Upper/Lower-case L	Ëë	Upper/Lower-case E with diaeresis
Mm	Upper/Lower-case M	Ìì	Upper/Lower-case I with grave accent
Nn	Upper/Lower-case N	Íí	Upper/Lower-case I with acute accent
Oo	Upper/Lower-case O	Îî	Upper/Lower-case I with circumflex accent

Char.	Description	Char.	Description
Pp	Upper/Lower-case P	Ïï	Upper/Lower-case I with diaeresis
Qq	Upper/Lower-case Q	††	Upper/Lower-case Icelandic eth
Rr	Upper/Lower-case R	Ññ	Upper/Lower-case N with tilde
Ss	Upper/Lower-case S	Òò	Upper/Lower-case O with grave accent
Tt	Upper/Lower-case T	Óó	Upper/Lower-case O with acute accent
Uu	Upper/Lower-case U	Ôô	Upper/Lower-case O with circumflex accent
Vv	Upper/Lower-case V	Õõ	Upper/Lower-case O with tilde
Ww	Upper/Lower-case W	Öö	Upper/Lower-case O with diaeresis
Xx	Upper/Lower-case X	Øø	Upper/Lower-case O with oblique stroke
Yy	Upper/Lower-case Y	Ùù	Upper/Lower-case U with grave accent
Zz	Upper/Lower-case Z	Úú	Upper/Lower-case U with acute accent
		Ûû	Upper/Lower-case U with circumflex accent
		Üü	Upper/Lower-case U with diaeresis
		††	Upper/Lower-case Y with acute accent
		††	Upper/Lower-case Icelandic thorn
		ß	Lower-case German sharp S
		ÿ	Lower-case Y with diaeresis

†† denotes character unprintable in this document

Decimal Digit Characters

0 1 2 3 4 5 6 7 8 9

Graphic Characters (Continued)

Char.	Description	Char.	Description
!	exclamation point	¡	inverted exclamation mark
"	double quote	¢	cent sign
#	number sign	£	pound sign
$	dollar sign	¤	currency sign
%	percent sign	¥	yen sign
&	ampersand	†	broken bar
’	apostrophe	§	section/paragraph sign
(	left parenthesis	¨	diaeresis
)	right parenthesis	©	copyright sign
*	asterisk	ª	feminine ordinal indicator
+	plus sign	«	left angle quotation mark
,	comma	¬	not sign
-	hyphen, minus sign	†	soft hyphen
.	period, full stop	®	registered trade mark sign
/	solidus	¯	macron
:	colon	°	ring above, degree sign
;	semicolon	±	plus-minus sign
<	less-than sign	2	superscript two
=	equals sign	3	superscript three
>	greater-than sign	´	acute
?	question mark	m	micro
@	commercial at	¶	pilcrow
[	left square bracket	•	middle dot

Char.	Description	Char.	Description
\	reverse solidus	¸	cedilla
]	right square bracket	1	superscript one
^	circumflex	º	masculine ordinal indicator
_	low line, underscore	»	right angle quotation mark
`	grave	†	vulgar fraction 1/4
{	left curly bracket	†	vulgar fraction 1/2
|	vertical line	†	vulgar fraction 3/4
}	right curly bracket	¿	inverted question mark
~	tilde	x	multiplication sign
		³	division sign

† *denotes character unprintable in this document.*

The Formatting Characters

Description	Abbreviation	ISO 646 Octal Value
alert	BEL	007
backspace	BS	010
horizontal tab	HT	011
newline	NL, LF	012
vertical tab	VT	013
form feed	FF	014
carriage return	CR	015

Tokens

There are five kinds of tokens: identifiers, keywords, literals, operators, and other separators. Blanks, horizontal and vertical tabs, newlines, formfeeds, and comments (collective, “white space”), as described below, are ignored except as they serve to separate tokens. Some white space is required to separate otherwise adjacent identifiers, keywords, and constants.

If the input stream has been parsed into tokens up to a given character, the next token is taken to be the longest string of characters that could possibly constitute a token.

Comments

The characters /* start a comment, which terminates with the characters */. These comments do not nest. The characters // start a comment, which terminates at the end of the line on which they occur. The comment characters //, /*, and */ have no special meaning within a // comment and are treated just like other characters. Similarly, the comment characters // and /* have no special meaning within a /* comment. Comments may contain alphabetic, digit, graphic, space, horizontal tab, vertical tab, form feed, and newline characters.

Identifiers

An identifier is an arbitrarily long sequence of alphabetic, digit, and underscore ("_") characters. The first character must be an alphabetic character. All characters are significant.

Identifiers that differ only in case collide and yield a compilation error. An identifier for a definition must be spelled consistently (with respect to case) throughout a specification.

When comparing two identifiers to see if they collide:

- Upper- and lower-case letters are treated as the same letter. Table defines the equivalence mapping of upper- and lower-case letters.
- The comparison does *not* take into account equivalences between digraphs and pairs of letters (e.g., "æ" and "ae" are not considered equivalent) or equivalences between accented and non-accented letters (e.g., "Á" and "A" are not considered equivalent).
- All characters are significant.

There is only one name space for VisualWorks identifiers. Using the same identifier for a constant and an interface, for example, produces a compilation error.

Keywords

The identifiers listed in the following table are reserved for use as keywords, and may not be used otherwise.

Reserved Keywords

any	default	interface	readonly	unsigned
attribute	double	long	sequence	union
boolean	enum	module	short	void
case	exception	octet	string	FALSE
char	float	oneway	struct	Object
const	in	out	switch	TRUE
context	inout	raises	typedef	

Keywords obey the rules for identifiers (see Identifiers) and must be written exactly as shown in the above list. For example, "boolean" is correct; "Boolean" produces a compilation error.

Distributed Smalltalk specifications use the characters shown in the following table as punctuation.

Punctuation Characters

;	{	}	:	,	=	+	-	(	)	<	>	[	]
'	"	\	|	^	&	*	/	%	~				

In addition, the tokens listed in the following table are used by the preprocessor.

Preprocessor Tokens

#	##	!	||	&&

Literals

This section describes literals?—?integer, character, and floating point constants and string literals.

Integer Literals

An integer literal consisting of a sequence of digits is taken to be decimal (base ten) unless it begins with 0 (digit zero). A sequence of digits starting with 0 is taken to be an octal integer (base eight). The digits 8 and 9 are not octal digits. A sequence of digits preceded by 0x or 0X is taken to be a hexadecimal integer (base sixteen). The hexadecimal digits include a or A through f or F with decimal values ten through fifteen, respectively. For example, the number twelve can be written 12, 014, or 0XC.

Character Literals

A character literal is one or more characters enclosed in single quotes, as in 'x'. Character literals have type `char`.

A character is an 8-bit quantity with a numerical value between 0 and 255 (decimal). The value of a space, alphabetic, digit or graphic character literal is the numerical value of the character as defined in the ISO Latin-1 (8859.1) character set standard (see Table , “Alphabetic Characters (Letter),” on page 246, Table , “Decimal Digit Characters,” on page 248, and Table , “Graphic Characters,” on page 248). The value of a null is 0. The value of a formatting character literal is the numerical value of the character as defined in the ISO 646 standard (see Table , “IDL EBNF Format,” on page 255). The meaning of all other characters is implementation-dependent.

Non-graphic characters must be represented using escape sequences as defined below in the following table. Note that escape sequences must be used to represent single quote and backslash characters in character literals.

Escape Sequences

Description	Escape Sequence
newline	\n
horizontal tab	\t
vertical tab	\v
backspace	\b

Description	Escape Sequence
carriage return	\r
form feed	\f
alert	\a
backslash	\\
question mark	\?
single quote	\'
double quote	\"
octal number	\ooo
hexadecimal number	\xhh

If the character following a backslash is not one of those specified, the behavior is undefined. An escape sequence specifies a single character.

The escape \ooo consists of the backslash followed by one, two, or three octal digits that are taken to specify the value of the desired character. The escape \xhh consists of the backslash followed by x followed by one or two hexadecimal digits that are taken to specify the value of the desired character. A sequence of octal or hexadecimal digits is terminated by the first character that is not an octal digit or a hexadecimal digit, respectively. The value of a character constant is implementation dependent if it exceeds that of the largest char.

Floating-point Literals

A floating-point literal consists of an integer part, a decimal point, a fraction part, an e or E, an optionally signed integer exponent, and an optional type suffix. The integer and fraction parts both consist of a sequence of decimal (base ten) digits. Either the integer part or the fraction part (but not both) may be missing; either the decimal point or the letter e (or E) and the exponent (but not both) may be missing.

String Literals

A string literal is a sequence of characters (as defined in “Character Literals,” earlier in this chapter) surrounded by double quotes, as in "…".

Adjacent string literals are concatenated. Characters in concatenated strings are kept distinct. For example,

```
"\xA" "B"
```

contains the two characters '\xA' and 'B' after concatenation (and not the single hexadecimal character '\xAB').

The size of a string literal is the number of character literals enclosed by the quotes, after concatenation. The size of the literal is associated with the literal. Within a string, the double quote character " must be preceded by a \.

A string literal may not contain the character '\0'.

B

IDL Grammar

The description of IDL grammar uses a syntax notation that is similar to Extended Backus-Naur format (EBNF).

The following table lists the symbols used in this format and their meanings.

IDL EBNF Format

Symbol	Meaning
::=	Is defined as
|	Alternatively
<text>	Non-terminal
“text”	Literal
*	The preceding syntactic unit can be repeated zero or more times
+	The preceding syntactic unit can be repeated one or more times
{}	The enclosed syntactic units are grouped as a single syntactic unit
[]	The enclosed syntactic unit is optional?—?it may occur zero or one time

The following is the IDL grammar:

(1) <specification>	::= <definition>+
(2) <definition>	::= <type_dcl> “;” | <const_dcl> “;” | <except_dcl> “;” | <interface> “;” | <module> “;”
(3) <module>	::= “module” <identifier> “(“ <definition>+ “)”
(4) <interface>	::= <interface_dcl> | <forward_dcl>
(5) <interface_dcl>	::= <interface_header> “{“ <interface_body~ “}”
(6) <forward_dcl>	::= “interface” <identifier>
(7) <interface_header>	::= “interface” <identifier> [<inheritance_spec>]
(8) <interface_body>	::= <export>
(9) <export>	::= <type_dcl> “;” | <const_dcl> “;” | <except_dcl> “;” | <attr_dcl> “;” | <op_dcl> “;”
(10) <inheritance_spec>	::= “:” <scoped_name> { “,” <scoped_name> }*
(11) <scoped_name>	::= <identifier> | “::” <identifier> | <scoped_name> “::” <identifier>
(12) <const_dcl>	“const” <const_type> <identifier> “=”<const_exp>
(13) <const_type>	::= <integer_type> | <char_type> | <boolean_type> | <floating_pt_type> | <string_type> | <scoped_name>

(14) <const_exp> ::= <or_expr>

(15) <or_expr> ::= <xor_expr>
<or_expr> “|” <xor_expr>

(16) <xor_expr> ::= <and_expr>
| <xor_expr> “^” <and_expr>

(17) <and_expr> ::= <shift_expr>
| <and_expr> “&” <shift_expr>

(18) <shift_expr> ::= <add_expr>
| <shift_expr> “>>” <add_expr>
| <shift_expr> “<<“ <add_expr>

(19) <add_expr> ::= <mult_expr>
| <add_expr> “+” <mult_expr>
| <add_expr> “-” <mult_expr>

(20) <mult_expr> ::= <unary_expr,
| <mult_expr> “*” <unary_expr>
| <mult_expr> “~” cunary_expr>
| <mult_expr> “%” cunary_expr>

(21) <unary_expr> ::= <unary_operator> cprimary_expr>
| <primary_expr>

(22) <unary_operator> ::= “-”
::= “+”
::= “~”

(23) <primary_expr> ::= <scoped_name>
| <literal>
| “(“ <const_exp> “)”

(24) <literal> ::= <integer_literal>
| <string_literal>
| <character_literal>
| <floating_pt_literal>
| <boolean_literal>

(25) <boolean_literal> ::= “TRUE”
| “FALSE”

(26) <positive_int_const> ::= <const_exp>

(27) <type_dcl>	::= “typedef” <type_declarator> | <struct_type> | <union_type> | <enum_type>
(28) <type_declarator>	::= <type_spec> <declarators>
(29) <type_spec>	::= <simple_type_spec> | <constr_type_spec>
(30) <simple_type_spec>	::= <base_type_spec> | <template_type_spec> | <scoped_name>
(31) <base_type_spec>	::= <floating_pt_type> | <integer_type> | <char_type> | <boolean_type> | <octet_type> | <any_type>
(32) <template_type_spec>	::= <sequence_type> | <string_type>
(33) <constr_type_spec>	::= <struct_type> | <union_type>| <enum_type>
(34) <declarators>	::= <declarator> { “,” <declarator>)*
(35) <declarator>	::= <simple_declarator> | <complex_declarator>
(36) <simple_declarator>	::= <identifier>
(37) <complex_declarator>	::= <array_declarator>
(38) <floating_pt_type>	::= “float” | “double”
(39) <integer_type>	::= <signed_int> | <unsigned_int>
(40) <signed_int>	::= <signed_long_int> | <signed_short_int>
(41) <signed_long_int>	::= “long”

```
(42) <signed_short_int>       ::=  “short”

(43) <unsigned_int>           ::= <unsigned_long_int>
                              |   <unsigned_short_int>

(44) <unsigned_long_int>      ::= “unsigned” “long”

(45) <unsigned_short_int>     ::= “unsigned” “short”

(46) <char_type>              ::= “char”

(47) <boolean_type>           ::= “boolean”

(48) <octet_type>             ::= “octet”

(49) <any_type>               ::= “any”

(50) <struct_type>            ::= “struct” <identifier> “{” <member_list> “}”

(51) <member_list>            ::= <member>+

(52) <member>                 ::= <type_spec> <declarators> “;”

(53) <union_type>             ::= “union” <identifier> “switch” “(”
                                  <switch_type_spec> “)”
                                  “(” <switch_body> “)”

(54) <switch_type_spec>       ::=  <integer_type>
                              |    <char_type>
                              |    <boolean_type>
                              |    <enum_type>
                              |    <scoped_name>

(55)  <switch_body>           ::= <case>+

(56)  <case>                  ::= <case_label>+ <element_spec> “;”

(57)  <case_label>            := “case” <const_exp> “;”
                              |   “default” “:”

(58)  <element_spec>          ::= <type_spec> <declarator>

(59) <enum_type>              ::= “enum” <identifier> “{” <enumerator
                                  {“,” <enumerator>}* “}”

(60) <enumerator>             ::= identifier
```

(61) <sequence_type>	::= “sequence” “<” <simple_type_spec> “,” <positive_int_const> “>”
	| “sequence” “<” <simple_type_spec> “>”
(62) <string_type>	::= “string” “<” <positive_int_const> “>”
	| “string”
(63) <array_declarator>	::= <identifier> <fixed_array_size>+
(64) <fixed_array_size>	::= “[” <positive_int_const> “]”
(65) <attr_dcl>	::= [“readonly”] “attribute” <param_type_spec> <simple_declarator> <declarators>{“,” <simple_declarator>}*
(66) <except_dcl>	::= “exception” <identifier> “{” <member>* “}”
(67) <op_dcl>	::= [<op_attribute> I <op_type_spec> <identifier> <parameter_dcls> [<raises_expr>] [<context_expr>]
(68) <op_attribute>	::= “oneway”
(69) <op_type_spec>	::= <simple_type_spec>
	| “void”
(70)<parameter_dcls>	::= “(” <param_dcl> { “,” <param_dcl>
	| “(” “)”
(71) <param_dcl>	::= <param_attribute> <simple_type_spec> <declarator>
(72) <param_attribute>	::= “in”
	| “out”
	| “inout”
(73) <raises_expr>	::= “raises” “(” <scoped_name> { “,” <scoped name>}* “)”
(74) <context_expr>	::= “context” “(“ <string_literal> { “,” <string_literal>}* “)”
(75) <param_type_spec>	::= <base_type_spec>
	| <string_type>
	| <scoped_name>

C

Bibliography

CORBA Resources

Robert Orfali, Dan Harkey, and Jeri Edwards, *The Essential Distributed Objects Survival Guide*John Wiley and Sons, New York, 1996, ISBN 0-471-12993-3.

An overview of CORBA, written in a chatty non-technical style.

Jon Siegel, *CORBA Fundamentals and Programming*John Wiley and Sons, New York, 1996, ISBN 0-471-12148-7.

An excellent guide to developing CORBA applications. Gives a complete example in Smalltalk.

Distributed Computing Resources

Nancy A. Lynch, *Distributed Algorithms*Morgan Kaufmann, San Francisco, 1996, ISBN 1-55860-348-4.

A survey of what is known about distributed algorithms, written for computer scientists who are familiar with the analysis of algorithms. Covers issues including consensus, communication, resource allocation, and synchronization.

Sape Mullender (editor), *Distributed Systems*ACM Press, New York, 1993, ISBN 0-201-62427-3.

An overview of the design and implementation of distributed systems, aimed at graduate students in computer science.

M. Tamer Özsu, Umeshwar Dayal, and Patrick Valduriez, *Distributed Object Management*Morgan Kaufmann, San Mateo, 1994, ISBN 1-55860-256-9.

A collection of papers from the International Workshop on Distributed Object Management. Addresses distributed database issues.

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