Sun microsystems

Sun Cluster 3.1 10/03 Data Services Developer’s Guide

Sun Microsystems, Inc.
4150 Network Circle
Santa Clara, CA 95054
U.S.A.

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Contents

Preface

The *Sun Cluster 3.1 10/03 Data Services Developer's Guide* contains information about using the Resource Management API to develop Sun Cluster data services.

Who Should Use This Book

This document is intended for experienced developers with extensive knowledge of Sun software and hardware. The information in this book assumes knowledge of the Solaris™ Operating Environment.

How This Book Is Organized

The *Sun Cluster 3.1 10/03 Data Services Developer's Guide* contains the following chapters and appendixes:

- Chapter 1 provides an overview of the concepts needed to develop a data service.
- Chapter 2 provides detailed information on developing a data service.
- Chapter 4 provides a reference to the access functions and callback methods that make up the Resource Management API (RMAPI).
- Chapter 5 provides a sample Sun Cluster data service for the `in.named()` application.
- Chapter 6 provides an overview of the application programming interfaces constituting the Data Services Development Library (DSDL)
- Chapter 7 explains the typical usage of the DSDL in designing and implementing resource types.

- Chapter 8 describes a sample resource type implemented with DSDL.
- Chapter 9 describes SunPlex Agent Builder.
- Chapter 10 describes how to create a generic data service.
- Chapter 11 describes the DSDL API functions.
- Appendix A describes the standard resource type, resource group, and resource properties.
- Appendix B provides the complete code for each method in the sample data service.
- Appendix C lists the complete code for each method in the `SUNW.xfnts()` resource type.
- Appendix D lists the requirements for legal characters for Resource Group Manager (RGM) names and values.
- Appendix E list the requirements for ordinary non-cluster aware applications to be candidates for high availability.

Related Documentation

Application	Title	Part Number
Concepts	*Sun Cluster 3.1 10/03 Concepts Guide*	817-0519
Software Installation	*Sun Cluster 3.1 10/03 Software Installation Guide*	817-0518
Administration	*Sun Cluster 3.1 10/03 System Administration Guide*	817-0516
API Development	*Sun Cluster 3.1 10/03 Data Services Developer's Guide*	817-0520
Error Messages	*Sun Cluster 3.1 10/03 Error Messages Guide*	817-0521
Hardware	*Sun Cluster 3.x Hardware Administration Manual*	817-0168
	Sun Cluster 3.x Hardware Administration Collection at `http://docs.sun.com/db/coll/1024.1`	
Data Services	*Sun Cluster 3.1 Data Service Planning and Administration Guide*	817-3305
	Sun Cluster 3.1 Data Services 10/03 Collection at `http://docs.sun.com/db/coll/573.10`	
Man Pages	*Sun Cluster 3.1 10/03 Reference Manual*	817–0522

Application	Title	Part Number
Release Notes	*Sun Cluster 3.1 10/03 Release Notes*	817–0638
	Sun Cluster 3.x Release Notes Supplement	816-3381

Getting Help

If you have problems installing or using Sun Cluster, contact your service provider and provide the following information.

- Your name and email address (if available)
- Your company name, address, and phone number
- The model number and serial number of your systems
- The release number of the operating environment (for example, Solaris 10)
- The release number of Sun Cluster (for example, Sun Cluster 3.1)

Use the following commands to gather information on your system for your service provider.

Command	Function
`prtconf -v`	Displays the size of the system memory and reports information about peripheral devices
`psrinfo -v`	Displays information about processors
`showrev -p`	Reports which patches are installed
`prtdiag -v`	Displays system diagnostic information
`/usr/cluster/bin/scinstall -pv`	Displays Sun Cluster release and package version information

Also have available the contents of the `/var/adm/messages` file.

Accessing Sun Documentation Online

The docs.sun.com^{SM} Web site enables you to access Sun technical documentation online. You can browse the docs.sun.com archive or search for a specific book title or subject. The URL is `http://docs.sun.com`.

Typographic Conventions

The following table describes the typographic changes used in this book.

TABLE P–1 Typographic Conventions

Typeface or Symbol	Meaning	Example
`AaBbCc123`	The names of commands, files, and directories; on-screen computer output	Edit your `.login` file. Use `ls -a` to list all files. `machine_name% you have mail.`
`AaBbCc123`	What you type, contrasted with on-screen computer output	`machine_name%` **`su`** `Password:`
AaBbCc123	Command-line placeholder: replace with a real name or value	The command to remove a file is `rm` *filename*.
AaBbCc123	Book titles, new words or terms, or words to be emphasized	Read Chapter 6 in the *User's Guide*. These are called *class* options. Do *not* save the file.

Shell Prompts in Command Examples

The following table shows the default system prompt and superuser prompt for the C shell, Bourne shell, and Korn shell.

TABLE P–2 Shell Prompts

Shell	Prompt
C shell prompt	`machine_name%`
C shell superuser prompt	`machine_name#`
Bourne shell and Korn shell prompt	`$`
Bourne shell and Korn shell superuser prompt	`#`

CHAPTER 1

Resource Management Overview

This book provides guidelines for creating a resource type for a software application such as Oracle, Sun™ One Web Server, DNS, and so on. As such, this book is targeted at resource type developers.

This chapter provides an overview of the concepts you need to understand in order to develop a data service and contains the following information.

- "Sun Cluster Application Environment" on page 17
- "RGM Model" on page 19
- "Resource Group Manager" on page 21
- "Callback Methods" on page 21
- "Programming Interfaces" on page 22
- "Resource Group Manager Administrative Interface" on page 24

Note – This book uses the terms *resource type* and *data service* interchangeably. The term *agent*, though rarely used in this book, is equivalent to *resource type* and *data service*.

Sun Cluster Application Environment

The Sun Cluster system enables applications to be run and administered as highly available and scalable resources. The cluster facility known as the Resource Group Manager, or RGM, provides the mechanism for high availability and scalability. The elements that form the programming interface to this facility include the following.

- A set of callback methods you write that enable the RGM to control an application on the cluster
- The Resource Management API (RMAPI), a set of low-level API commands and functions that you can use to write the callback methods. These APIs are implemented in the `libscha.so` library.

- Process management facilities for monitoring and restarting processes on the cluster
- The Data Service Development Library (DSDL), a set of library functions that encapsulates the low-level API and process-management functionality at a higher level and adds some additional functionality to ease the writing of callback methods. These functions are implemented in the `libdsdev.so` library.

The following figure shows the interrelationship of these elements.

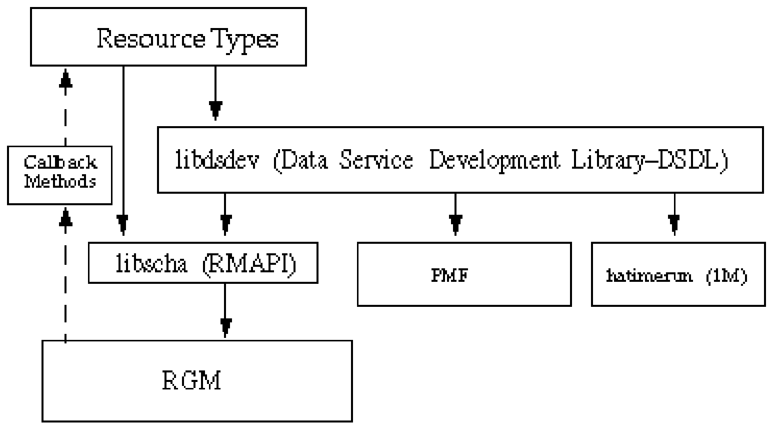


FIGURE 1–1 Programming Architecture

Included in the Sun Cluster package is SunPlex Agent Builder™, a tool that automates the process of creating a data service (see Chapter 9). Agent Builder generates data service code in either C (using DSDL functions to write the callback methods) or in Korn shell (`ksh`) (using low-level API commands to write the callback methods).

The RGM runs as a daemon on each cluster node and automatically starts and stops resources on selected nodes according to preconfigured policies. The RGM makes a resource highly available in the event of a node failure or reboot by stopping the resource on the affected node and starting it on another. The RGM also automatically starts and stops resource-specific monitors that can detect resource failures and relocate failing resources onto another node or can monitor other aspects of resource performance.

The RGM supports both failover resources, which can be online on at most one node at a time, and scalable resources, which can be online on multiple nodes simultaneously.

RGM Model

This section introduces some fundamental terminology and explains in more detail the RGM and its associated interfaces.

The RGM handles three major kinds of interrelated objects: resource types, resources, and resource groups. One way to introduce these objects is by means of an example, as described below.

A developer implements a resource type, `ha-oracle`, that makes an existing Oracle DBMS application highly available. An end user defines separate databases for marketing, engineering, and finance, each of which is a resource of type `ha-oracle`. The cluster administrator places these resources in separate resource groups so they can run on different nodes and fail over independently. A developer creates a second resource type, ha-calendar, to implement a highly available calendar server that requires an Oracle database. The cluster administrator places the resource for the finance calendar into the same resource group as the finance database resource so that both resources run on the same node and fail over together.

Resource Types

A resource type consists of a software application to be run on the cluster, control programs used as callback methods by the RGM to manage the application as a cluster resource, and a set of properties that form part of the static configuration of a cluster. The RGM uses resource type properties to manage resources of a particular type.

Note – In addition to a software application, a resource type can represent other system resources such as network addresses.

The resource type developer specifies the properties for the resource type and sets their values in a resource type registration (RTR) file. The RTR file follows a well-defined format described in "Setting Resource and Resource Type Properties" on page 30 and in the `rt_reg`(4) man page. See also "Defining the Resource Type Registration File" on page 82 for a description of a sample resource type registration file.

Table A–1 provides a list of the resource type properties.

The cluster administrator installs and registers the resource type implementation and underlying application on a cluster. The registration procedure enters into the cluster configuration the information from the resource type registration file. The *Sun Cluster 3.1 Data Service Planning and Administration Guide* describes the procedure for registering a data service.

Resources

A resource inherits the properties and values of its resource type. In addition, a developer can declare resource properties in the resource type registration file. See Table A–2 for a list of resource properties.

The cluster administrator can change the values of certain properties depending on how they were specified in the resource type registration (RTR) file. For example, property definitions can specify a range of allowable values and specify when the property is tunable, for example, at creation, any time, or never. Within these specifications, the cluster administrator can make changes to properties using administration commands.

The cluster administrator can create many resources of the same type, each resource having its own name and set of property values, so that more than one instance of the underlying application can run on the cluster. Each instantiation requires a unique name within the cluster.

Resource Groups

Each resource must be configured in a resource group. The RGM brings all resources in a group online and offline together on the same node. When the RGM brings a resource group online or offline, it invokes callback methods on the individual resources in the group.

The nodes on which a resource group is currently online are called its *primaries* or *primary nodes*. A resource group is *mastered* by each of its primaries. Each resource group has an associated `Nodelist` property, which is set by the cluster administrator, that identifies all *potential primaries* or masters of the resource group.

A resource group also has a set of properties. These properties include configuration properties that can be set by the cluster administrator and dynamic properties, set by the RGM, that reflect the active state of the resource group.

The RGM defines two types of resource groups, failover and scalable. A failover resource group can be online on one node only at any time while a scalable resource group can be online on multiple nodes simultaneously. The RGM provides a set of properties to support the creation of each type of resource group. See "Transferring a Data Service to a Cluster" on page 29 and "Implementing Callback Methods" on page 38 for details about these properties.

See Table A–3 for a list of resource group properties.

Resource Group Manager

The Resource Group Manager (RGM) is implemented as a daemon, `rgmd`, that runs on each member node of the cluster. All of the `rgmd` processes communicate with each other and act together as a single cluster-wide facility.

The RGM supports the following functions:

- Whenever a node boots or crashes, the RGM attempts to maintain availability of all managed resource groups by automatically bringing them online on appropriate masters.
- If a particular resource fails, its monitor program can request that the resource group be restarted on the same master or switched to a new master.
- The cluster administrator can issue an administrative command to request one of the following actions:
  - Change mastery of a resource group
  - Enable or disable a particular resource within a resource group
  - Create, delete, or modify a resource, a resource group, or a resource type

Whenever the RGM activates configuration changes, it coordinates its actions across all member nodes of the cluster. This kind of activity is known as a reconfiguration. To effect a state change on an individual resource, the RGM invokes a resource-type specific callback method on that resource.

Callback Methods

The Sun Cluster framework uses a callback mechanism to provide communication between a data service and the RGM. The framework defines a set of callback methods, including their arguments and return values, and the circumstances under which the RGM calls each method.

You create a data service by coding a set of individual callback methods and implementing each method as a control program callable by the RGM. That is, the data service does not consist of a single executable but rather consists of a number of executable scripts (`ksh`) or binaries (C), each of which is directly callable by the RGM.

Callback methods are registered with the RGM through the resource type registration (RTR) file. In the RTR file you identify the program for each method you have implemented for the data service. When a system administrator registers the data service on a cluster, the RGM reads the RTR file, which provides, among other information, the identity of the callback programs.

The only required callback methods for a resource type are a start method (`Start` or `Prenet_start`), and a stop method (`Stop` or `Postnet_stop`).

The callback methods can be grouped into the following categories:

- Control and initialization methods
  - `Start` and `Stop` start and stop resources in a group that is being brought online or offline.
  - `Init`, `Fini`, `Boot` execute initialization and termination code on resources.
- Administrative support methods
  - `Validate` verifies properties set by administrative action.
  - `Update` updates the property settings of an online resource.
- Net-relative methods
  - `Prenet_start` and `Postnet_stop` do special startup or shutdown actions before network addresses in the same resource group are configured up or after they are configured down.
- Monitor control methods
  - `Monitor_start` and `Monitor_stop` start or stop the monitor for a resource.
  - `Monitor_check` assesses the reliability of a node before a resource group is moved to the node.

See Chapter 4 and the `rt_callbacks`(1HA) man page for more information on the callback methods. Also see Chapter 5 and Chapter 8 for callback methods in sample data services.

Programming Interfaces

For writing data service code, the resource management architecture provides a low-level, or base API, a higher-level library built on top of the base API, and a tool, SunPlex Agent Builder, that automatically generates a data service from basic input that you provide.

RMAPI

The RMAPI (Resource Management API) provides a set of low-level routines that enable a data service to access information about the resources, resource types and resource groups in the system, request a local restart or failover, and set the resource status. You access these functions through the `libscha.so` library. The RMAPI provides these callback methods both in the form of shell commands and in the form of C functions. See `scha_calls`(3HA) and Chapter 4 for more information on the RMAPI routines. Also see Chapter 5 for examples of how to use these routines in sample data service callback methods.

Data Service Development Library (DSDL)

Built on top of the RMAPI is the DSDL, which provides a higher-level integrated framework while retaining the underlying method-callback model of the RGM. The DSDL brings together various facilities for data-service development, including:

- `libscha.so`—the low-level resource management APIs
- PMF—the process management facility, which provides a means of monitoring processes and their descendants, and restarting them if they die (see `pmfadm`(1M) and `rpc.pmfd`(1M)).
- `hatimerun`—a facility for running programs under a timeout (see `hatimerun`(1M).

For the majority of applications, the DSDL provides most or all of the functionality you need to build a data service. Note, however, that the DSDL does not replace the low-level API but encapsulates and extends it. In fact, many DSDL functions call the `libscha.so` functions. Likewise you can directly call `libscha.so` functions while using the DSDL to code the bulk of your data service. The `libdsdev.so` library contains the DSDL functions.

See Chapter 6 and the `scha_calls`(3HA) man page for more information about the DSDL.

SunPlex Agent Builder

Agent Builder is a tool that automates the creation of a data service. You input basic information about the target application and the data service to be created.Agent Builder generates a data service, complete with source and executable code (C or Korn shell), customized RTR file, and a Solaris package.

For most applications, you can use Agent Builder to generate a complete data service with only minor manual changes on your part. Applications with more sophisticated requirements, such as adding validation checks for additional properties, might require work that Agent Builder cannot do. However, even in these cases you might be able to use Agent Builder to generate the bulk of the code and manually code the rest. At minimum, you can use Agent Builder to generate the Solaris package for you.

Resource Group Manager Administrative Interface

Sun Cluster provides both a graphical user interface and a set of commands for administering a cluster.

SunPlex Manager

SunPlex Manager is a Web-based tool that enables you to perform the following tasks.

- Install a cluster
- Administer a cluster
- Create and configure resources and resource groups
- Configure data services with the Sun Cluster software

See the *Sun Cluster 3.1 10/03 Software Installation Guide* for instructions on how to install SunPlex Manager and how to use SunPlex Manager to install cluster software. SunPlex Manager provides online help for most unique administrative tasks.

Administrative Commands

The Sun Cluster commands for administering RGM objects are `scrgadm`(1M), `scswitch`(1M), and `scstat`(1M) `-g`.

The `scrgadm` command allows viewing, creating, configuring and deleting the resource type, resource group, and resource objects used by the RGM. The command is part of the administrative interface for the cluster, and is not to be used in the same programming context as the application interface described in the rest of this chapter. However, `scrgadm` is the tool for constructing the cluster configuration in which the API operates. Understanding the administrative interface sets the context for understanding the application interface. Refer to the `scrgadm`(1M) man page for details on the administrative tasks that can be performed by the command.

The `scswitch` command switches resource groups online and offline on specified nodes and enables or disables a resource or its monitor. See the `scswitch`(1M) man page for details on the administrative tasks that the command can perform.

The `scstat -g` command shows the current dynamic state of all resource groups and resources.

CHAPTER 2

Developing a Data Service

This chapter provides detailed information about developing a data service.

This chapter covers the following topics:

Analyzing the Application for Suitability

The first step in creating a data service is to determine that the target application satisfies the requirements for being made highly available or scalable. If the application fails to meet all requirements, you might be able to modify the application source code to make it so.

The list that follows summarizes the requirements for an application to be made highly available or scalable. If you need more detail or if you need to modify the application source code, refer to Appendix B.

Note – A scalable service must meet all the following conditions for high availability as well as some additional criteria.

- Both network aware (client-server model) and non-network aware (client-less) applications are potential candidates for being made highly available or scalable in the Sun Cluster environment. However Sun Cluster cannot provide enhanced availability in time-sharing environments in which applications are run on a server that is accessed through `telnet` or `rlogin`.
- The application must be crash tolerant. That is, it must recover disk data (if necessary) when it is started after an unexpected node death. Furthermore, the recovery time after a crash must be bounded. Crash tolerance is a prerequisite for making an application highly available because the ability to recover the disk and restart the application is a data integrity issue. The data service is not required to be able to recover connections
- The application must not depend upon the physical hostname of the node on which it is running. See "Host Names" on page 307 for additional information.
- The application must operate correctly in environments in which multiple IP addresses are configured up; for example, environments with multihomed hosts, in which the node is on more than one public network, and environments with nodes on which multiple, logical interfaces are configured up on one hardware interface.
- To be highly available, the application data must reside in the cluster file systems—see "Multihosted Data" on page 305.

  If the application uses a hard-wired path name for the location of the data, you could change that path to a symbolic link that points to a location in the cluster file system, without changing application source code. See "Using Symbolic Links for Multihosted Data Placement" on page 306 for additional information.
- Application binaries and libraries can reside locally on each node or on the cluster file system. The advantage of residing on the cluster file system is that a single installation is sufficient. The disadvantage is that rolling upgrade becomes an issue because the binaries are in use while the application is running under control of the RGM.
- The client should have some capacity to retry a query automatically if the first attempt times out. If the application and protocol already handle the case of a single server crashing and rebooting, then they also will handle the case of the containing resource group being failed over or switched over. See "Client Retry" on page 309 for additional information.
- The application must not have Unix domain sockets or named pipes in the cluster file system.

Additionally, scalable services must meet the following requirements.

- The application must have the ability to run multiple instances, all operating on the same application data in the cluster file system.

- The application must provide data consistency for simultaneous access from multiple nodes.
- The application must implement sufficient locking with a globally visible mechanism, such as the cluster file system.

For a scalable service, application characteristics also determine the load-balancing policy. For example, the load-balancing policy, `LB_WEIGHTED`, which allows any instance to respond to client requests, does not work for an application that makes use of an in-memory cache on the server for client connections. In this case, you should specify a load-balancing policy that restricts a given client's traffic to one instance of the application. The load-balancing policies, `LB_STICKY` and `LB_STICKY_WILD`, repeatedly send all requests by a client to the same application instance—where they can make use of an in-memory cache. Note that if multiple client requests come in from different clients, the RGM distributes the requests among the instances of the service. See "Implementing a Failover Resource" on page 45 for more information about setting the load balancing policy for scalable data services.

Determining the Interface to Use

The Sun Cluster developer support package (`SUNWscdev`) provides two sets of interfaces for coding data service methods:

- The Resource Management API (RMAPI), a set of low-level routines (in the `libscha.so` library)
- The Data Services Development Library (DSDL), a set of higher level functions (in the `libdsdev.so` library) that encapsulate the functionality of the RMAPI and provides some additional functionality

Also included in the Sun Cluster developer support package is SunPlex Agent Builder, a tool that automates the creation of a data service.

The recommended approach to developing a data service is:

1. Decide whether to code in C or the Korn shell. If you decide to use the Korn shell, you cannot use the DSDL, which provides a C interface only.
2. Run Agent Builder, specify the requested inputs, and generate a data service, which includes source and executable code, an RTR file, and a package.
3. If the generated data service requires customizing, you can add DSDL code to the generated source files. Agent Builder indicates, with comments, specific places in the source files where you can add your own code.
4. If the code requires further customizing to support the target application, you can add RMAPI functions to the existing source code.

In practice, you could take numerous approaches to creating a data service. For example, rather than add your own code to specific places in the code generated by Agent Builder, you could replace entirely one of the generated methods or the generated monitor program with a program you write from scratch using DSDL or RMAPI functions. However, regardless of the manner you proceed, in almost every case, starting with Agent Builder makes sense, for the following reasons:

- The code generated by Agent Builder, while generic in nature, has been tested in numerous data services.
- Agent Builder generates an RTR file, a make file, a package for the resource, and other support files for the data service. Even if you use none of the data service code, using these other files can save you a considerable amount of work.
- You can modify the generated code.

Note – Unlike the RMAPI, which provides a set of C functions and a set of commands for use in scripts, the DSDL provides a C function interface only. Therefore, if you specify Korn shell (`ksh`) output in Agent Builder, the generated source code makes calls to RMAPI because there are no DSDL `ksh` commands.

Setting Up the Development Environment for Writing a Data Service

Before beginning data service development, you must have installed the Sun Cluster development package (`SUNWscdev`) to have access to the Sun Cluster header and library files. Although this package is already installed on all cluster nodes, typically, you do development on a separate, non-cluster development machine, not on a cluster node. In this typical case, you must use `pkgadd` to install the `SUNWscdev` package on your development machine.

When compiling and linking your code, you must set particular options to identify the header and library files. When you have finished development (on a non-cluster node) you can transfer the completed data service to a cluster for running and testing.

Note – Be certain you are using a development version of Solaris 5.8 or higher.

Use the procedures in this section to:

- Install the Sun Cluster development package (`SUNWscdev`) and set the appropriate compiler and linker options

- Transfer the data service to a cluster

▼ Setting Up the Development Environment

This procedure describes how to install the `SUNWscdev` package and set the compiler and linker options for data service development.

1. **Become superuser or assume an equivalent role and change directory to the CD-ROM directory that you want.**

   ```
   # cd CD-ROM_directory
   ```

2. **Install the SUNWscdev package in the current directory.**

   ```
   # pkgadd -d . SUNWscdev
   ```

3. **In the `Makefile`, specify compiler and linker options that identify the include and library files for your data service code.**

   Specify the `-I` option to identify the Sun Cluster header files, the `-L` option to specify the compile-time library search path on the development system, and the `-R` option to specify the library search path to the runtime linker on the cluster.

   ```
   # Makefile for sample data service
   ...

   -I /usr/cluster/include

   -L /usr/cluster/lib

   -R /usr/cluster/lib
   ...
   ```

Transferring a Data Service to a Cluster

When you have completed development of a data service on a development machine, you must transfer it to a cluster for testing. To reduce the chance of error, the best way to accomplish this transfer is to package together the data service code and the RTR file and then install the package on all nodes of the cluster.

Note – Whether you use `pkgadd` or some other way to install the data service, you must put the data service on all cluster nodes. Agent Builder automatically packages together the RTR file and data service code.

Setting Resource and Resource Type Properties

Sun Cluster provides a set of resource type properties and resource properties that you use to define the static configuration of a data service. Resource type properties specify the type of the resource, its version, the version of the API, and so on, as well as paths to each of the callback methods. Table A–1 lists all the resource type properties.

Resource properties, such as `Failover_mode`, `Thorough_probe_interval`, and method timeouts, also define the static configuration of the resource. Dynamic resource properties such as `Resource_state` and `Status` reflect the active state of a managed resource. Table A–2 describes the resource properties.

You declare the resource type and resource properties in the resource type registration (RTR) file, which is an essential component of a data service. The RTR file defines the initial configuration of the data service at the time the cluster administrator registers the data service with Sun Cluster.

It is recommended that you use Agent Builder to generate the RTR file for your data service because Agent Builder declares the set of properties that are both useful and required for any data service. For example certain properties (such as `Resource_type`) must be declared in the RTR file or registration of the data service fails. Other properties, though not required, will not be available to a system administrator unless you declare them in the RTR file, while some properties are available whether you declare them or not, because the RGM defines them and provides a default value. To avoid this level of complexity, you can simply use Agent Builder to guarantee generation of a proper RTR file. Later on you can edit the RTR file to change specific values if you need to do so.

The rest of this section leads you through a sample RTR file, created by Agent Builder.

Declaring Resource Type Properties

The cluster administrator cannot configure the resource type properties you declare in the RTR file. They become part of the permanent configuration of the resource type.

Note – One resource type property, `Installed_nodes`, is configurable by a system administrator. In fact, it is only configurable by a system administrator and you cannot declare it in the RTR file.

The syntax for resource type declarations is:

property_name = *value*;

Note – The RGM treats property names as case insensitive. The convention for properties in Sun-supplied RTR files, with the exception of method names, is uppercase for the first letter of the name and lowercase for the rest of the name. Method names—as well as property attributes—contain all uppercase letters.

Following are the resource type declarations in the RTR file for a sample (`smpl`) data service:

```
# Sun Cluster Data Services Builder template version 1.0
# Registration information and resources for smpl
#
#NOTE: Keywords are case insensitive, i.e., you can use
#any capitalization style you prefer.
#
Resource_type = "smpl";
Vendor_id = SUNW;
RT_description = "Sample Service on Sun Cluster";

RT_version ="1.0";
API_version = 2;
Failover = TRUE;

Init_nodes = RG_PRIMARIES;

RT_basedir=/opt/SUNWsmpl/bin;

Start           =    smpl_svc_start;
Stop            =    smpl_svc_stop;

Validate        =    smpl_validate;
Update          =    smpl_update;

Monitor_start   =    smpl_monitor_start;
Monitor_stop    =    smpl_monitor_stop;
Monitor_check   =    smpl_monitor_check;
```

Tip – You must declare the `Resource_type` property as the first entry in the RTR file. Otherwise, registration of the resource type will fail.

The first set of resource type declarations provide basic information about the resource type, as follows:

`Resource_type` and `Vendor_id`	Provide a name for the resource type. You can specify the resource type name with the `Resource_type` property alone (`smpl`) or using the `Vendor_id` as a prefix with a “.”

separating it from the resource type (SUNW.smpl), as in the sample. If you use Vendor_id, make it the stock symbol for the company defining the resource type. The resource type name must be unique in the cluster.

Note – By convention, the resource type name (*Resource_typeVendor_id*) is used as the package name. Package names are limited to nine characters, so it is a good idea to limit the total number of characters in these two properties to nine or fewer characters, though the RGM does not enforce this limit. Agent Builder, on the other hand, explicitly generates the package name from the resource type name, so it does enforce the nine character limit.

Rt_version	Identifies the version of the sample data service.
API_version	Identifies the version of the API. For example, API_version = 2, indicates that the data service runs under Sun Cluster, version 3.0.
Failover = TRUE	Indicates that the data service cannot run in a resource group that can be online on multiple nodes at once, that is, specifies a failover data service. See "Transferring a Data Service to a Cluster" on page 29 for more information.
Start, Stop, Validate, and so on	Provide the paths to the respective callback method programs called by the RGM. These paths are relative to the directory specified by RT_basedir.

The remaining resource type declarations provide configuration information, as follows:

Init_nodes = RG_PRIMARIES	Specifies that the RGM call the Init, Boot, Fini, and Validate methods only on nodes that can master the data service. The nodes specified by RG_PRIMARIES is a subset of all nodes on which the data service is installed. Set the value to RT_INSTALLED_NODES to

	specify that the RGM call these methods all nodes on which the data service is installed.
`RT_basedir`	Points to `/opt/SUNWsample/bin` as the directory path to complete relative paths, such as callback method paths.
`Start`, `Stop`, `Validate`, and so on	Provide the paths to the respective callback method programs called by the RGM. These paths are relative to the directory specified by `RT_basedir`.

Declaring Resource Properties

As with resource type properties, you declare resource properties in the RTR file. By convention, resource property declarations follow the resource type declarations in the RTR file. The syntax for resource declarations is a set of attribute value pairs enclosed by curly brackets:

```
{
    Attribute = Value;
    Attribute = Value;
                .
                .
                .
    Attribute = Value;
}
```

For resource properties provided by Sun Cluster, so-called *system-defined* properties, you can change specific attributes in the RTR file. For example, Sun Cluster provides method timeout properties for each of the callback methods, and specifies default values. In the RTR file, you can specify different default values.

You can also define new resource properties in the RTR file, so-called *extension* properties, using a set of property attributes provided by Sun Cluster. Table A–4 lists the attributes for changing and defining resource properties. Extension property declarations follow the system-defined property declarations in the RTR file.

The first set of system-defined resource properties specifies timeout values for the callback methods:

```
...

# Resource property declarations appear as a list of bracketed
# entries after the resource-type declarations. The property
# name declaration must be the first attribute after the open
# curly bracket of a resource property entry.
#
# Set minimum and default for method timeouts.
{
```

```
                PROPERTY = Start_timeout;
                MIN=60;
                DEFAULT=300;
        }

        {
                PROPERTY = Stop_timeout;
                MIN=60;
                DEFAULT=300;
        }
        {
                PROPERTY = Validate_timeout;
                MIN=60;
                DEFAULT=300;
        }
        {
                PROPERTY = Update_timeout;
                MIN=60;
                DEFAULT=300;
        }
        {
                PROPERTY = Monitor_Start_timeout;
                MIN=60;
                DEFAULT=300;
        }
        {
                PROPERTY = Monitor_Stop_timeout;
                MIN=60;
                DEFAULT=300;
        {
                PROPERTY = Monitor_Check_timeout;
                MIN=60;
                DEFAULT=300;
        }
```

The name of the property (`PROPERTY` = *value*) must be the first attribute for each resource-property declaration. You can configure resource properties, within limits defined by the property attributes in the RTR file. For example, the default value for each method timeout in the sample is 300 seconds. An administrator can change this value; however, the minimum allowable value, specified by the `MIN` attribute, is 60 seconds. See Table A–4 for a complete list of resource property attributes.

The next set of resource properties defines properties that have specific uses in the data service.

```
{
        PROPERTY = Failover_mode;
        DEFAULT=SOFT;
        TUNABLE = ANYTIME;
}
{
        PROPERTY = Thorough_Probe_Interval;
        MIN=1;
        MAX=3600;
        DEFAULT=60;
        TUNABLE = ANYTIME;
}

# The number of retries to be done within a certain period before concluding
# that the application cannot be successfully started on this node.
{
        PROPERTY = Retry_Count;
        MAX=10;
        DEFAULT=2;
        TUNABLE = ANYTIME;
}

# Set Retry_Interval as a multiple of 60 since it is converted from seconds
# to minutes, rounding up. For example, a value of 50 (seconds)
# is converted to 1 minute. Use this property to time the number of
# retries (Retry_Count).
{
        PROPERTY = Retry_Interval;
        MAX=3600;
        DEFAULT=300;
        TUNABLE = ANYTIME;
}

{
        PROPERTY = Network_resources_used;
        TUNABLE = WHEN_DISABLED;
        DEFAULT = "";
}
{
        PROPERTY = Scalable;
        DEFAULT = FALSE;
        TUNABLE = AT_CREATION;
}
{
        PROPERTY = Load_balancing_policy;
        DEFAULT = LB_WEIGHTED;
        TUNABLE = AT_CREATION;
}
{
        PROPERTY = Load_balancing_weights;
        DEFAULT = "";
        TUNABLE = ANYTIME;
}
{
        PROPERTY = Port_list;
        TUNABLE = AT_CREATION;
        DEFAULT = ;
}
```

These resource-property declarations add the `TUNABLE` attribute, which limits the occasions on which the system administrator can change their values. `AT_CREATION` means the administrator can only specify the value when the resource is created and cannot change it later.

For most of these properties you can accept the default values as generated by Agent Builder unless you have a reason to change them. Information about these properties follows (for additional information, see "Resource Properties" on page 235 or the `r_properties`(5) man page):

`Failover_mode`
: Indicates whether the RGM should relocate the resource group or abort the node in the case of a failure of a `Start` or `Stop` method.

`Thorough_probe_interval`, `Retry_count`, `Retry_interval`
: Used in the fault monitor. `Tunable` equals `Anytime`, so a system administrator can adjust them if the fault monitor is not functioning optimally.

`Network_resources_used`
: A list of logical hostname or shared address resources used by the data service. Agent Builder declares this property so a system administrator can specify a list of resources, if there are any, when configuring the data service.

`Scalable`
: Set to `FALSE` to indicate this resource does not use the cluster networking (shared address) facility. This setting is consistent with the resource type `Failover` property set to `TRUE` to indicate a failover service. See "Transferring a Data Service to a Cluster" on page 29 and "Implementing Callback Methods" on page 38 for additional information about how to use this property.

`Load_balancing_policy`, `Load_balancing_weights`
: Automatically declares these properties, however, they have no use in a failover resource type.

`Port_list`
: Identifies the list of ports on which the server is listening. Agent Builder declares this property so a system administrator can specify a list of ports, when configuring the data service.

Declaring Extension Properties

At the end of the sample RTR file are extension properties, as shown in the following listing

```
# Extension Properties
#

# The cluster administrator must set the value of this property to point to the
# directory that contains the configuration files used by the application.
# For this application, smpl, specify the path of the configuration file on
# PXFS (typically named.conf).
{
        PROPERTY = Confdir_list;
        EXTENSION;
        STRINGARRAY;
        TUNABLE = AT_CREATION;
        DESCRIPTION = "The Configuration Directory Path(s)";
}

# The following two properties control restart of the fault monitor.
{
        PROPERTY = Monitor_retry_count;
        EXTENSION;
        INT;
        DEFAULT = 4;
        TUNABLE = ANYTIME;
        DESCRIPTION = "Number of PMF restarts allowed for fault monitor.";
}
{
        PROPERTY = Monitor_retry_interval;
        EXTENSION;
        INT;
        DEFAULT = 2;
        TUNABLE = ANYTIME;
        DESCRIPTION = "Time window (minutes) for fault monitor restarts.";
}
# Time out value in seconds for the probe.
{
        PROPERTY = Probe_timeout;
        EXTENSION;
        INT;
        DEFAULT = 120;
        TUNABLE = ANYTIME;
        DESCRIPTION = "Time out value for the probe (seconds)";
}

# Child process monitoring level for PMF (-C option of pmfadm).
# Default of -1 means to not use the -C option of pmfadm.
# A value of 0 or greater indicates the desired level of child-process.
# monitoring.
{
        PROPERTY = Child_mon_level;
        EXTENSION;
        INT;
        DEFAULT = -1;
        TUNABLE = ANYTIME;
        DESCRIPTION = "Child monitoring level for PMF";
}
# User added code -- BEGIN VVVVVVVVVVVV
# User added code -- END   ^^^^^^^^^^^^
```

Agent Builder creates some extension properties that are useful for most data services, as follows.

`Confdir_list`
: Specifies the path to the application configuration directory, which is useful information for many applications. The system administrator can provide the location of this directory when configuring the data service.

`Monitor_retry_count`, `Monitor_retry_interval`, `Probe_timeout`
: Control restarts of the fault monitor itself, not of the server daemon.

`Child_mon_level`
: Sets the level of monitoring to be done by PMF. See `pmfadm`(1M) for more information.

You can create additional extension properties in the area delimited by the *User added code* comments.

Implementing Callback Methods

This section provides some information that pertains to implementing the callback methods in general.

Accessing Resource and Resource Group Property Information

Generally, callback methods require access to the properties of the resource. The RMAPI provides both shell commands and C functions that you can use in callback methods to access the system-defined and extension properties of resources. See the `scha_resource_get`(1HA) and `scha_resource_get`(3HA) man pages.

The DSDL provides a set of C functions (one for each property) to access system-defined properties, and a function to access extension properties. See the `scds_property_functions`(3HA) and `scds_get_ext_property`(3HA) man pages.

You cannot use the property mechanism to store dynamic state information for a data service because no API functions are available for setting resource properties (other than for setting `Status` and `Status_msg`). Rather, you should store dynamic state information in global files.

Note – The cluster administrator can set certain resource properties using the `scrgadm` command or through an available graphical administrative command or through an available graphical administrative interface. However, do not call `scrgadm` from any callback method because `scrgadm` fails during cluster reconfiguration, that is, when the RGM calls the method.

Idempotency for Methods

In general, the RGM does not call a method more than once in succession on the same resource with the same arguments. However, if a `Start` method fails, the RGM could call a `Stop` method on a resource even though the resource was never started. Likewise, a resource daemon could die of its own accord and the RGM might still invoke its `Stop` method on it. The same scenarios apply to the `Monitor_start` and `Monitor_stop` methods.

For these reasons, you must build idempotency into your `Stop` and `Monitor_stop` methods. Repeated calls of `Stop` or `Monitor_stop` on the same resource with the same parameters achieve the same results as a single call.

One implication of idempotency is that `Stop` and `Monitor_stop` must return 0 (success) even if the resource or monitor is already stopped and no work is to done.

Note – The `Init`, `Fini`, `Boot`, and `Update` methods must also be idempotent. A `Start` method need not be idempotent.

Generic Data Service

A generic data service (GDS) is a mechanism for making simple applications highly available or scalable by plugging them into the Sun Cluster's Resource Group Manager framework. This mechanism does not require the coding of an agent which is the typical approach for making an application highly available or scalable.

The GDS model relies on a precompiled resource type, SUNW.gds, to interact with the RGM framework

See Chapter 10 for additional information.

Controlling an Application

Callback methods enable the RGM to take control of the underlying resource (application) whenever nodes are in the process of joining or leaving the cluster.

Starting and Stopping a Resource

A resource type implementation requires, at a minimum, a `Start` method and a `Stop` method. The RGM calls a resource type's method programs at appropriate times and on the appropriate nodes for bringing resource groups offline and online. For example, after the crash of a cluster node, the RGM moves any resource groups mastered by that node onto a new node. You must implement a `Start` method to provide the RGM with a way of restarting each resource on the surviving host node.

A `Start` method must not return until the resource has been started and is available on the local node. Be certain that resource types requiring a long initialization period have sufficiently long timeouts set on their `Start` methods (set default and minimum values for the `Start_timeout` property in the resource type registration file).

You must implement a `Stop` method for situations in which the RGM takes a resource group offline. For example, suppose a resource group is taken offline on Node1 and back online on Node2. While taking the resource group offline, the RGM calls the `Stop` method on resources in the group to stop all activity on Node1. After the `Stop` methods for all resources have completed on Node1, the RGM brings the resource group back online on Node2.

A `Stop` method must not return until the resource has completely stopped all its activity on the local node and has completely shut down. The safest implementation of a `Stop` method would terminate all processes on the local node related to the resource. Resource types requiring a long time to shut down should have sufficiently long timeouts set on their `Stop` methods. Set the `Stop_timeout` property in the resource type registration file.

Failure or timeout of a `Stop` method causes the resource group to enter an error state that requires operator intervention. To avoid this state, the `Stop` and `Monitor_stop` method implementations should attempt to recover from all possible error conditions. Ideally, these methods should exit with 0 (success) error status, having successfully stopped all activity of the resource and its monitor on the local node.

Deciding Which `Start` and `Stop` Methods to Use

This section provides some tips about when to use the `Start` and `Stop` methods versus using the `Prenet_start` and `Postnet_stop` methods. You must have in-depth knowledge of both the client and the data service's client-server networking protocol to decide the methods that are correct to use.

Services that use network address resources might require that start or stop steps be done in a particular order that is relative to the logical hostname address configuration. The optional callback methods `Prenet_start` and `Postnet_stop` allow a resource type implementation to do special start-up and shutdown actions before and after network addresses in the same resource group are configured up or configured down.

The RGM calls methods that plumb (but do not configure up) the network addresses before calling the data service's `Prenet_start` method. The RGM calls methods that unplumb the network addresses after calling the data service's `Postnet_stop` methods. The sequence is as follows when the RGM takes a resource group online.

1. Plumb network addresses.
2. Call data service's `Prenet_start` method (if any).
3. Configure network addresses up.
4. Call data service's `Start` method (if any).

The reverse happens when the RGM takes a resource group offline:

1. Call data service's `Stop` method (if any).
2. Configure network addresses down.
3. Call data service's `Postnet_stop` method (if any).
4. Unplumb network addresses.

When deciding whether to use the `Start`, `Stop`, `Prenet_start`, or `Postnet_stop` methods, first consider the server side. When bringing online a resource group containing both data service application resources and network address resources, the RGM calls methods to configure up the network addresses before it calls the data service resource `Start` methods. Therefore, if a data service requires network addresses to be configured up at the time it starts, use the `Start` method to start the data service.

Likewise, when bringing offline a resource group that contains both data service resources and network address resources, the RGM calls methods to configure down the network addresses after it calls the data service resource `Stop` methods. Therefore, if a data service requires network addresses to be configured up at the time it stops, use the `Stop` method to stop the data service.

For example, to start or stop a data service, you might have to invoke the data service's administrative utilities or libraries. Sometimes, the data service has administrative utilities or libraries that use a client-server networking interface to perform the administration. That is, an administrative utility makes a call to the server daemon, so the network address might need to be up to use the administrative utility or library. Use the `Start` and `Stop` methods in this scenario.

If the data service requires that the network addresses be configured down at the time it starts and stops, use the `Prenet_start` and `Postnet_stop` methods to start and stop the data service. Consider whether your client software will respond differently depending on whether the network address or the data service comes online first after a cluster reconfiguration (either `scha_control()` with the `SCHA_GIVEOVER` argument or a switchover with `scswitch`). For example, the client implementation might do minimal retries, giving up soon after determining that the data service port is not available.

If the data service does not require the network address to be configured up when it starts, start it before the network interface is configured up. This ensures that the data service is able to respond immediately to client requests as soon as the network address has been configured up, and clients are less likely to stop retrying. In this scenario, use the `Prenet_start` method rather than the `Start` method to start the data service.

If you use the `Postnet_stop` method, the data service resource is still up at the point the network address is configured to be down. Only after the network address is configured down is the `Postnet_stop` method invoked. As a result, the data service's TCP or UDP service port, or its RPC program number, always appears to be available to clients on the network, except when the network address also is not responding.

The decision to use the `Start` and `Stop` methods versus the `Prenet_start` and `Postnet_stop` methods, or to use both, must take the requirements and behavior of both the server and client into account.

`Init`, `Fini`, and `Boot` Methods

Three optional methods, `Init`, `Fini`, and `Boot` enable the RGM to execute initialization and termination code on a resource. The RGM invokes the `Init` method to perform a one-time initialization of the resource when the resource becomes managed—either when the resource group it is in is switched from an unmanaged to a managed state, or when it is created in a resource group that is already managed.

The RGM invokes the `Fini` method to clean up after the resource when the resource becomes unmanaged—either when the resource group it is in is switched to an unmanaged state or when it is deleted from a managed resource group. The clean up must be idempotent, that is, if the clean up has already been done, `Fini` exits 0 (success).

The RGM invokes the `Boot` method on nodes that have newly joined the cluster, that is, have been booted or rebooted.

The `Boot` method normally performs the same initialization as `Init`. This initialization must be idempotent, that is, if the resource has already been initialized on the local node, `Boot` and `Init` exit 0 (success).

Monitoring a Resource

Typically, you implement monitors to run periodic fault probes on resources to detect whether the probed resources are functioning correctly. If a fault probe fails, the monitor can attempt to restart locally or request failover of the affected resource group by calling the `scha_control()` RMAPI function or the `scds_fm_action()` DSDL function.

You can also monitor the performance of a resource and tune or report performance. Writing a resource type-specific fault monitor is completely optional. Even if you choose not to write such a fault monitor, the resource type benefits from the basic monitoring of the cluster that Sun Cluster itself does. Sun Cluster detects failures of the host hardware, gross failures of the host's operating system, and failures of a host to be able to communicate on its public networks.

Although the RGM does not call a resource monitor directly, it does provide for automatically starting monitors for resources. When bringing a resource offline, the RGM calls the `Monitor_stop` method to stop the resource's monitor on the local nodes before stopping the resource itself. When bringing a resource online, the RGM calls the `Monitor_start` method after the resource itself has been started.

The `scha_control()` RMAPI function and the `scds_fm_action()` DSDL function (which calls `scha_control()`) allow resource monitors to request the failover of a resource group to a different node. As one of its sanity checks, `scha_control()` calls `Monitor_check` (if defined), to determine if the requested node is reliable enough to master the resource group containing the resource. If `Monitor_check` reports back that the node is not reliable, or the method times out, the RGM looks for a different node to honor the failover request. If `Monitor_check` fails on all nodes, the failover is canceled.

The resource monitor can set the `Status` and `Status_msg` properties to reflect the monitor's view of the resource state. Use the RMAPI `scha_resource_setstatus()` function or `scha_resource_setstatus` command, or the DSDL `scds_fm_action()` function to set these properties.

Note – Although `Status` and `Status_msg` are of particular use to a resource monitor, any program can set these properties.

See "Defining a Fault Monitor" on page 98 for an example of a fault monitor implemented with the RMAPI. See "`SUNW.xfnts` Fault Monitor" on page 142 for an example of a fault monitor implemented with the DSDL. See the *Sun Cluster 3.1 Data Service Planning and Administration Guide* for information about fault monitors that are built into data services that are supplied by Sun.

Adding Message Logging to a Resource

If you want to record status messages in the same log file as other cluster messages, use the convenience function `scha_cluster_getlogfacility()` to retrieve the facility number being used to log cluster messages.

Use this facility number with the regular Solaris `syslog()` function to write messages to the cluster log. You can also access the cluster log facility information through the generic `scha_cluster_get()` interface.

Providing Process Management

The RMAPI and the DSDL provide process management facilities to implement resource monitors and resource control callbacks. The RMAPI defines the following facilities (see the man pages for details about each of these commands and programs):

Process Monitor Facility: `pmfadm` and `rpc.pmfd`
: The Process Monitor Facility (PMF), provides a means of monitoring processes and their descendants, and restarting processes if they die. The facility consists of the `pmfadm` command for starting and controlling monitored processes, and the `rpc.pmfd` daemon.

`halockrun`
: A program for running a child program while holding a file lock. This command is convenient for use in shell scripts.

`hatimerun`
: A program for running a child program under time-out control. This is a convenience command for use in shell scripts.

The DSDL provides the `scds_hatimerun` function to implement the `hatimerun` functionality.

The DSDL provides a set of functions (`scds_pmf_*`) to implement the PMF functionality. See "PMF Functions" on page 196 for an overview of the DSDL PMF functionality and for a list of the individual functions.

Providing Administrative Support for a Resource

Administrative actions on resources include setting and changing resource properties. The API defines the `Validate` and `Update` callback methods so you can hook into these administrative actions.

The RGM calls the optional `Validate` method when a resource is created and when administrative action updates the properties of the resource or its containing group. The RGM passes the property values for the resource and its resource group to the `Validate` method. The RGM calls `Validate` on the set of cluster nodes indicated by the `Init_nodes` property of the resource's type (see "Resource Type Properties" on page 229, or the `rt_properties`(5) man page, for information about `Init_nodes`. The RGM calls `Validate` before the creation or update is applied, and a failure exit code from the method on any node causes the creation or update to fail.

The RGM calls `Validate` only when resource or group properties are changed through administrative action, not when the RGM sets properties, or when a monitor sets the resource properties `Status` and `Status_msg`.

The RGM calls the optional `Update` method to notify a running resource that properties have been changed. The RGM invokes `Update` after an administrative action succeeds in setting properties of a resource or its group. The RGM calls this method on nodes where the resource is online. This method can use the API access functions to read property values that might affect an active resource and adjust the running resource accordingly.

Implementing a Failover Resource

A failover resource group contains network addresses such as the built in resource types logical hostname and shared address, and failover resources such as the data service application resources for a failover data service. The network address resources, along with their dependent data service resources move between cluster nodes when data services fail over or are switched over. The RGM provides a number of properties that support implementation of a failover resource.

Set the boolean resource type property `Failover` to `TRUE`, to restrict the resource from being configured in a resource group that can be online on more than one node at a time. This property defaults to `FALSE`, so you must declare it as `TRUE` in the RTR file for a failover resource.

The `Scalable` resource property determines if the resource uses the cluster shared-address facility. For a failover resource, set `Scalable` to `FALSE` because a failover resource does not use shared addresses.

The `RG_mode` resource group property allows the cluster administrator to identify a resource group as failover or scalable. If `RG_mode` is `FAILOVER`, the RGM sets the `Maximum_primaries` property of the group to 1 and restricts the resource group to being mastered by a single node. The RGM does not allow a resource whose `Failover` property is `TRUE` to be created in a resource group whose `RG_mode` is `SCALABLE`.

The `Implicit_network_dependencies` resource group property specifies that the RGM should enforce implicit strong dependencies of non-network-address resources on all network-address resources (logical hostname and shared address) within the group. This means that the non-network address (data service) resources in the group will not have their `Start` methods called until the network addresses in the group are configured up. The `Implicit_network_dependencies` property defaults to `TRUE`.

Implementing a Scalable Resource

A scalable resource can be online on more than one node simultaneously. Scalable resources include data services such as Sun Cluster HA for Sun One Web Server and HA-Apache.

The RGM provides a number of properties that support implementation of a scalable resource.

Set the boolean resource type property, `Failover`, to `FALSE`, to allow the resource to be configured in a resource group that can be online on more than one node at a time.

The `Scalable` resource property determines if the resource uses the cluster shared-address facility. Set this property to `TRUE` because a scalable service uses a shared-address resource to make the multiple instances of the scalable service appear as a single service to the client.

The `RG_mode` property enables the cluster administrator to identify a resource group as failover or scalable. If `RG_mode` is `SCALABLE`, the RGM allows `Maximum_primaries` to have a value greater than 1, meaning the group can be mastered by multiple nodes simultaneously. The RGM allows a resource whose `Failover` property is `FALSE` to be instantiated in a resource group whose `RG_mode` is `SCALABLE`.

The cluster administrator creates a scalable resource group to contain scalable service resources, and a separate failover resource group to contain the shared-address resources upon which the scalable resource depends.

The cluster administrator uses the `RG_dependencies` resource group property to specify the order in which resource groups are brought online and offline on a node. This ordering is important for a scalable service because the scalable resources and the shared address resources upon which they depend are in different resource groups. A scalable data service requires that its network address (shared address) resources be configured up before it is started. Therefore, the administrator must set the `RG_dependencies` property (of the resource group containing the scalable service) to include the resource group containing the shared address resources.

When you declare the Scalable property in the RTR file for a resource, the RGM automatically creates the following set of scalable properties for the resource:

`Network_resources_used`	Identifies the shared address resources used by this resource. This property defaults to the empty string so the cluster administrator must provide the actual list of shared addresses the scalable service uses when creating the resource. The `scsetup` command and SunPlex Manager provide features to automatically set up the necessary resources and groups for scalable services.
`Load_balancing_policy`	Specifies the load balancing policy for the resource. You can explicitly set the policy in the RTR file (or allow the default, LB_WEIGHTED). In either case, the cluster administrator can change the value when creating the resource (unless you set `Tunable` for `Load_balancing_policy` to `NONE` or `FALSE` in the RTR file). Legal values are:

`LB_WEIGHTED`	The load is distributed among various nodes according to the weights set in the `Load_balancing_weights` property.
`LB_STICKY`	A given client (identified by the client IP address) of the scalable service, is always sent to the same node of the cluster.
`LB_STICKY_WILD`	A given client (identified by the client's IP address), that connects to an IP address of a wildcard sticky service, is always sent to the same cluster node regardless of the port number it is coming to.

	For a scalable service with `Load_balancing_policy` `LB_STICKY` or `LB_STICKY_WILD`, changing `Load_balancing_weights` while the service is online can cause existing client affinities to be reset. In that case, a different node might service a subsequent client request even if the client had been previously serviced by another node in the cluster. Similarly, starting a new instance of the service on a cluster, might reset existing client affinities.
`Load_balancing_weights`	Specifies the load to be sent to each node. The format is *weight@node,weight@node*, where *weight* is an integer reflecting the relative portion of load distributed to the specified *node*. The fraction of load distributed to a node is the weight for this node divided by the sum of all weights of active instances. For example, `1@1,3@2` specifies that node 1 receives 1/4 of the load and node 2 receives 3/4.
`Port_list`	Identifies the ports on which the server is listening. This property defaults to the empty string. You can provide a list of ports in the RTR file. Otherwise, the cluster administrator must provide the actual list of ports when creating the resource.

You can create a data service that can be configured by the administrator to be either scalable or failover. To do so, declare both the `Failover` resource type property and the `Scalable` resource property as `FALSE` in the data service's RTR file. Specify the `Scalable` property to be tunable at creation.

The `Failover` property value (`FALSE`) allows the resource to be configured into a scalable resource group. The administrator can enable shared addresses by changing the value of `Scalable` to `TRUE` when creating the resource, and thusly create a scalable service.

On the other hand, even though `Failover` is set to `FALSE`, the administrator can configure the resource into a failover resource group to implement a failover service. The administrator does not change the value of `Scalable`, which is `FALSE`. To support this contingency, you should provide a check in the `Validate` method on the `Scalable` property. If `Scalable` is `FALSE`, verify that the resource is configured into a failover resource group.

The *Sun Cluster 3.1 10/03 Concepts Guide* contains additional information about scalable resources.

Validation Checks for Scalable Services

Whenever a resource is created or updated with the scalable property set to `TRUE`, the RGM validates various resource properties. If the properties are not configured correctly, the RGM rejects the attempted update or creation. The RGM performs the following checks:

- The `Network_resources_used` property must be non-empty and contain the names of existing shared address resources. Every node in the `Nodelist` of the resource group containing the scalable resource must appear in either the `NetIfList` property or `AuxNodeList` property of each of the named shared address resources.
- The RG_dependencies property of the resource group that contains the scalable resource must include the resource groups of all shared address resources listed in the scalable resource's `Network_resources_used` property.
- The Port_list property must be non-empty and contain a list of port-protocol pairs such that protocol is either tcp or udp. For example,

  ```
  Port_list=80/tcp,40/udp
  ```

Writing and Testing Data Services

This section provides some information about writing and testing data services.

Using Keep-Alives

On the server side, using TCP keep-alives protects the server from wasting system resources for a down (or network-partitioned) client. If these resources are not cleaned up (in a server that stays up long enough), eventually the wasted resources grow without bound as clients crash and reboot.

If the client-server communication uses a TCP stream, then both the client and the server should enable the TCP keep-alive mechanism. This provision applies even in the non-HA, single-server case.

Other connection-oriented protocols might also have a keep-alive mechanism.

On the client side, using TCP keep-alives enables the client to be notified when a network address resource has failed over or switched over from one physical host to another. That transfer of the network address resource breaks the TCP connection. However, unless the client has enabled the keep-alive, it does not necessarily learn of the connection break if the connection happens to be quiescent at the time.

For example, suppose the client is waiting for a response from the server to a long-running request, and the client's request message has already arrived at the server and has been acknowledged at the TCP layer. In this situation, the client's TCP module has no need to keep retransmitting the request, and the client application is blocked, waiting for a response to the request.

Where possible, in addition to using the TCP keep-alive mechanism, the client application also must perform its own periodic keep-alive at its level, because the TCP keep-alive mechanism is not perfect in all possible boundary cases. Using an application-level keep-alive typically requires that the client-server protocol supports a null operation or at least an efficient read-only operation such as a status operation.

Testing HA Data Services

This section provides suggestions about how to test a data service implementation in the HA environment. The test cases are suggestions and are not exhaustive. You need access to a test-bed Sun Cluster configuration so the testing work does not impact production machines.

Test that your HA data service behaves properly in all cases where a resource group is moved between physical hosts. These cases include system crashes and the use of the `scswitch` command. Test that client machines continue to get service after these events.

Test the idempotency of the methods. For example, replace each method temporarily with a short shell script that calls the original method two or more times.

Coordinating Dependencies Between Resources

Sometimes one client-server data service makes requests on another client-server data service while fulfilling a request for a client. Informally, a data service A depends on a data service B if, for A to provide its service, B must provide its service. Sun Cluster provides for this requirement by permitting resource dependencies to be configured within a resource group. The dependencies affect the order in which Sun Cluster starts and stops data services. See the `scrgadm`(1M) man page for details.

If resources of your resource type depend on resources of another type, you need to instruct the user to configure the resources and resource groups appropriately, or provide scripts or tools to correctly configure them. If the dependent resource must run on the same node as the depended-on resource, then both resources must be configured in the same resource group.

Decide whether to use explicit resource dependencies, or to omit them and poll for the availability of the other data service(s) in your HA data service's own code. In the case that the dependent and depended-on resource can run on different nodes, configure them into separate resource groups. In this case, polling is required because it is not possible to configure resource dependencies across groups.

Some data services store no data directly themselves, but instead depend on another back-end data service to store all their data. Such a data service translates all read and update requests into calls on the back-end data service. For example, consider a hypothetical client-server appointment calendar service that keeps all of its data in an SQL database such as Oracle. The appointment calendar service has its own client-server network protocol. For example, it might have defined its protocol using an RPC specification language, such as ONC RPC.

In the Sun Cluster environment, you can use HA-ORACLE to make the back-end Oracle database highly available. Then you can write simple methods for starting and stopping the appointment calendar daemon. Your end user registers the appointment calendar resource type with Sun Cluster.

If the appointment calendar application must run on the same node as the Oracle database, then the end user configures the appointment calendar resource in the same resource group as the HA-ORACLE resource, and makes the appointment calendar resource dependent on the HA-ORACLE resource. This dependency is specified using the `Resource_dependencies` property tag in `scrgadm`.

If the HA-ORACLE resource is able to run on a different node than the appointment calendar resource, the end user configures them into two separate resource groups. The end user might configure a resource group dependency of the calendar resource group on the Oracle resource group. However resource group dependencies are only effective when both resource groups are being started or stopped on the same node at the same time. Therefore, the calendar data service daemon, after it has been started, might poll waiting for the Oracle database to become available. The calendar resource type's `Start` method usually would just return success in this case, because if the `Start` method blocked indefinitely it would put its resource group into a busy state, which would prevent any further state changes (such as edits, failovers, or switchovers) on the group. However, if the calendar resource's `Start` method timed-out or exited non-zero, it might cause the resource group to ping-pong between two or more nodes while the Oracle database remained unavailable.

CHAPTER 3

Upgrading a Resource Type

This chapter discusses the issues that you need to understand to upgrade a resource type and migrate a resource.

Overview

System administrators require the ability to install and register a new version of an existing resource type, to allow the registration of multiple versions of a given resource type, and to migrate an existing resource to a new version of the resource type without having to delete and recreate the resource. Resource developers need to understand the requirements for providing resource type upgrade and resource migration.

Resource types developed with upgrade in mind are called *upgrade aware*.

A new version of a resource type can differ from a previous version in several ways:

- Attributes of resource type properties may change

- The set of declared resource properties, including standard and extension properties, may change
- Attributes of resource properties, such as `default`, `min`, `max`, `arraymin`, `arraymax` or tunability may change
- The set of declared methods may differ
- The implementation of methods or monitors may change.

The resource type developer decides when an existing resource can be migrated to a new version from among the following tunability options. The options are listed from least restrictive to most restrictive:

- Any time (`Anytime`)
- When the resource is unmonitored (`When_unmonitored`)
- When the resource is offline (`When_offline`)
- When the resource is disabled (`When_disabled`)
- When the resource group is unmanaged (`When_unmanaged`)
- At creation (`At_creation`)

See "Resource `Type_version` Property" on page 56 for an explanation of each option.

Note – Throughout this chapter, the `scrgadm` command is used when discussing how to do an upgrade. The administrator is not restricted to using the `scrgadm` command but can also use the GUI or the `scsetup` command to do the upgrade.

Resource Type Registration File

Resource Type Name

The three components of the resource type name are properties specified in the RTR file as *Vendor_id*, *Resource_type*, and *RT_version*. The `scrgadm` command inserts the period and the colon delimiters to create the name of the resource type:

```
vendor_id.resource_type:rt_version
```

The *Vendor_id* prefix serves to distinguish between two registration files of the same name provided by different vendors. The *RT_version* distinguishes between multiple registered versions (upgrades) of the same base resource type. To ensure that the *Vendor_id* is unique, the recommended approach is to use the stock symbol for the company creating the resource type.

Registration of the resource type will fail if the *RT_version* string includes a blank, tab, slash (/), backslash (\), asterisk (*), question mark (?), comma (,), semicolon (;), left square bracket ([), or right square bracket (]) character.

The `RT_Version` property, which was optional in Sun Cluster 3.0, is mandatory starting in Sun Cluster 3.1.

The fully qualified name is the name returned by the following command:

```
scha_resource_get -O Type -R resource_name -G resource_group_name
```

Resource type names registered prior to Sun Cluster 3.1 continue to use the form:

```
vendor_id.resource_type
```

Directives

RTR files for upgrade aware resource types must include a `#$upgrade` directive, followed by zero or more directives of the form:

```
#$upgrade_from version tunability
```

The `upgrade_from` directive consists of the string `#$upgrade_from`, followed by the `RT_Version`, followed by the tunability constraint on the resource. If the resource type from which the upgrade is being performed does not have a version, the `RT_Version` is specified as the empty string, as shown in the last example below:

```
#$upgrade_from   "1.1"   when_offline
#$upgrade_from   "1.2"   when_offline
#$upgrade_from   "1.3"   when_offline
#$upgrade_from   "2.0"   when_unmonitored
#$upgrade_from   "2.1"   anytime
#$upgrade_from   ""      when_unmanaged
```

The RGM enforces these constraints on a resource when the system administrator attempts to change the resource `Type_version`. If the current version of the resource type does not appear in the list, the RGM imposes the tunability of `When_unmanaged`.

These directives must appear between the resource type property declarations section of the RTR file and the resource declarations section of the RTR file. See `rt_reg`(4).

Changing the `RT_Version` in an RTR file

Change the `RT_Version` string in an RTR file whenever the contents of the RTR file changes. The value of this property must make it obvious which is the newer version of the resource type and which is the older. There is no need to change the `RT_Version` string if there are no changes to the RTR file.

Resource Type Names in Earlier Versions of Sun Cluster

Resource type names in Sun Cluster 3.0 did not contain the version suffix:

```
vendor_id.resource_name
```

A resource type that was originally registered under Sun Cluster 3.0 continues to have a name of this form even after you upgrade the clustering software to Sun Cluster 3.1. Similarly, a resource type whose RTR file is missing the `#$upgrade` directive is given a Sun Cluster 3.0 format name, without the version suffix, if the RTR file is registered on a cluster running Sun Cluster 3.1 software.

You can register RTR files with the `#$upgrade` or `#$upgrade_from` directive in Sun Cluster 3.0, but, migrating existing resources to new resource types in Sun Cluster 3.0 is not supported.

Resource `Type_version` Property

The standard resource property `Type_version` stores the `RT_Version` property of a resource's type. This property does not appear in the RTR file. The system administrator edits this property value by using the following command:

```
scrgadm -c -j resource -y Type_version=new_version
```

This property's tunability is derived from:

- The current version of the resource type
- The `#$upgrade_from` directives in the RTR file

Use the following tunability values in the `#$upgrade_from` directives:

`Anytime`
: If there are no restrictions on when the resource can be upgraded. The resource can be fully online.

`When_unmonitored`
: If the new resource type version's `Update`, `Stop`, `Monitor_check`, and `Postnet_stop` methods are known to be compatible with older resource type version's starting methods (`Prenet_stop` and `Start`), and if the new resource type version's `Fini` method is known to be compatible with the `Init` method of older versions. This scenario requires only that the resource monitor program be stopped before the upgrade

`When_offline`
: If the new resource type version's `Update`, `Stop`, `Monitor_check`, or `Postnet_stop` methods are known not to be compatible with older resource type

version's starting methods (`Prenet_stop` and `Start`) but are known to be compatible with the `Init` method of older versions, the resource must be offline when the type upgrade is applied to it.

`When_disabled`
Similar to `When_offline`. However, this tunability value imposes the stronger condition that the resource be disabled.

`When_unmanaged`
If the new resource type version's `Fini` method is not compatible with the `Init` method of older versions. This tunability value requires the existing resource group to be switched to the unmanaged state before you can upgrade the resource.

`At_creation`
If resources cannot be upgraded to the new resource type version. Only new resources of the new version can be created.

The tunability of `At_creation` means that the resource type developer can prohibit the migration of an existing resource to the new type. In this case, the system administrator must delete and recreate the resource. This is equivalent to declaring that the resource's version can only be set at creation time.

Migrating a Resource to a Different Version

An existing resource takes on the new resource type version when the system administrator edits the `Type_version` property of the resource. This follows the same conventions that are used to edit other resource properties, except that some information will be derived or taken from the new resource type version instead of the current version:

- Resource property attributes for all properties such as `min`, `max`, `arraymin`, `arraymax`, default, and tunability are taken from the new resource type version
- The tunability applicable to the `Type_version` property is taken from the `#$upgrade_from` directives in the RTR file and the `RT_version` property of the resource type of the existing resource. This tunability is unlike the tunability described in `property_attributes`(5).
- The `Validate` method for the new resource type version will be applied. This ensures that the property attributes are valid for the new resource type. If the existing resource property attributes do not satisfy the validation conditions of the new resource type version, the system administrator has to provide valid values for such properties on the `scrgadm` command line. This can occur if the newer resource type version starts to use a property that was not declared in the earlier version and which does not have a default. It might also occur if the existing

resource already has a property which was assigned a value that is invalid for the newer resource type version.

- Resource properties that were declared in an older version of the resource type can be undeclared in the newer version. When the resource is migrated to the newer version, the property will be deleted from the resource.

Note – The `Validate` method can query the current `Type_version` of the resource (using `scha_resource_get`) as well as the new `Type_version` (which is passed on the `Validate` command line). Therefore, `Validate` can rule out upgrades from unsupported versions.

Upgrading and Downgrading a Resource Type

The section "Upgrading a Resource Type" in *Sun Cluster 3.1 Data Service Planning and Administration Guide* contains additional information about upgrading or migrating a resource type.

▼ How to Upgrade a Resource Type

1. **Read the upgrade documentation for the new resource type to find out the resource type changes and resource tunability constraints.**

2. **Install the resource type upgrade package on all cluster nodes.**

   The recommended practice for installing new resource type packages is in a rolling upgrade fashion: the `pkgadd` occurs while the node is booted in non-cluster mode.

   There are scenarios in which it would be possible to install new resource type packages on a node in cluster mode:

   - If resource type package installation leaves the method code unchanged and only updates the monitor, then it is necessary to stop monitoring on all resources of that type during the installation.
   - If resource type package installation leaves both the method and monitor code unchanged then it is not necessary to stop monitoring on the resource during the installation, because the installation is only putting a new RTR file on the disk.

3. **Register the new resource type version using the `scrgadm` (or equivalent) command, referencing the RTR file of the upgrade.**

The RGM creates a new resource type whose name is of the form

```
vendor_id.resource_type:version
```

4. **If the resource type upgrade is installed on only a subset of the nodes, you must set the `Installed_nodes` property of the new resource type to the nodes on which it is actually installed.**

   When a resource takes on the new type (either by being newly created or updated), the RGM requires that the resource group `nodelist` be a subset of the `Installed_nodes` list of the resource type.

   ```
   scrgadm -c -t resource_type -h installed_node_list
   ```

5. **For each resource of the preupgraded type that is to be migrated to the upgraded type, invoke `scswitch` to change the state of the resource or its resource group to the appropriate state as dictated by the upgrade documentation.**

6. **For each resource of the preupgraded type that is to be migrated to the upgraded type, edit the resource, changing its `Type_version` property to the new version.**

   ```
   scrgadm -c -j resource -y Type_version=new_version
   ```

   If necessary, edit other properties of the same resource to appropriate values in the same command.

7. **Restore the previous state of the resource or resource group by reversing the command invoked in Step 5.**

▼ How to Downgrade a Resource to an Older Version of Its Resource Type

You can downgrade a resource to an older version of its resource type. The conditions under which you can downgrade a resource to an older version of the resource type are more restrictive than when you upgrade to a newer version of the resource type. You must first unmanage the resource group. In addition, you can only downgrade a resource to an upgrade-enabled version of the resource type. You can identify upgrade-enabled versions by using the `scrgadm -p` command. In the output, upgrade-enabled versions contain the suffix `:`*version*.

1. **Switch the resource group that contains the resource you want to downgrade offline.**

   ```
   scswitch -F -g resource_group
   ```

2. **Disable the resource that you want to downgrade and all resources in the resource group.**

   ```
   scswitch -n -j resource_to_downgrade
   scswitch -n -j resource1
   scswitch -n -j resource2
   ```

```
scswitch -n -j resource3
...
```

Note – Disable resources in order of dependency, starting with the most dependent (application resources) and ending with the least dependent (network address resources).

---

3. **Unmanage the resource group.**

   ```
   scswitch -u -g resource_group
   ```

4. **Is the old version of the resource type to which you want to downgrade still registered in the cluster?**

   - If yes, go to the next step.
   - If no, re-register the old version that you want.

     ```
     scrgadm -a -t resource_type_name
     ```

5. **Downgrade the resource by specifying the old version that you want for `Type_version`.**

   ```
   scrgadm -c -j resource_to_downgrade -y Type_version=old_version
   ```

   If necessary, edit other properties of the same resource to appropriate values in the same command.

6. **Bring the resource group that contains the resource that you downgraded to a managed state, enable all the resources, and switch the group online.**

   ```
   scswitch -Z -g resource_group
   ```

Default Property Values

The RGM stores all resources such that any property that was not explicitly set by the system administrator (and which was defaulted) is not stored in the resource entry in the CCR (cluster configuration repository). The RGM obtains the default value of a missing resource property from the resource type (or if not defined there, using a system-defined default) when a resource is read in from the CCR. It is this method of storing properties that permits an upgraded resource type to define new properties or new default values for existing properties.

When resource properties are edited, the RGM stores in the CCR the properties that were specified in the edit command.

If an upgraded version of the resource type declares a new default value for a defaulted property, the new default value is inherited by existing resources, even if the property is declared tunable only `At_creation` or `When_disabled`. If the application of the new default would cause a method such as `Stop` or `Postnet_stop` or `Fini` to fail, the resource type implementor must accordingly restrict the state of the resource at the time that it is upgraded. This is done by limiting the tunability of the `Type_version` property.

The new resource type version `Validate` method can check to make sure that existing property attributes are appropriate. If they are not, the system administrator can edit the properties of an existing resource to appropriate values in the same command that edits the `Type_version` property to upgrade the resource to the new resource type version.

Note – Resources that were created in Sun Cluster 3.0 do not inherit new default property attributes from the resource type when they are migrated to a later version because their default properties are stored in the CCR.

Resource Type Developer Documentation

The resource type developer must provide documentation with the new resource that provides the following information:

- Describe any property additions, changes, or deletions
- Describe how to make the properties conform to the new requirements
- State the tunability constraints on resources
- Call out any new default property attributes
- Inform the system administrator that existing resource properties are editable to appropriate values using the same command used to edit the `Type_version` property to upgrade the resource to the new resource type version

Resource Type Name and Resource Type Monitor Implementations

You can register an upgrade aware resource type in Sun Cluster 3.0, but its name is recorded in the CCR without the version suffix. To run correctly in both Sun Cluster 3.0 and Sun Cluster 3.1, the monitor for this resource type must be able to handle both naming conventions:

```
vendor_id.resource_name:version
vendor_id.resource_name
```

The monitor code can determine the proper name to use by running the equivalent of:

```
scha_resourcetype_get -O RT_VERSION -T VEND.myrt
scha_resourcetype_get -O RT_VERSION -T VEND.myrt:vers
```

Then compare the output values with `vers`. Only one of these commands will succeed for a particular value of `vers`, because it is not possible to register the same version of the resource type twice under two different names.

Application Upgrades

The upgrading of application code is unlike the upgrading of agent code, although some of the issues are similar. An application upgrade might or might not be accompanied by a resource type upgrade.

Resource Type Upgrade Examples

These examples illustrate several different resource type installation and upgrade scenarios. Tunability and packaging information have been chosen based on the types of changes made to the resource type implementation. Tunability applies to the migration of the resource to the new resource type.

All examples assume that:

- The resource type is delivered in a Solaris-style package. See `pkgadd`(1M) and `pkgrm`(1M).
- There is only one previous version of the resource type and, therefore, only one `#$upgrade_from` directive in the new RTR file

- The installation procedure will not remove or overwrite the methods if it is possible that the RGM could call the methods while they are removed from the disk
- New methods are compatible with old methods unless otherwise stated
- Resources and resource groups are moved to the required state before installation or migration using the correct `scswitch`(1M) command or equivalent. The following example shows how to move the resource group to an unmanaged state:

  ```
  scswitch -M -n -j resource
  scswitch -n -j resource
  scswitch -F -g resource_group
  scswitch -u -g resource_group
  ```
- You register a resource type by using this command:

  ```
  scrgadm -a -t resource_type -f path_to_RTR_file
  ```
- You migrate a resource by using this command:

  ```
  scrgadm -c -j resource -y Type_version=version \
             -y property=value \
             -x property=value ...
  ```
- Resources and resource groups are restored to their previous state after migration using the appropriate `scswitch`(1M) command or equivalent:

  ```
  scswitch -M -e -j resource
  scswitch -e -j resource
  scswitch -o -g resource_group
  scswitch -Z -g resource_group
  ```

The resource type developer might need to specify more restrictive tunability values than the ones used in these examples. The tunability values depend on the exact changes made to the resource type implementation. Also, the resource type developer might choose to use a different packaging scheme in place of the Solaris-style packaging used in these examples.

TABLE 3–1 Examples of Upgrading a Resource Type

Type of change	Tunability	Packaging	Procedure
Property changes are only made in the RTR file.	`Anytime`	Only deliver new RTR file.	Do a `pkgadd` of the new RTR file on all nodes. Register the new resource type. Migrate the resource.

TABLE 3–1 Examples of Upgrading a Resource Type *(Continued)*

Type of change	Tunability	Packaging	Procedure
Methods are updated.	`Anytime`	Place the updated methods in a distinct path from the old methods.	Do a `pkgadd` of the updated methods on all nodes. Register the new resource type. Migrate the resource.
New monitor program.	`When_unmonitored`	Only overwrite the previous version of the monitor.	Disable monitoring. Do a `pkgadd` of the new monitor program on all nodes. Register the new resource type. Migrate the resource. Enable monitoring.
Methods are updated. The new `Update/Stop` methods are incompatible with the old `Start` methods.	`When_offline`	Place the updated methods in a distinct path from the old methods.	Do a `pkgadd` of the updated methods on all nodes. Register the new resource type. Take the resource offline. Migrate the resource. Bring the resource online.
Methods are updated and new properties are added to the RTR file. The new methods require new properties. (The goal is to allow the containing resource group to remain online but to prevent the resource from coming online should the resource group move from the offline state to the online state on a node.)	`When_disabled`	Overwrite the previous versions of the methods.	Disable the resource. For each node: ■ Take the node out of the cluster ■ Do a `pkgrm/pkgadd` of the methods being updated ■ Restore the node to the cluster Register the new resource type. Migrate the resource. Enable the resource.

TABLE 3–1 Examples of Upgrading a Resource Type *(Continued)*

Type of change	Tunability	Packaging	Procedure
Methods are updated and new properties are added to the RTR file. New methods do not require new properties.	`Anytime`	Overwrite the previous versions of the methods.	For each node: ■ Take the node out of the cluster ■ Do a `pkgrm/pkgadd` of the methods being updated ■ Restore the node to the cluster During this procedure, the RGM will call the new methods even though migration (which would configure the new properties) has not yet been performed. It is important that the new methods be able to work without the new properties. Register the new resource type. Migrate the resource.
Methods are updated. The new `Fini` method is incompatible with the old `Init` method.	`When_unmanaged`	Place the updated methods in a distinct path from the old methods.	Make the containing resource group unmanaged. Do a `pkgadd` of the updated methods on all nodes. Register the resource type. Migrate the resource. Make the containing resource group managed.
Methods are updated. No changes are made to the RTR file.	Not applicable. No changes are made to RTR file	Overwrite the previous versions of the methods.	For each node: ■ Take the node out of the cluster ■ Do a `pkgadd` of the updated methods ■ Restore the node to the cluster. Because there were no changes to the RTR file, the resource does not need to be registered or migrated.

Installation Requirements for Resource Type Packages

There are two requirements related to the installation of the new resource type packages:

- When a new resource type is registered, its RTR file must be accessible on disk
- When a resource of the new type is created, all of the declared method pathnames and the monitor program for the new type must be on disk and executable. The old method and monitor programs must remain in place as long as the resource is in use.

  To decide on the most appropriate packaging, the resource type implementor must consider the following:

  - Does the RTR file change?
  - Does the default value or tunability of a property change?
  - Does the `min` or `max` value of a property change?
  - Does the upgrade add or delete properties?
  - Does the method code change?
  - Does the monitor code change?
  - Are the new methods or monitor code compatible with the previous version?

Information That You Need to Know Before Changing the RTR File

Some resource type upgrades do not involve new method or monitor code. For example, a resource type upgrade might only change the default value or tunability of a resource property. Since the method code is not changing, the only requirement for installing the upgrade is to have a valid pathname to a readable RTR file.

If there is no need to reregister the old resource type, the new RTR file can overwrite the previous version. Otherwise the new RTR file can be placed in a new pathname.

If the upgrade changes the default value or tunability of a property, the `Validate` method for the new version can verify at migration time that the existing property attributes are valid for the new resource type. If the upgrade changes the `min`, `max`, or `type` attributes of a property, the `scrgadm` command automatically validates these constraints at migration time.

The upgrade documentation must call out any new default property attributes. The documentation must inform the system administrator that existing resource properties are editable to appropriate values using the same command that edits the `Type_version` property to upgrade the resource to the new resource type version.

If the upgrade adds or deletes properties, it is likely that some callback methods or monitor code also must be changed.

Changing Monitor Code

If the monitor code is the only change in the updated resource type, then the package installation can overwrite the monitor binaries. The documentation must instruct the system administrator to suspend monitoring before installing the new package.

Changing Method Code

If the method code is the only change in the updated resource type, it is important to determine whether the new method code is compatible with the previous version. This determines whether the new method code must be stored in a new pathname or whether the old methods can be overwritten.

If the new `Stop`, `Postnet_stop` and `Fini` methods (if declared) can be applied to resources that were initialized or started by the old versions of the `Start`, `Prenet_stop`, or `Init` methods, then it is possible to overwrite the old methods with the new methods.

If the new method code is not compatible with the previous version, then it is necessary to stop or unconfigure a resource using the old versions of the methods before it can be migrated to the upgraded resource type. If the new methods overwrite the old ones, it can require shutting down (and possibly unmanaging) all resources of the type before doing the resource type upgrade. If the new methods are stored separately from the old (and both are accessible at once), then even without backward compatibility it is possible to install the new resource type version and upgrade the resources one by one.

Even if the new methods are backward compatible, it might be a requirement to upgrade one resource at a time to use the new methods, while other resources continue to use the old methods. It still is necessary to store the new methods in a separate directory rather than overwriting the old ones.

An advantage to storing each resource type version's methods in a separate directory is that it makes it easy to switch resources back to the older resource type version if a problem arises with the newer version.

One packaging approach is to include all of the earlier versions that are still supported in the package. This permits the new package version to replace the older version, without overwriting or deleting the old method paths. It is up to the resource type developer to decide how many previous versions to support.

Note – It is not recommended to overwrite methods or `pkgrm/pkgadd` methods on a node that is currently in the cluster. If the RGM were to call a method when the method is not accessible on disk, unexpected results can occur. Removing or replacing the binary of a running method might also cause unexpected results.

CHAPTER 4

Resource Management API Reference

This chapter provides a reference to the access functions and callback methods that make up the Resource Management API (RMAPI). It lists and briefly describes each function and method. However, the definitive reference for these functions and methods is the RMAPI man pages.

The information in this chapter includes:

- "RMAPI Access Methods" on page 70 – in the form of shell script commands and C functions
  - `scha_resource_get`(1HA), `scha_resource_close`(3HA), `scha_resource_get`(3HA), `scha_resource_open`(3HA)
  - `scha_resource_setstatus`(1HA), `scha_resource_setstatus`(3HA)
  - `scha_resourcetype_get`(1HA), `scha_resourcetype_close`(3HA), `scha_resourcetype_get`(3HA), `scha_resourcetype_open`(3HA)
  - `scha_resourcegroup_get`(1HA), `scha_resourcegroup_get`(3HA), `scha_resourcegroup_close`(3HA), `scha_resourcegroup_open`(3HA)
  - `scha_control`(1HA), `scha_control`(3HA)
  - `scha_cluster_get`(1HA), `scha_cluster_close`(3HA), `scha_cluster_get`(3HA), `scha_cluster_open`(3HA)
  - `scha_cluster_getlogfacility`(3HA)
  - `scha_cluster_getnodename`(3HA)
  - `scha_strerror`(3HA)
- "RMAPI Callback Methods" on page 75 – described in the `rt_callbacks`(1HA) man page.
  - `Start`
  - `Stop`
  - `Init`
  - `Fini`
  - `Boot`

- `Prenet_start`
- `Postnet_stop`
- `Monitor_start`
- `Monitor_stop`
- `Monitor_check`
- `Update`
- `ValidateS`

RMAPI Access Methods

The API provides functions to access resource, resource type, and resource group properties, and other cluster information. These functions are provided both in the form of shell commands and C functions, enabling resource type providers to implement control programs as shell scripts or as C programs.

RMAPI Shell Commands

Shell commands are to be used in shell script implementations of the callback methods for resource types representing services controlled by the cluster's RGM. You can use these commands to:

- Access information about resources, resource types, resource groups, and clusters
- Use with a monitor to set the `Status` and `Status_msg` properties of a resource
- Request the restart or relocation of a resource group

Note – Although this section provides brief descriptions of the shell commands, the individual man pages in the section 1HA provide the definitive reference for the shell commands. Each command has a man page of the same name unless otherwise noted.

RMAPI Resource Commands

You can access information about a resource or set the `Status` and `Status_msg` properties of a resource with these commands.

`scha_resource_get`
Accesses information about a resource or resource type under the control of the RGM. It provides the same information as the `scha_resource_get()` function.

`scha_resource_setstatus`
Sets the `Status` and `Status_msg` properties of a resource under the control of the RGM. It is used by the resource's monitor to indicate the resource's state as

perceived by the monitor. It provides the same functionality as the `scha_resource_setstatus()` C function.

Note – Although `scha_resource_setstatus()` is of particular use to a resource monitor, any program can call it.

Resource Type Command

This command accesses information about a resource type registered with the RGM.

`scha_resourcetype_get`
This command provides the same functionality as the `scha_resourcetype_get()` C function.

Resource Group Commands

You can access information about or restart a resource group with these commands.

`scha_resourcegroup_get`
Accesses information about a resource group under the control of the RGM. This command provides the same functionality as the `scha_resourcetype_get()` C function.

`scha_control`
Requests the restart of a resource group under the control of the RGM or its relocation to a different node. This command provides the same functionality as the `scha_control()` C function.

Cluster Command

This command accesses information about a cluster, such as node names, IDs, and states, the cluster name, resource groups, and so on.

`scha_cluster_get`
This command provides the same information as the `scha_cluster_get()` C function.

C Functions

C functions are to be used in C program implementations of the callback methods for resource types representing services controlled by the cluster's RGM. You can use these functions to do the following:

- Access information about resources, resource types, resource groups, and clusters

- Use with a monitor to set the `Status` and `Status_msg` properties of a resource
- Request the restart or relocation of a resource group
- Convert an error code to an appropriate error message

Note – Although this section provides brief descriptions of the C functions, the individual `(3HA)` man pages provide the definitive reference for the C functions. Each function has a man page of the same name unless otherwise noted. See the `scha_calls`(3HA) man page for information on the output arguments and return codes of the C functions.

Resource Functions

These functions access information about a resource managed by the RGM or indicate the state of the resource as perceived by the monitor.

`scha_resource_open()`, `scha_resource_get()`, and `scha_resource_close()`

Together these functions access information on a resource managed by the RGM. The `scha_resource_open()` function initializes access to a resource and returns a handle for `scha_resource_get()`, which accesses the resource information. The `scha_resource_close()` function invalidates the handle and frees memory allocated for `scha_resource_get()` return values.

A resource can change, through cluster reconfiguration or administrative action, after `scha_resource_open()` returns the resource's handle, in which case the information `scha_resource_get()` obtains through the handle could be inaccurate. In cases of cluster reconfiguration or administrative action on a resource, the RGM returns the `scha_err_seqid` error code to `scha_resource_get()` to indicate information about the resource might have changed. This is a non-fatal error message; the function returns successfully. You can choose to ignore the message and accept the returned information, or you can close the current handle and open a new handle to access information about the resource.

A single man page describes these three functions. You can access this man page through any of the individual functions, `scha_resource_open`(3HA), `scha_resource_get`(3HA), or `scha_resource_close`(3HA).

`scha_resource_setstatus()`

Sets the `Status` and `Status_msg` properties of a resource under the control of the RGM. The resource's monitor uses this function to indicate the resource's state.

Note – Although `scha_resource_setstatus()` is of particular use to a resource monitor, any program can call it.

Resource Type Functions

Together these functions access information about a resource type registered with the RGM.

`scha_resourcetype_open()`, `scha_resourcetype_get()`, `scha_resourcetype_close()`

The `scha_resourcetype_open()` function initializes access to a resource and returns a handle for `scha_resourcetype_get()`, which accesses the resource type information. The `scha_resourcetype_close()` function invalidates the handle and frees memory allocated for `scha_resourcetype_get()` return values.

A resource type can change, through cluster reconfiguration or administrative action, after `scha_resourcetype_open()` returns the resource type's handle, in which case the information `scha_resourcetype_get()` obtains through the handle could be inaccurate. In cases of cluster reconfiguration or administrative action on a resource type, the RGM returns the `scha_err_seqid` error code to `scha_resourcetype_get()` to indicate information about the resource type might have changed. This is a non-fatal error message; the function returns successfully. You can choose to ignore the message and accept the returned information, or you can close the current handle and open a new handle to access information about the resource type.

A single man page describes these three functions. You can access this man page through any of the individual functions, `scha_resourcetype_open`(3HA), `scha_resourcetype_get`(3HA), or `scha_resourcetype_close`(3HA).

Resource Group Functions

You can access information about or restart a resource group with these functions.

`scha_resourcegroup_open`(3HA), `scha_resourcegroup_get`(3HA), and `scha_resourcegroup_close`(3HA)

Together these functions access information on a resource group managed by the RGM. The `scha_resourcegroup_open()` function initializes access to a resource group and returns a handle for `scha_resourcegroup_get()`, which accesses the resource group information. The `scha_resourcegroup_close()` function invalidates the handle and frees memory allocated for `scha_resourcegroup_get()` return values.

A resource group can change, through cluster reconfiguration or administrative action, after `scha_resourcegroup_open()` returns the resource group's handle, in which case the information `scha_resourcegroup_get()` obtains through the handle could be inaccurate. In cases of cluster reconfiguration or administrative action on a resource group, the RGM returns the `scha_err_seqid` error code to `scha_resourcegroup_get()` to indicate information about the resource group might have changed. This is a non-fatal error message; the function returns successfully. You can choose to ignore the message and accept the returned information, or you can close the current handle and open a new handle to access information about the resource group.

`scha_control`(3HA)
: Requests the restart of a resource group under the control of the RGM or its relocation to a different node.

Cluster Functions

These functions access or return information about a cluster.

`scha_cluster_open`(3HA), `scha_cluster_get`(3HA), `scha_cluster_close`(3HA)
: Together these functions access information about a cluster, such as node names, IDs, and states, cluster name, resource groups, and so on.

  A cluster can change—through reconfiguration or administrative action—after `scha_cluster_open()` returns the cluster's handle, in which case the information `scha_cluster_get()` obtains through the handle could be inaccurate. In cases of reconfiguration or administrative action on a cluster, the RGM returns the `scha_err_seqid` error code to `scha_cluster_get()` to indicate information about the cluster might have changed. This is a non-fatal error message; the function returns successfully. You can choose to ignore the message and accept the returned information, or you can close the current handle and open a new handle to access information about the cluster.

`scha_cluster_getlogfacility`(3HA)
: Returns the number of the system log facility being used as the cluster log. Uses the returned value with the Solaris `syslog()` function to record events and status messages to the cluster log.

`scha_cluster_getnodename`(3HA)
: Returns the name of the cluster node on which the function is called.

Utility Function

This function converts an error code to an error message.

`scha_strerror`(3HA)
: Translates an error code—returned by one of the `scha_` functions—to the appropriate error message. Use this function with `logger` to log messages to the system log (`syslog`).

RMAPI Callback Methods

Callback methods are the key elements provided by the API for implementing a resource type. Callback methods enable the RGM to control resources in the cluster in the event of a change in cluster membership, such as a node boot or crash.

Note – The callback methods are executed by the RGM with root permissions because the client programs control HA services on the cluster system. Install and administer these methods with restrictive file ownership and permissions. Specifically, give them a privileged owner, such as `bin` or `root`, and do not make them writable.

This section describes callback method arguments and exit codes and lists and describes callback methods in the following categories:

- Control and initialization methods
- Administrative support methods
- Net-relative methods
- Monitor control methods

Note – Although this section provides brief descriptions of the callback methods, including the point at which the method is invoked and the expected effect on the resource, the `rt_callbacks`(1HA) man page is the definitive reference for the callback methods.

Method Arguments

The RGM invokes callback methods as follows:

method `-R` *resource-name* `-T` *type-name* `-G` *group-name*

The method is the path name of the program that is registered as the `Start`, `Stop`, or other callback. The callback methods of a resource type are declared in its registration file.

All callback method arguments are passed as flagged values, with `-R` indicating the name of the resource instance, `-T` indicating the type of the resource, and `-G` indicating the group into which the resource is configured. Use the arguments with access functions to retrieve information about the resource.

The `Validate` method is called with additional arguments (the property values of the resource and resource group on which it is called).

See `scha_calls`(3HA) for more information.

Exit Codes

All callback methods have the same exit codes defined to specify the effect of the method invocation on the resource state. The `scha_calls`(3HA) man page describes all these exit codes. The exit codes are:

- 0 – Method succeeded
- Any nonzero value – Method failed

The RGM also handles abnormal failures of callback method execution, such as time outs and core dumps.

Method implementations must output failure information using `syslog` on each node. Output written to `stdout` or `stderr` is not guaranteed to be delivered to the user (though it currently is displayed on the console of the local node).

Control and Initialization Callback Methods

The primary control and initialization callback methods start and stop a resource. Other methods execute initialization and termination code on a resource.

`Start`

This required method is invoked on a cluster node when the resource group containing the resource is brought online on that node. This method activates the resource on that node.

A `Start` method should not exit until the resource it activates has been started and is available on the local node. Therefore, before exiting, the `Start` method should poll the resource to determine that it has started. In addition, you should set a sufficiently long time-out value for this method. For example, certain resources, such as database daemons, take more time to start, and thus require that the method have a longer timeout value.

The way in which the RGM responds to failure of the `Start` method depends on the setting of the `Failover_mode` property.

The `START_TIMEOUT` property in the resource type registration file sets the time-out value for a resource's `Start` method.

`Stop`

This required method is invoked on a cluster node when the resource group containing the resource is brought offline on that node. This method deactivates the resource if it is active.

A `Stop` method should not exit until the resource it controls has completely stopped all its activity on the local node and has closed all file descriptors. Otherwise, because the RGM assumes the resource has stopped, when in fact it is still active, data corruption can result. The safest way to avoid data corruption is to terminate all processes on the local node related to the resource.

Before exiting, the `Stop` method should poll the resource to determine that it has stopped. In addition, you should set a sufficiently long time-out value for this method. For example, certain resources, such as database daemons, take more time to stop, and thus require that the method have a longer time-out value.

The way in which the RGM responds to failure of the `Stop` method depends on the setting of the `Failover_mode` property (see Table A–2).

The `STOP_TIMEOUT` property in the resource type registration file sets the time-out value for a resource's `Stop` method.

`Init`
This optional method is invoked to perform a one-time initialization of the resource when the resource becomes managed—either when the resource group it is in is switched from an unmanaged to a managed state, or when the resource is created in a resource group that is already managed. The method is called on nodes determined by the `Init_nodes` resource property.

`Fini`
This optional method is invoked to clean up after the resource when the resource becomes unmanaged—either when the resource group it is in is switched to an unmanaged state or when the resource is deleted from a managed resource group. The method is called on nodes determined by the `Init_nodes` resource property.

`Boot`
This optional method, similar to Init, is invoked to initialize the resource on nodes that join the cluster after the resource group containing the resource has already been put under the management of the RGM. The method is invoked on nodes determined by the `Init_nodes` resource property. The `Boot` method is called when the node joins or rejoins the cluster as the result of being booted or rebooted.

Note – Failure of the `Init`, `Fini`, or `Boot` methods causes the `syslog()` function to generate an error message but does not otherwise affect RGM management of the resource.

Administrative Support Methods

Administrative actions on resources include setting and changing resource properties. The `Validate` and `Update` callback methods enable a resource type implementation to hook into these administrative actions.

`Validate`

This optional method is called when a resource is created and when administrative action updates the properties of the resource or its containing resource group. This method is called on the set of cluster nodes indicated by the Init_nodes property of the resource's type. `Validate` is called before the creation or update is applied, and a failure exit code from the method on any node causes the creation or update to be canceled.

`Validate` is called only when resource or resource group properties are changed through administrative action, not when the RGM sets properties, or when a monitor sets the resource properties `Status` and `Status_msg`.

`Update`

This optional method is called to notify a running resource that properties have been changed. `Update` is invoked after an administration action succeeds in setting properties of a resource or its group. This method is called on nodes where the resource is online. The method uses the API access functions to read property values that might affect an active resource and adjust the running resource accordingly.

Failure of the `Update` method causes the `syslog()` function to generate an error message but does not otherwise affect RGM management of the resource.

Net-Relative Callback Methods

Services that use network address resources might require that start or stop steps be done in a certain order relative to the network address configuration. The following optional callback methods, `Prenet_start` and `Postnet_stop`, enable a resource type implementation to do special startup and shutdown actions before and after a related network address is configured or unconfigured.

`Prenet_start`

This optional method is called to do special startup actions before network addresses in the same resource group are configured.

`Postnet_stop`

This optional method is called to do special shutdown actions after network addresses in the same resource group are configured down.

Monitor Control Callback Methods

A resource type implementation optionally can include a program to monitor the performance of a resource, report on its status, or take action on resource failure. The `Monitor_start`, `Monitor_stop`, and `Monitor_check` methods support the implementation of a resource monitor in a resource type implementation.

`Monitor_start`
: This optional method is called to start a monitor for the resource after the resource is started.

`Monitor_stop`
: This optional method is called to stop a resource's monitor before the resource is stopped.

`Monitor_check`
: This optional method is called to assess the reliability of a node before a resource group is relocated to the node. The `Monitor_check` method must be implemented so that it does not conflict with the concurrent running of another method.

CHAPTER 5

Sample Data Service

This chapter describes a sample Sun Cluster data service, HA-DNS, for the `in.named` application. The `in.named` daemon is the Solaris implementation of the Domain Name Service (DNS). The sample data service demonstrates how to make an application highly available, using the Resource Management API.

The Resource Management API supports a shell script interface and a C program interface. The sample application in this chapter is written using the shell script interface.

The information in this chapter includes:

Overview of the Sample Data Service

The sample data service starts, stops, restarts and switches the DNS application among the nodes of the cluster in response to cluster events such as administrative action, application failure, or node failure.

Application restart is managed by the Process Monitor Facility (PMF). If application deaths exceed the failure count within the failure time window, the fault monitor fails the resource group containing the application resource over to another node.

The sample data service provides fault monitoring in the form of a `PROBE` method. that uses the `nslookup` command to ensure that the application is healthy. If the probe detects a hung DNS service, it tries to correct the situation by restarting the DNS application locally. If this does not improve the situation and the probe repeatedly detects problems with the service, then the probe attempts to fail over the service to another node in the cluster.

Specifically, the sample data service includes:

- A resource type registration file that defines the static properties of the data service.
- A `Start` callback method invoked by the RGM to start the `in.named` daemon when the resource group containing the HA-DNS data service is brought online.
- A `Stop` callback method invoked by the RGM to stop the `in.named` daemon when the resource group containing HA-DNS goes offline.
- A fault monitor to check the availability of the service by verifying that the DNS server is running. The fault monitor is implemented by a user-defined `PROBE` method and started and stopped by `Monitor_start` and `Monitor_stop` callback methods.
- A `Validate` callback method invoked by the RGM to validate that the configuration directory for the service is accessible.
- An `Update` callback method invoked by the RGM to restart the fault monitor when the system administrator changes the value of a resource property.

Defining the Resource Type Registration File

The resource type registration (RTR) file in this example defines the static configuration of the DNS resource type. Resources of this type inherit the properties defined in the RTR file.

The information in the RTR file is read by the RGM when the cluster administrator registers the HA-DNS data service.

RTR File Overview

The RTR file follows a well-defined format. Resource type properties are defined first in the file, system-defined resource properties are defined next, and extension properties are defined last. See the `rt_reg`(4) man page and "Setting Resource and Resource Type Properties" on page 30 for more information.

This section describes the specific properties in the sample RTR file. It provides listings of different parts of the file. For a complete listing of the contents of the sample RTR file, see “Resource Type Registration File Listing” on page 249.

Resource Type Properties in the Sample RTR File

The sample RTR file begins with comments followed by resource type properties that define the HA-DNS configuration, as shown in the following listing.

```
#
# Copyright (c) 1998-2003 by Sun Microsystems, Inc.
# All rights reserved.
#
# Registration information for Domain Name Service (DNS)
#

#pragma ident   “@(#)SUNW.sample   1.1   00/05/24 SMI”

RESOURCE_TYPE = “sample”;
VENDOR_ID = SUNW;
RT_DESCRIPTION = “Domain Name Service on Sun Cluster”;

RT_VERSION =”1.0”;
API_VERSION = 2;
FAILOVER = TRUE;

RT_BASEDIR=/opt/SUNWsample/bin;
PKGLIST = SUNWsample;

START         =   dns_svc_start;
STOP          =   dns_svc_stop;

VALIDATE      =   dns_validate;
UPDATE        =   dns_update;

MONITOR_START =   dns_monitor_start;
MONITOR_STOP  =   dns_monitor_stop;
MONITOR_CHECK =   dns_monitor_check;
```

Tip – You must declare the `Resource_type` property as the first entry in the RTR file. Otherwise, registration of the resource type will fail.

Note – The RGM treats property names as case insensitive. The convention for properties in Sun-supplied RTR files, with the exception of method names, is uppercase for the first letter of the name and lowercase for the rest of the name. Method names—as well as property attributes—contain all uppercase letters.

Some information about these properties follows.

- The resource type name can be specified by the `Resource_type` property alone (`sample`) or using the `Vendor_id` as a prefix with a "." separating it from the resource type (`SUNW.sample`).

  If you use `Vendor_id`, make it the stock symbol for the company defining the resource type. The resource type name must be unique in the cluster.
- The `Rt_version` property identifies the version of the sample data service as specified by the vendor.
- The `API_version` property identifies the Sun Cluster version. For example, `API_version = 2`, indicates that the data service runs under Sun Cluster version 3.0.
- `Failover = TRUE` indicates that the data service cannot run in a resource group that can be online on multiple nodes at once.
- `RT_basedir` points to `/opt/SUNWsample/bin` as the directory path to complete relative paths, such as callback method paths.
- `Start`, `Stop`, `Validate`, and so on provide the paths to the respective callback method programs invoked by the RGM. These paths are relative to the directory specified by `RT_basedir`.
- `Pkglist` identifies `SUNWsample` as the package that contains the sample data service installation.

Resource type properties not specified in this RTR file, such as `Single_instance`, `Init_nodes`, and `Installed_nodes`, get their default value. See Table A–1 for a complete list of the resource type properties, including their default values.

The cluster administrator cannot change the values specified for resource type properties in the RTR file.

Resource Properties in the Sample RTR File

By convention, you declare resource properties following the resource type properties in the RTR file. Resource properties include system-defined properties provided by Sun Cluster and extension properties you define. For either type you can specify a number of property attributes supplied by Sun Cluster, such as minimum, maximum, and default values.

System-Defined Properties in the RTR File

The following listing shows the system-defined properties in the sample RTR file.

```
# A list of bracketed resource property declarations follows the
# resource-type declarations. The property-name declaration must be
# the first attribute after the open curly bracket of each entry.

# The <method>_timeout properties set the value in seconds after which
# the RGM concludes invocation of the method has failed.

# The MIN value for all method timeouts is set to 60 seconds. This
# prevents administrators from setting shorter timeouts, which do not
# improve switchover/failover performance, and can lead to undesired
# RGM actions (false failovers, node reboot, or moving the resource group
# to ERROR_STOP_FAILED state, requiring operator intervention). Setting
# too-short method timeouts leads to a *decrease* in overall availability
# of the data service.
{
   PROPERTY = Start_timeout;
   MIN=60;
   DEFAULT=300;
}

{
   PROPERTY = Stop_timeout;
   MIN=60;
   DEFAULT=300;
}
{
        PROPERTY = Validate_timeout;
        MIN=60;
        DEFAULT=300;
}
{
        PROPERTY = Update_timeout;
        MIN=60;
        DEFAULT=300;
}
{
        PROPERTY = Monitor_Start_timeout;
        MIN=60;
        DEFAULT=300;
}
{
        PROPERTY = Monitor_Stop_timeout;
        MIN=60;
        DEFAULT=300;
}
{
        PROPERTY = Thorough_Probe_Interval;
        MIN=1;
        MAX=3600;
        DEFAULT=60;
        TUNABLE = ANYTIME;
}

# The number of retries to be done within a certain period before concluding
# that the application cannot be successfully started on this node.
{
        PROPERTY = Retry_Count;
        MIN=0;
        MAX=10;
        DEFAULT=2;
        TUNABLE = ANYTIME;
}

# Set Retry_Interval as a multiple of 60 since it is converted from seconds
# to minutes, rounding up. For example, a value of 50 (seconds)
# is converted to 1 minute. Use this property to time the number of
# retries (Retry_Count).
{
        PROPERTY = Retry_Interval;
        MIN=60;
        MAX=3600;
        DEFAULT=300;
        TUNABLE = ANYTIME;
}

{
        PROPERTY = Network_resources_used;
        TUNABLE = AT_CREATION;
        DEFAULT = "";
}
```

Although Sun Cluster provides the system-defined properties, you can set different default values using resource property attributes. See "Resource Property Attributes" on page 248 for a complete list of attributes available for applying to resource properties.

Note the following about the system-defined resource properties in the sample RTR file:

- Sun Cluster provides a minimum value (1 second) and a default value (3600 seconds) for all timeouts. The sample RTR file changes the minimum 60 and changes the default to 300 seconds. A cluster administrator can accept this default value or change the value of the timeout to something else, (60 or greater). Sun Cluster has no maximum allowable value.
- The properties `Thorough_Probe_Interval`, `Retry_count`, and `Retry_interval`, have the `TUNABLE` attribute set to `ANYTIME`. This settings means the cluster administrator can change the value of these properties, even when the data service is running. These properties are used by the fault monitor implemented by the sample data service. The sample data service implements an `Update` method to stop and restart the fault monitor when these or other resource properties are changed by administrative action. See "`Update` Method" on page 111.
- Resource properties are classified as

- *required*—the cluster administrator must specify a value when creating a resource;
- *optional*—if the administrator does not specify a value, the system supplies a default value.
- *conditional*—the RGM creates the property only if it is declared in the RTR file.

The fault monitor of the sample data service makes use of the `Thorough_probe_interval`, `Retry_count`, `Retry_interval`, and `Network_resources_used` conditional properties, so the developer needed to declare them in the RTR file. See the `r_properties`(5) man page or "Resource Properties" on page 235 for information about how properties are classified.

Extension Properties in the RTR File

At the end of the sample RTR file are extension properties, as shown in the following listing

```
# Extension Properties

# The cluster administrator must set the value of this property to point to the
# directory that contains the configuration files used by the application.
# For this application, DNS, specify the path of the DNS configuration file on
# PXFS (typically named.conf).
{
   PROPERTY = Confdir;
   EXTENSION;
   STRING;
   TUNABLE = AT_CREATION;
   DESCRIPTION = "The Configuration Directory Path";
}

# Time out value in seconds before declaring the probe as failed.
{
        PROPERTY = Probe_timeout;
        EXTENSION;
        INT;
        DEFAULT = 120;
        TUNABLE = ANYTIME;
        DESCRIPTION = "Time out value for the probe (seconds)";
}
```

The sample RTR file defines two extension properties, `Confdir` and `Probe_timeout`. `Confdir` specifies the path to the DNS configuration directory. This directory contains the `in.named` file, which DNS requires to operate successfully. The sample data service's `Start` and `Validate` methods use this property to verify that the configuration directory and the `in.named` file are accessible before starting DNS.

When the data service is configured, the `Validate` method verifies that the new directory is accessible.

The sample data services's PROBE method is not a Sun Cluster callback method but a user-defined method. Therefore, Sun Cluster doesn't provide a Probe_timeout property for it. The developer has defined an extension property in the RTR file to allow a cluster administrator to configure a Probe_timeout value.

Providing Common Functionality to All Methods

This section describes the following functionality that is used in all callback methods of the sample data service:

- "Identifying the Command Interpreter and Exporting the Path" on page 88.
- "Declaring the PMF_TAG and SYSLOG_TAG Variables" on page 88.
- "Parsing the Function Arguments" on page 89.
- "Generating Error Messages" on page 91.
- "Obtaining Property Information" on page 91.

Identifying the Command Interpreter and Exporting the Path

The first line of a shell script must identify the command interpreter. Each of the method scripts in the sample data service identifies the command interpreter as follows:

```
#!/bin/ksh
```

All method scripts in the sample application export the path to the Sun Cluster binaries and libraries rather than rely on the user's PATH settings.

```
#######################################################################
# MAIN
#######################################################################

export PATH=/bin:/usr/bin:/usr/cluster/bin:/usr/sbin:/usr/proc/bin:$PATH
```

Declaring the PMF_TAG and SYSLOG_TAG Variables

All the method scripts (with the exception of Validate) use pmfadm to launch (or stop) either the data service or the monitor, passing the name of the resource. Each script defines a variable, PMF_TAG that can be passed to pmfadm to identify either the data service or the monitor.

Likewise each method script uses the `logger` command to log messages with the system log. Each script defines a variable, `SYSLOG_TAG` that can be passed to `logger` with the `-t` option to identify the resource type, resource group, and resource name of the resource for which the message is being logged.

All methods define `SYSLOG_TAG` in the same way, as shown in the following sample. The `dns_probe`, `dns_svc_start`, `dns_svc_stop`, and `dns_monitor_check` methods define `PMF_TAG` as follows (the use of `pmfadm` and `logger` is from the `dns_svc_stop` method):

```
#########################################################################
# MAIN
#########################################################################

PMF_TAG=$RESOURCE_NAME.named

SYSLOG_TAG=$RESOURCETYPE_NAME,$RESOURCEGROUP_NAME,$RESOURCE_NAME

   # Send a SIGTERM signal to the data service and wait for 80% of the
   # total timeout value.
   pmfadm -s $PMF_TAG.named -w $SMOOTH_TIMEOUT TERM
   if [ $? -ne 0 ]; then
      logger -p ${SYSLOG_FACILITY}.info \
          -t [$SYSLOG_TAG] \
          "${ARGV0} Failed to stop HA-DNS with SIGTERM; Retry with \
           SIGKILL"
```

The `dns_monitor_start`, `dns_monitor_stop`, and `dns_update`, methods define `PMF_TAG` as follows (the use of `pmfadm` is from the `dns_monitor_stop` method):

```
#########################################################################
# MAIN
#########################################################################

PMF_TAG=$RESOURCE_NAME.monitor
SYSLOG_TAG=$RESOURCETYPE_NAME,$RESOURCEGROUP_NAME,$RESOURCE_NAME
...

# See if the monitor is running, and if so, kill it.
if pmfadm -q $PMF_TAG.monitor; then
   pmfadm -s $PMF_TAG.monitor KILL
```

Parsing the Function Arguments

The RGM invokes all of the callback methods—with the exception of `Validate`—as follows.

method_name `-R` *resource_name* `-T` *resource_type_name* `-G` *resource_group_name*

The method name is the path name of the program that implements the callback method. A data service specifies the path name for each method in the RTR file. These path names are relative to the directory specified by the `Rt_basedir` property, also in the RTR file. For example, in the sample data service's RTR file, the base directory and method names are specified as follows.

```
RT_BASEDIR=/opt/SUNWsample/bin;
START = dns_svc_start;
STOP =  dns_svc_stop;
...
```

All callback method arguments are passed as flagged values, with `-R` indicating the name of the resource instance, `-T` indicating the type of the resource, and `-G` indicating the group into which the resource is configured. See the `rt_callbacks`(1HA) man page for more information on callback methods.

Note – The `Validate` method is called with additional arguments (the property values of the resource and resource group on which it is called). See "Handling Property Updates" on page 107 for more information.

Each callback method needs a function to parse the arguments it is passed. Because the callbacks are all passed the same arguments, the data service provides a single parse function that is used in all the callbacks in the application.

The following shows the `parse_args()` function used for the callback methods in the sample application.

```
#########################################################################
# Parse program arguments.
#
function parse_args # [args ...]
{
      typeset opt

      while getopts 'R:G:T:' opt
      do
             case "$opt" in
             R)
                  # Name of the DNS resource.
                  RESOURCE_NAME=$OPTARG
                  ;;
             G)
                  # Name of the resource group in which the resource is
                  # configured.
                  RESOURCEGROUP_NAME=$OPTARG
                  ;;
             T)
                  # Name of the resource type.
                  RESOURCETYPE_NAME=$OPTARG
                  ;;
             *)
```

```
                    logger -p ${SYSLOG_FACILITY}.err \
                    -t [$RESOURCETYPE_NAME,$RESOURCEGROUP_NAME,$RESOURCE_NAME] \
                    "ERROR: Option $OPTARG unknown"
                    exit 1
                        ;;
               esac
     done
}
```

Note – Although the PROBE method in the sample application is user defined (not a Sun Cluster callback method), it is called with the same arguments as the callback methods. Therefore, this method contains a parse function identical to the one used by the other callback methods.

The parse function is called in MAIN as:

```
parse_args “$@”
```

Generating Error Messages

It is recommended that callback methods use the syslog facility to output error messages to end users. All callback methods in the sample data service use the scha_cluster_get() function to retrieve the number of the syslog facility used for the cluster log, as follows:

```
SYSLOG_FACILITY=‘scha_cluster_get -O SYSLOG_FACILITY‘
```

The value is stored in a shell variable, SYSLOG_FACILITY and can be used as the facility of the logger command to log messages in the cluster log. For example, the Start method in the sample data service retrieves the syslog facility and logs a message that the data service has been started, as follows:

```
SYSLOG_FACILITY=‘scha_cluster_get -O SYSLOG_FACILITY‘
...

if [ $? -eq 0 ]; then
   logger -p ${SYSLOG_FACILITY}.err \
         -t [$SYSLOG_TAG] \
         "${ARGV0} HA-DNS successfully started"
fi
```

See the scha_cluster_get(1HA) man page for more information.

Obtaining Property Information

Most callback methods need to obtain information about resource and resource type properties of the data service. The API provides the scha_resource_get() function for this purpose.

Two kinds of resource properties, system-defined properties and extension properties, are available. System-defined properties are predefined whereas you define extension properties in the RTR file.

When you use `scha_resource_get()` to obtain the value of a system-defined property, you specify the name of the property with the `-O` parameter. The command returns only the *value* of the property. For example, in the sample data service, the `Monitor_start` method needs to locate the probe program so it can launch it. The probe program resides in the base directory for the data service, which is pointed to by the `RT_BASEDIR` property, so the `Monitor_start` method retrieves the value of `RT_BASEDIR`, and places it in the `RT_BASEDIR` variable, as follows.

```
RT_BASEDIR=‘scha_resource_get -O RT_BASEDIR -R $RESOURCE_NAME -G \
$RESOURCEGROUP_NAME‘
```

For extension properties, you must specify with the `-O` parameter that it is an extension property and supply the name of the property as the last parameter. For extension properties, the command returns both the *type* and *value* of the property. For example, in the sample data service, the probe program retrieves the type and value of the `probe_timeout` extension property, and then uses `awk` to put the value only in the `PROBE_TIMEOUT` shell variable, as follows.

```
probe_timeout_info=‘scha_resource_get -O Extension -R $RESOURCE_NAME \
-G $RESOURCEGROUP_NAME Probe_timeout‘
PROBE_TIMEOUT=‘echo $probe_timeout_info | awk '{print $2}'‘
```

Controlling the Data Service

A data service must provide a `Start` or `Prenet_start` method to activate the application daemon on the cluster, and a `Stop` or `Postnet_stop` method to stop the application daemon on the cluster. The sample data service implements a `Start` and a `Stop` method. See “Deciding Which `Start` and `Stop` Methods to Use” on page 41 for information about when you might want to use `Prenet_start` and `Postnet_stop` instead.

`Start` Method

The RGM invokes the `Start` method on a cluster node when the resource group containing the data service resource is brought online on that node or when the resource group is already online and the resource is enabled. In the sample application, the `Start` method activates the `in.named` (DNS) daemon on that node.

This section describes the major pieces of the `Start` method for the sample application. It does not describe functionality common to all callback methods, such as the `parse_args()` function and obtaining the syslog facility, which are described in "Providing Common Functionality to All Methods" on page 88.

For the complete listing of the `Start` method, see "`Start` Method" on page 252.

`Start` Overview

Before attempting to launch DNS, the `Start` method in the sample data service verifies the configuration directory and configuration file (`named.conf`) are accessible and available. Information in `named.conf` is essential to successful operation of DNS.

This callback method uses the process monitor facility (`pmfadm`) to start the DNS daemon (`in.named`). If DNS crashes or fails to start, the PMF attempts to start it a prescribed number of times during a specified interval. The number of retries and the interval are specified by properties in the data service's RTR file.

Verifying the Configuration

In order to operate, DNS requires information from the `named.conf` file in the configuration directory. Therefore, the `Start` method performs some sanity checks to verify that the directory and file are accessible before attempting to launch DNS.

The `Confdir` extension property provides the path to the configuration directory. The property itself is defined in the RTR file. However, the cluster administrator specifies the actual location when configuring the data service.

In the sample data service, the `Start` method retrieves the location of the configuration directory using the `scha_resource_get()` function.

Note – Because `Confdir` is an extension property, `scha_resource_get()` returns both the type and value. The `awk` command retrieves just the value and places it in a shell variable, `CONFIG_DIR`.

```
# find the value of Confdir set by the cluster administrator at the time of
# adding the resource.
config_info=‘scha_resource_get -O Extension -R $RESOURCE_NAME \
-G $RESOURCEGROUP_NAME Confdir‘

# scha_resource_get returns the "type" as well as the "value" for the
# extension properties. Get only the value of the extension property
CONFIG_DIR=‘echo $config_info | awk '{print $2}'‘
```

The `Start` method then uses the value of `CONFIG_DIR` to verify that the directory is accessible. If it is not accessible, `Start` logs an error message and exits with error status. See "`Start` Exit Status" on page 95.

```
# Check if $CONFIG_DIR is accessible.
if [ ! -d $CONFIG_DIR ]; then
   logger -p ${SYSLOG_FACILITY}.err \
         -t [$SYSLOG_TAG] \
         "${ARGV0} Directory $CONFIG_DIR is missing or not mounted"
   exit 1
fi
```

Before starting the application daemon, this method performs a final check to verify that the `named.conf` file is present. If it is not present, `Start` logs an error message and exits with error status.

```
# Change to the $CONFIG_DIR directory in case there are relative
# pathnames in the data files.
cd $CONFIG_DIR

# Check that the named.conf file is present in the $CONFIG_DIR directory
if [ ! -s named.conf ]; then
   logger -p ${SYSLOG_FACILITY}.err \
         -t [$SYSLOG_TAG] \
         "${ARGV0} File $CONFIG_DIR/named.conf is missing or empty"
   exit 1
fi
```

Starting the Application

This method uses the process manager facility (`pmfadm`) to launch the application. The `pmfadm` command allows you to set the number of times to restart the application during a specified time frame. The RTR file contains two properties, `Retry_count`, which specifies the number of times to attempt restarting an application, and `Retry_interval`, which specifies the time period over which to do so.

The `Start` method retrieves the values of `Retry_count` and `Retry_interval` using the `scha_resource_get()` function and stores their values in shell variables. It then passes these values to `pmfadm` using the `-n` and `-t` options.

```
# Get the value for retry count from the RTR file.
RETRY_CNT=‘scha_resource_get -O Retry_Count -R $RESOURCE_NAME \
-G $RESOURCEGROUP_NAME‘
# Get the value for retry interval from the RTR file. This value is in seconds
# and must be converted to minutes for passing to pmfadm. Note that the
# conversion rounds up; for example, 50 seconds rounds up to 1 minute.
((RETRY_INTRVAL=‘scha_resource_get -O Retry_Interval -R $RESOURCE_NAME \
-G $RESOURCEGROUP_NAME‘ / 60))

# Start the in.named daemon under the control of PMF. Let it crash and restart
# up to $RETRY_COUNT times in a period of $RETRY_INTERVAL; if it crashes
# more often than that, PMF will cease trying to restart it.
# If there is a process already registered under the tag
# <$PMF_TAG>, then PMF sends out an alert message that the
# process is already running.
pmfadm -c $PMF_TAAG -n $RETRY_CNT -t $RETRY_INTRVAL \
    /usr/sbin/in.named -c named.conf

# Log a message indicating that HA-DNS has been started.
if [ $? -eq 0 ]; then
   logger -p ${SYSLOG_FACILITY}.err \
         -t [$SYSLOG_TAG] \
         "${ARGV0} HA-DNS successfully started"
fi
exit 0
```

`Start` Exit Status

A `Start` method should not exit with success until the underlying application is actually running and available, particularly if other data services are dependent on it. One way to verify success is to probe the application to verify it is running before exiting the `Start` method. For a complex application, such as a database, be certain to set the value for the `Start_timeout` property in the RTR file sufficiently high to allow time for the application to initialize and perform crash recovery.

Note – Because the application resource, DNS, in the sample data service launches quickly, the sample data service does not poll to verify it is running before exiting with success.

If this method fails to start DNS and exits with failure status, the RGM checks the `Failover_mode` property, which determines how to react. The sample data service does not explicitly set the `Failover_mode` property, so this property has the default value `NONE` (unless the cluster administrator has overridden the default and specified a different value). In this case, the RGM takes no action other than to set the state of the data service. User intervention is required to restart on the same node or fail over to a different node.

`Stop` Method

The `Stop` method is invoked on a cluster node when the resource group containing the HA-DNS resource is brought offline on that node or if the resource group is online and the resource is disabled. This method stops the `in.named` (DNS) daemon on that node.

This section describes the major pieces of the `Stop` method for the sample application. It does not describe functionality common to all callback methods, such as the `parse_args()` function and obtaining the syslog facility, which are described in "Providing Common Functionality to All Methods" on page 88.

For the complete listing of the `Stop` method, see "`Stop` Method" on page 255.

Stop Overview

There are two primary considerations when attempting to stop the data service. The first is to provide an orderly shutdown. Sending a SIGTERM signal through pmfadm is the best way to accomplish an orderly shutdown.

The second consideration is to ensure that the data service is actually stopped to avoid putting it in Stop_failed state. The best way to accomplish this is to send a SIGKILL signal through pmfadm.

The Stop method in the sample data service takes both these considerations into account. It first sends a SIGTERM signal. If this signal fails to stop the data service, the method sends a SIGKILL signal.

Before attempting to stop DNS, this Stop method verifies that the process is actually running. If the process is running, Stop uses the process monitor facility (pmfadm) to stop it.

This Stop method is guaranteed to be idempotent. Although the RGM should not call a Stop method twice without first starting the data service with a call to its Start method, the could call a Stop method on a resource even though the resource was never started or it died of its own accord. Therefore, this Stop method exits with success even if DNS is not running.

Stopping the Application

The Stop method provides a two-tiered approach to stopping the data service: an orderly or smooth approach using a SIGTERM signal through pmfadm and an abrupt or hard approach using a SIGKILL signal. The Stop method obtains the Stop_timeout value (the amount of time in which the Stop method must return). Stop then allocates 80% of this time to stopping smoothly and 15% to stopping abruptly (5% is reserved), as shown in the following sample.

```
STOP_TIMEOUT=`scha_resource_get -O STOP_TIMEOUT -R $RESOURCE_NAME
\

-G $RESOURCEGROUP_NAMÈ
((SMOOTH_TIMEOUT=$STOP_TIMEOUT * 80/100))

((HARD_TIMEOUT=$STOP_TIMEOUT * 15/100))
```

The Stop method uses pmfadm -q to verify that the DNS daemon is running. If it is, Stop first uses pmfadm -s to send a TERM signal to terminate the DNS process. If this signal fails to terminate the process after 80% of the timeout value has expired Stop sends a SIGKILL signal. If this signal also fails to terminate the process within 15% of the timeout value, the method logs an error message and exits with error status.

If pmfadm terminates the process, the method logs a message that the process has stopped and exits with success.

If the DNS process is not running, the method logs a message that it is not running and exits with success anyway. The following code sample shows how `Stop` uses `pmfadm` to stop the DNS process.

```
# See if in.named is running, and if so, kill it.
if pmfadm -q $PMF_TAG; then
   # Send a SIGTERM signal to the data service and wait for 80% of
the
   # total timeout value.
   pmfadm -s $RESOURCE_NAME.named -w $SMOOTH_TIMEOUT TERM
   if [ $? -ne 0 ]; then
      logger -p ${SYSLOG_FACILITY}.err \
          -t [$RESOURCETYPE_NAME,$RESOURCEGROUP_NAME,$RESOURCE_NAME] \
          "${ARGV0} Failed to stop HA-DNS with SIGTERM; Retry with \
           SIGKILL"

      # Since the data service did not stop with a SIGTERM signal, use
      # SIGKILL now and wait for another 15% of the total timeout value.
      pmfadm -s $PMF_TAG -w $HARD_TIMEOUT KILL
      if [ $? -ne 0 ]; then
          logger -p ${SYSLOG_FACILITY}.err \
          -t [$SYSLOG_TAG]
          "${ARGV0} Failed to stop HA-DNS; Exiting UNSUCCESFUL"

          exit 1
      fi
fi
else
   # The data service is not running as of now. Log a message and
   # exit success.
   logger -p ${SYSLOG_FACILITY}.err \
           -t [$SYSLOG_TAG] \
           "HA-DNS is not started"

   # Even if HA-DNS is not running, exit success to avoid putting
   # the data service resource in STOP_FAILED State.

   exit 0

fi

# Could successfully stop DNS. Log a message and exit success.
logger -p ${SYSLOG_FACILITY}.err \
    -t [$RESOURCETYPE_NAME,$RESOURCEGROUP_NAME,$RESOURCE_NAME]
\
    "HA-DNS successfully stopped"
exit 0
```

`Stop` Exit Status

A `Stop` method should not exit with success until the underlying application is actually stopped, particularly if other data services have dependencies on it. Failure to do so can result in data corruption.

For a complex application, such as a database, be certain to set the value for the `Stop_timeout` property in the RTR file sufficiently high to allow time for the application to clean up while stopping.

If this method fails to stop DNS and exits with failure status, the RGM checks the `Failover_mode` property, which determines how to react. The sample data service does not explicitly set the `Failover_mode` property, so it has the default value `NONE` (unless the cluster administrator has overridden the default and specified a different value). In this case, the RGM takes no action other than to set the state of the data service to `Stop_failed`. User intervention is required to stop the application forcibly and clear the `Stop_failed` state.

Defining a Fault Monitor

The sample application implements a basic fault monitor to monitor the reliability of the DNS resource (`in.named`). The fault monitor consists of:

- `dns_probe`, a user-defined program that uses `nslookup` to verify that the DNS resource controlled by the sample data service is running. If DNS is not running, this method attempts to restart it locally, or depending on the number of restart attempts, requests that the RGM relocate the data service to a different node.
- `dns_monitor_start`, a callback method that launches `dns_probe`. The RGM automatically calls `dns_monitor_start` after the sample data service is brought online if monitoring is enabled.
- `dns_monitor_stop`, a callback method that stops `dns_probe`. The RGM automatically calls `dns_monitor_stop` before bringing the sample data service offline.
- `dns_monitor_check`, a callback method that calls the `Validate` method to verify that the configuration directory is available when the `PROBE` program fails the data service over to a new node.

Probe Program

The `dns_probe` program implements a continuously running process that verifies the DNS resource controlled by the sample data service is running. The `dns_probe` is launched by the `dns_monitor_start` method, which is automatically invoked by the RGM after the sample data service is brought online. The data service is stopped by the `dns_monitor_stop` method, which then RGM invokes before bringing the sample data service offline.

This section describes the major pieces of the PROBE method for the sample application. It does not describe functionality common to all callback methods, such as the parse_args() function and obtaining the syslog facility, which are described in "Providing Common Functionality to All Methods" on page 88.

For the complete listing of the PROBE method, see "PROBE Program" on page 259.

Probe Overview

The probe runs in an infinite loop. It uses nslookup to verify that the proper DNS resource is running. If DNS is running, the probe sleeps for a prescribed interval (set by the Thorough_probe_interval system-defined property) and then checks again. If DNS is not running, this program attempts to restart it locally, or depending on the number of restart attempts, requests that the RGM relocate the data service to a different node.

Obtaining Property Values

This program needs the values of the following properties:

- Thorough_probe_interval – To set the period during which the probe sleeps
- Probe_timeout – to enforce the time-out value of the probe on the nslookup command that does the probing
- Network_resources_used – To obtain the IP address on which DNS is running
- Retry_count and Retry_interval – To determine the number of restart attempts and the period over which to count them
- Rt_basedir – To obtain the directory containing the PROBE program and the gettime utility

The scha_resource_get() function obtains the values of these properties and stores them in shell variables, as follows.

```
PROBE_INTERVAL=`scha_resource_get -O THOROUGH_PROBE_INTERVAL \
-R $RESOURCE_NAME -G $RESOURCEGROUP_NAME`

probe_timeout_info=`scha_resource_get -O Extension -R $RESOURCE_NAME
\
-G $RESOURCEGROUP_NAME Probe_timeout`
PROBE_TIMEOUT=`echo $probe_timeout_info | awk '{print $2}'`

DNS_HOST=`scha_resource_get -O NETWORK_RESOURCES_USED -R $RESOURCE_NAME
\
-G $RESOURCEGROUP_NAME`

RETRY_COUNT=`scha_resource_get -O RETRY_COUNT -R $RESOURCE_NAME
-G\
 $RESOURCEGROUP_NAME`
```

```
RETRY_INTERVAL=`scha_resource_get -O RETRY_INTERVAL -R $RESOURCE_NAME
-G\
 $RESOURCEGROUP_NAME`

RT_BASEDIR=`scha_resource_get -O RT_BASEDIR -R $RESOURCE_NAME -G\
 $RESOURCEGROUP_NAME`
```

Note – For system-defined properties, such as `Thorough_probe_interval`, `scha_resource_get()` returns the value only. For extension properties, such as `Probe_timeout`, `scha_resource_get()` returns the type and value. Use the `awk` command to obtain the value only.

Checking the Reliability of the Service

The probe itself is an infinite `while` loop of `nslookup` commands. Before the while loop, a temporary file is set up to hold the `nslookup` replies. The *probefail* and *retries* variables are initialized to 0.

```
# Set up a temporary file for the nslookup replies.
DNSPROBEFILE=/tmp/.$RESOURCE_NAME.probe
probefail=0
retries=0
```

The `while` loop itself:

- Sets the sleep interval for the probe
- Uses `hatimerun` to launch `nslookup` passing the `Probe_timeout` value and identifying the target host
- Sets the *probefail* variable based on the success or failure of the `nslookup` return code
- If *probefail* is set to 1 (failure), verifies that the reply to `nslookup` came from the sample data service and not some other DNS server

Here is the `while` loop code.

```
while :
do
   # The interval at which the probe needs to run is specified in the
   # property THOROUGH_PROBE_INTERVAL. Therefore, set the probe to sleep
   # for a duration of THOROUGH_PROBE_INTERVAL.
   sleep $PROBE_INTERVAL

   # Run an nslookup command of the IP address on which DNS is serving.
   hatimerun -t $PROBE_TIMEOUT /usr/sbin/nslookup $DNS_HOST $DNS_HOST \
          > $DNSPROBEFILE 2>&1

      retcode=$?
      if [ $retcode -ne 0 ]; then
```

```
            probefail=1
        fi

   # Make sure that the reply to nslookup comes from the HA-DNS
   # server and not from another nameserver mentioned in the
   # /etc/resolv.conf file.
   if [ $probefail -eq 0 ]; then
# Get the name of the server that replied to the nslookup query.
   SERVER=` awk ' $1=="Server:" { print $2 }' \
   $DNSPROBEFILE | awk -F. ' { print $1 } ' `
   if [ -z "$SERVER" ]; then
      probefail=1
      else
         if [ $SERVER != $DNS_HOST ]; then
            probefail=1
         fi
   fi
fi
```

Evaluating Restart Versus Failover

If the *probefail* variable is something other than 0 (success), it means the `nslookup` command timed out or that the reply came from a server other than the sample service's DNS. In either case, the DNS server is not functioning as expected and the fault monitor calls the `decide_restart_or_failover()` function to determine whether to restart the data service locally or request that the RGM relocate the data service to a different node. If the *probefail* variable is 0, then a message is generated that the probe was successful.

```
   if [ $probefail -ne 0 ]; then
         decide_restart_or_failover
   else
         logger -p ${SYSLOG_FACILITY}.err\
         -t [$SYSLOG_TAG]\
         "${ARGV0} Probe for resource HA-DNS successful"
   fi
```

The `decide_restart_or_failover()` function uses a time window (`Retry_interval`) and a failure count (`Retry_count`) to determine whether to restart DNS locally or request that the RGM relocate the data service to a different node. It implements the following conditional code (see the code listing for `decide_restart_or_failover()` in "`PROBE` Program" on page 259).

- If this is the first failure, restart the data service. Log an error message and bump the counter in the `retries` variable.
- If this is not the first failure, but the window has been exceeded, restart the data service. Log an error message, reset the counter, and slide the window.
- If the time is still within the window and the retry counter has been exceeded, then fail over to another node. If the fail over does not succeed, log an error and exit the probe program with status 1 (failure).

- If time is still within the window but the retry counter has not been exceeded, restart the data service. Log an error message and bump the counter in the `retries` variable.

If the number of restarts reaches the limit during the time interval, the function requests that the RGM relocate the data service to a different node. If the number of restarts is under the limit, or the interval has been exceeded so the count begins again, the function attempts to restart DNS on the same node. Note the following about this function:

- The `gettime` utility is used to track the time between restarts. This is a C program residing in the (`Rt_basedir`) directory.
- The `Retry_count` and `Retry_interval` system-defined resource properties determine the number of restart attempts and the interval over which to count. These properties default to 2 attempts in a period of 5 minutes (300 seconds) in the RTR file, though the cluster administrator could change them.
- The `restart_service()` function is called to attempt to restart the data service on the same node. See the next section, "Restarting the Data Service" on page 102, for information about this function.
- The `scha_control()` API function, with the `GIVEOVER` option, brings the resource group containing the sample data service offline and back online on a different node.

Restarting the Data Service

The `restart_service()` function is called by `decide_restart_or_failover()` to attempt to restart the data service on the same node. This function does the following.

- It determines if the data service is still registered under PMF. If the service is still registered, the function:
  - Obtains the `Stop` method name and the `Stop_timeout` value for the data service.
  - Uses `hatimerun` to launch the `Stop` method for the data service, passing the `Stop_timeout` value.
  - (If the data service is successfully stopped) obtains the `Start` method name and the `Start_timeout` value for the data service.
  - Uses `hatimerun` to launch the `Start` method for the data service, passing the `Start_timeout` value.
- If the data service is no longer registered under PMF, the implication is that the data service has exceeded the maximum number of allowable retries under PMF, so the `scha_control()` function is called with the `GIVEOVER` option to fail the data service over to a different node.

```
function restart_service
{
        # To restart the data service, first verify that the
        # data service itself is still registered under PMF.
        pmfadm -q $PMF_TAG
        if [[ $? -eq 0 ]]; then
                # Since the TAG for the data service is still registered under
                # PMF, first stop the data service and start it back up again.

                # Obtain the Stop method name and the STOP_TIMEOUT value for
                # this resource.
                STOP_TIMEOUT=`scha_resource_get -O STOP_TIMEOUT \
                        -R $RESOURCE_NAME -G $RESOURCEGROUP_NAME`
                STOP_METHOD=`scha_resource_get -O STOP \
                        -R $RESOURCE_NAME -G $RESOURCEGROUP_NAME`
                hatimerun -t $STOP_TIMEOUT $RT_BASEDIR/$STOP_METHOD \
                        -R $RESOURCE_NAME -G $RESOURCEGROUP_NAME \
                        -T $RESOURCETYPE_NAME

                if [[ $? -ne 0 ]]; then
                        logger-p ${SYSLOG_FACILITY}.err -t [$SYSLOG_TAG] \
                                "${ARGV0} Stop method failed."
                        return 1
                fi

                # Obtain the START method name and the START_TIMEOUT value for
                # this resource.
                START_TIMEOUT=`scha_resource_get -O START_TIMEOUT \
                        -R $RESOURCE_NAME -G $RESOURCEGROUP_NAME`
                START_METHOD=`scha_resource_get -O START \
                        -R $RESOURCE_NAME -G $RESOURCEGROUP_NAME`
                hatimerun -t $START_TIMEOUT $RT_BASEDIR/$START_METHOD \
                        -R $RESOURCE_NAME -G $RESOURCEGROUP_NAME \
                        -T $RESOURCETYPE_NAME

                if [[ $? -ne 0 ]]; then
                        logger-p ${SYSLOG_FACILITY}.err -t [$SYSLOG_TAG] \
                                "${ARGV0} Start method failed."
                        return 1
                fi


        else
                # The absence of the TAG for the dataservice
                # implies that the data service has already
                # exceeded the maximum retries allowed under PMF.
                # Therefore, do not attempt to restart the
                # data service again, but try to failover
                # to another node in the cluster.
                scha_control -O GIVEOVER -G $RESOURCEGROUP_NAME \
                        -R $RESOURCE_NAME
        fi

        return 0
}
```

Probe Exit Status

The sample data service's PROBE program exits with failure if attempts to restart locally have failed and the attempt to fail over to a different node has failed as well. It logs the message, "Failover attempt failed".

Monitor_start Method

The RGM calls the Monitor_start method to launch the dns_probe method after the sample data service is brought online.

This section describes the major pieces of the Monitor_start method for the sample application. This section does not describe functionality common to all callback methods, such as the parse_args() function and obtaining the syslog facility, which are described in "Providing Common Functionality to All Methods" on page 88.

For the complete listing of the Monitor_start method, see "Monitor_start Method" on page 265.

Monitor_start Overview

This method uses the process monitor facility (pmfadm) to launch the probe.

Starting the Probe

The Monitor_start method obtains the value of the Rt_basedir property to construct the full path name for the PROBE program. This method launches the probe using the infinite retries option of pmfadm (-n -1, -t -1), which means if the probe fails to start, PMF tries to start it an infinite number of times over an infinite period of time.

```
# Find where the probe program resides by obtaining the value of the
# RT_BASEDIR property of the resource.
RT_BASEDIR=`scha_resource_get -O RT_BASEDIR -R $RESOURCE_NAME -G \
$RESOURCEGROUP_NAME`

# Start the probe for the data service under PMF. Use the infinite retries
# option to start the probe. Pass the resource name, type, and group to the
# probe program.
pmfadm -c $RESOURCE_NAME.monitor -n -1 -t -1 \
   $RT_BASEDIR/dns_probe -R $RESOURCE_NAME -G $RESOURCEGROUP_NAME \
   -T $RESOURCETYPE_NAME
```

Monitor_stop Method

The RGM calls the Monitor_stop method to stop execution of dns_probe when the sample data service is brought offline.

This section describes the major pieces of the `Monitor_stop` method for the sample application. This section does not describe functionality common to all callback methods, such as the `parse_args()` function and obtaining the syslog facility, which are described in "Providing Common Functionality to All Methods" on page 88.

For the complete listing of the `Monitor_stop` method, see "`Monitor_stop` Method" on page 267.

`Monitor_stop` Overview

This method uses the process monitor facility (`pmfadm`) to see if the probe is running, and if so, to stop it.

Stopping the Monitor

The `Monitor_stop` method uses `pmfadm -q` to see if the probe is running, and if so, uses `pmfadm -s` to stop it. If the probe is already stopped, the method exits successfully anyway, which guarantees the idempotency of the method.

```
# See if the monitor is running, and if so, kill it.
if pmfadm -q $PMF_TAG; then
   pmfadm -s $PMF_TAG KILL
   if [ $? -ne 0 ]; then
         logger -p ${SYSLOG_FACILITY}.err \
            -t [$SYSLOG_TAG] \
            "${ARGV0} Could not stop monitor for resource " \
            $RESOURCE_NAME
           exit 1
   else
         # could successfully stop the monitor. Log a message.
         logger -p ${SYSLOG_FACILITY}.err \
            -t [$SYSLOG_TAG] \
            "${ARGV0} Monitor for resource " $RESOURCE_NAME \
            " successfully stopped"
   fi
fi
exit 0
```

Caution – Be certain to use the `KILL` signal with `pmfadm` to stop the probe and not a maskable signal such as `TERM`. Otherwise the `Monitor_stop` method can hang indefinitely and eventually time out. The reason for this problem is that the `PROBE` method calls `scha_control()` when it is necessary to restart or fail over the data service. When `scha_control()` calls `Monitor_stop` as part of the process of bringing the data service offline, if `Monitor_stop` uses a maskable signal, it hangs waiting for `scha_control()` to complete and `scha_control()` hangs waiting for `Monitor_stop` to complete.

`Monitor_stop` Exit Status

The `Monitor_stop` method logs an error message if it cannot stop the `PROBE` method. The RGM puts the sample data service into `MONITOR_FAILED` state on the primary node, which can panic the node.

`Monitor_stop` should not exit before the probe has been stopped.

`Monitor_check` Method

The RGM calls the `Monitor_check` method whenever the `PROBE` method attempts to fail the resource group containing the data service over to a new node.

This section describes the major pieces of the `Monitor_check` method for the sample application. This section does not describe functionality common to all callback methods, such as the `parse_args()` function and obtaining the syslog facility, which are described in “Providing Common Functionality to All Methods” on page 88.

For the complete listing of the `Monitor_check` method, see “`Monitor_check` Method” on page 269.

The `Monitor_check` method must be implemented so that it does not conflict with other methods running concurrently.

The `Monitor_check` method calls the `Validate` method to verify that the DNS configuration directory is available on the new node. The `Confdir` extension property points to the DNS configuration directory. Therefore `Monitor_check` obtains the path and name for the `Validate` method and the value of `Confdir`. It passes this value to `Validate`, as shown in the following listing.

```
# Obtain the full path for the Validate method from
# the RT_BASEDIR property of the resource type.
RT_BASEDIR=`scha_resource_get -O RT_BASEDIR -R $RESOURCE_NAME \
   -G $RESOURCEGROUP_NAME`

# Obtain the name of the Validate method for this resource.
VALIDATE_METHOD=`scha_resource_get -O VALIDATE \
   -R $RESOURCE_NAME -G $RESOURCEGROUP_NAME`

# Obtain the value of the Confdir property in order to start the
# data service. Use the resource name and the resource group entered to
# obtain the Confdir value set at the time of adding the resource.
config_info=`scha_resource_get -O Extension -R $RESOURCE_NAME \
 -G $RESOURCEGROUP_NAME Confdir`

# scha_resource_get returns the type as well as the value for extension
# properties. Use awk to get only the value of the extension property.
CONFIG_DIR=`echo $config_info | awk ‘{print $2}’`

# Call the validate method so that the dataservice can be failed over
# successfully to the new node.
$RT_BASEDIR/$VALIDATE_METHOD -R $RESOURCE_NAME -G $RESOURCEGROUP_NAME \
   -T $RESOURCETYPE_NAME -x Confdir=$CONFIG_DIR
```

See the "`Validate` Method" on page 107 to see how the sample application verifies the suitability of a node for hosting the data service.

Handling Property Updates

The sample data service implements `Validate` and `Update` methods to handle updating of properties by a cluster administrator.

`Validate` Method

The RGM calls the `Validate` method when a resource is created and when administrative action updates the properties of the resource or its containing group. The RGM calls `Validate` before the creation or update is applied, and a failure exit code from the method on any node causes the creation or update to be canceled.

The RGM calls `Validate` only when resource or group properties are changed through administrative action, not when the RGM sets properties, or when a monitor sets the resource properties `Status` and `Status_msg`.

Note – The `Monitor_check` method also explicitly calls the `Validate` method whenever the `PROBE` method attempts to fail the data service over to a new node.

`Validate` Overview

The RGM calls `Validate` with additional arguments to those passed to other methods, including the properties and values being updated. Therefore this method in the sample data service must implement a different `parse_args()` function to handle the additional arguments.

The `Validate` method in the sample data service verifies a single property, the `Confdir` extension property. This property points to the DNS configuration directory, which is critical to successful operation of DNS.

Note – Because the configuration directory cannot be changed while DNS is running, the `Confdir` property is declared in the RTR file as `TUNABLE = AT_CREATION`. Therefore, the `Validate` method is never called to verify the `Confdir` property as the result of an update, but only when the data service resource is being created.

If `Confdir` is one of the properties the RGM passes to `Validate`, the `parse_args()` function retrieves and saves its value. `Validate` then verifies that the directory pointed to by the new value of `Confdir` is accessible and that the `named.conf` file exists in that directory and contains some data.

If the `parse_args()` function cannot retrieve the value of `Confdir` from the command-line arguments passed by the RGM, `Validate` still attempts to validate the `Confdir` property. `Validate` uses `scha_resource_get()` to obtain the value of `Confdir` from the static configuration. Then it performs the same checks to verify that the configuration directory is accessible and contains a non-empty `named.conf` file.

If `Validate` exits with failure, the update or creation of all properties, not just `Confdir`, fails.

`Validate` Method Parsing Function

The RGM passes the `Validate` method a different set of parameters than the other callback methods so `Validate` requires a different function for parsing arguments than the other methods. See the `rt_callbacks`(1HA) man page for more information on the parameters passed to `Validate` and the other callback methods. The following shows the `Validate` `parse_args()` function.

```
#########################################################################
# Parse Validate arguments.
#
function parse_args # [args...]
{

   typeset opt
   while getopts 'cur:x:g:R:T:G:' opt
   do
         case "$opt" in
         R)
                  # Name of the DNS resource.
                  RESOURCE_NAME=$OPTARG
                  ;;
         G)
                  # Name of the resource group in which the resource is
                  # configured.
                  RESOURCEGROUP_NAME=$OPTARG
                  ;;
         T)
```

```
                    # Name of the resource type.
                    RESOURCETYPE_NAME=$OPTARG
                    ;;
        r)
                    # The method is not accessing any system defined
                    # properties so this is a no-op
                    ;;
        g)
                    # The method is not accessing any resource group
                    # properties, so this is a no-op
                    ;;
        c)
                    # Indicates the Validate method is being called while
                    # creating the resource, so this flag is a no-op.
                    ;;
        u)
                    # Indicates the updating of a property when the
                    # resource already exists. If the update is to the
                    # Confdir property then Confdir should appear in the
                    # command-line arguments. If it does not, the method must
                    # look for it specifically using scha_resource_get.
                    UPDATE_PROPERTY=1
                    ;;
        x)
                    # Extension property list. Separate the property and
                    # value pairs using "=" as the separator.
                    PROPERTY=`echo $OPTARG | awk -F= '{print $1}'`
                    VAL=`echo $OPTARG | awk -F= '{print $2}'`
                    # If the Confdir extension property is found on the
                    # command line, note its value.
                    if [ $PROPERTY == "Confdir" ]; then
                              CONFDIR=$VAL
                              CONFDIR_FOUND=1
                    fi
                    ;;
        *)
                    logger -p ${SYSLOG_FACILITY}.err \
                    -t [$SYSLOG_TAG] \
                    "ERROR: Option $OPTARG unknown"
                    exit 1
                    ;;
        esac
    done
}
```

As with the `parse_args()` function for other methods, this function provides a flag (`R`) to capture the resource name, (`G`) to capture the resource group name, and (`T`) to capture the resource type passed by the RGM.

The `r` flag (indicating a system-defined property), `g` flag (indicating a resource group property), and the `c` flag (indicating that the validation is occurring during creation of the resource) are ignored, because this method is being called to validate an extension property when the resource is being updated.

The `u` flag sets the value of the `UPDATE_PROPERTY` shell variable to `1` (`TRUE`). The `x` flag captures the names and values of the properties being updated. If `Confdir` is one of the properties being updated, its value is placed in the *CONFDIR* shell variable and the variable *CONFDIR_FOUND* is set to `1` (`TRUE`).

Validating `Confdir`

In its `MAIN` function, `Validate` first sets the *CONFDIR* variable to the empty string and *UPDATE_PROPERTY* and *CONFDIR_FOUND* to 0.

```
CONFDIR=""
UPDATE_PROPERTY=0
CONFDIR_FOUND=0
```

`Validate` then calls `parse_args()` to parse the arguments passed by the RGM.

```
parse_args "$@"
```

`Validate` then checks if `Validate` is being called as the result of an update of properties and if the `Confdir` extension property was on the command line. `Validate` then verifies that the `Confdir` property has a value, and if not, exits with failure status and an error message.

```
if ( (( $UPDATE_PROPERTY == 1 )) &&  (( CONFDIR_FOUND == 0 )) ); then
         config_info=‘scha_resource_get -O Extension -R $RESOURCE_NAME \
            -G $RESOURCEGROUP_NAME Confdir‘
         CONFDIR=‘echo $config_info | awk ’{print $2}’‘
fi

# Verify that the Confdir property has a value. If not there is a failure
# and exit with status 1
if [[ -z $CONFDIR ]]; then
         logger -p ${SYSLOG_FACILITY}.err \
            "${ARGV0} Validate method for resource "$RESOURCE_NAME " failed"
         exit 1
fi
```

Note – Specifically, the preceding code checks if `Validate` is being called as the result of an update (`$UPDATE_PROPERTY == 1`) and if the property was *not* found on the command line (`CONFDIR_FOUND == 0`), in which case it retrieves the existing value of `Confdir` using `scha_resource_get()`. If `Confdir` was found on the command line (`CONFDIR_FOUND == 1`), the value of *CONFDIR* comes from the `parse_args()` function, not from `scha_resource_get()`.

The `Validate` method then uses the value of *CONFDIR* to verify that the directory is accessible. If it is not accessible, `Validate` logs an error message and exits with error status.

```
# Check if $CONFDIR is accessible.
if [ ! -d $CONFDIR ]; then
```

```
   logger -p ${SYSLOG_FACILITY}.err \
         -t [$SYSLOG_TAG] \
         "${ARGV0} Directory $CONFDIR missing or not mounted"
   exit 1
fi
```

Before validating the update of the `Confdir` property, `Validate` performs a final check to verify that the `named.conf` file is present. If it is not, the method logs an error message and exits with error status.

```
# Check that the named.conf file is present in the Confdir directory
if [ ! -s $CONFDIR/named.conf ]; then
         logger -p ${SYSLOG_FACILITY}.err \
            -t [$SYSLOG_TAG] \
            "${ARGV0} File $CONFDIR/named.conf is missing or empty"
         exit 1
fi
```

If the final check is passed, `Validate` logs a message indicating success and exits with success status.

```
# Log a message indicating that the Validate method was successful.
logger -p ${SYSLOG_FACILITY}.err \
   -t [$SYSLOG_TAG] \
   "${ARGV0} Validate method for resource "$RESOURCE_NAME \
   " completed successfully"

exit 0
```

`Validate` Exit Status

If `Validate` exits with success (0) `Confdir` is created with the new value. If `Validate` exits with failure (1), `Confdir` and any other properties are not created and a message indicating why is sent to the cluster administrator.

`Update` Method

The RGM calls the `Update` method to notify a running resource that its properties have been changed. The RGM invokes `Update` after an administrative action succeeds in setting properties of a resource or its group. This method is called on nodes where the resource is online.

`Update` Overview

The `Update` method doesn't update properties—that is done by the RGM. Rather, it notifies running processes that an update has occurred. The only process in the sample data service affected by a property update is the fault monitor, so it is this process the `Update` method stops and restarts.

The `Update` method must verify the fault monitor is running and then kill it using `pmfadm`. The method obtains the location of the probe program that implements the fault monitor, then restarts it using `pmfadm` again.

Stopping the Monitor With `Update`

The `Update` method uses `pmfadm -q` to verify that the monitor is running, and if so kills it with `pmfadm -s TERM`. If the monitor is successfully terminated, a message to that effect is sent to the administrative user. If the monitor cannot be stopped, `Update` exits with failure status and sends an error message to the administrative user.

```
if pmfadm -q $RESOURCE_NAME.monitor; then

# Kill the monitor that is running already
pmfadm -s $PMF_TAG TERM
    if [ $? -ne 0 ]; then
       logger -p ${SYSLOG_FACILITY}.err \
              -t [$SYSLOG_TAG] \
                 "${ARGV0} Could not stop the monitor"
       exit 1
    else
    # could successfully stop DNS. Log a message.
       logger -p ${SYSLOG_FACILITY}.err \
              -t [$RESOURCETYPE_NAME,$RESOURCEGROUP_NAME,$RESOURCE_NAME] \
                 "Monitor for HA-DNS successfully stopped"
    fi
```

Restarting the Monitor

To restart the monitor, the `Update` method must locate the script that implements the probe program. The probe program resides in the base directory for the data service, which is pointed to by the `Rt_basedir` property. `Update` retrieves the value of `Rt_basedir` and stores it in the *RT_BASEDIR* variable, as follows.

```
RT_BASEDIR=`scha_resource_get -O RT_BASEDIR -R $RESOURCE_NAME -G \
$RESOURCEGROUP_NAME`
```

`Update` then uses the value of *RT_BASEDIR* with `pmfadm` to restart the dns_probe program. If successful, `Update` exits with success and sends a message to that effect to the administrative user. If `pmfadm` cannot launch the probe program, `Update` exits with failure status and logs an error message.

`Update` Exit Status

`Update` method failure causes the resource to be put into an "update failed" state. This state has no effect on RGM management of the resource, but indicates the failure of the update action to administration tools through the syslog facility.

CHAPTER 6

Data Service Development Library (DSDL)

This chapter provides an overview of the application programming interfaces constituting the Data Service Development Library, or DSDL. The DSDL is implemented in the `libdsdev.so` library and is included in the Sun Cluster package.

This chapter covers the following topics:

DSDL Overview

The DSDL API is layered on top of the RMAPI. As such, it does not supersede the RMAPI but rather encapsulates and extends the RMAPI functionality. The DSDL simplifies data service development by providing predetermined solutions to specific Sun Cluster integration issues. Consequently, you can devote the majority of development time to the high availability and scalability issues intrinsic to your application, and avoid spending a large amount of time on integrating the application startup, shutdown, and monitor procedures with Sun Cluster.

Managing Configuration Properties

All callback methods require access to the configuration properties. The DSDL supports access to properties by:

- Initializing the environment
- Providing a set of convenience functions to retrieve property values

The `scds_initialize` function, which must be called at the beginning of each callback method, does the following:

- Checks and processes the command-line arguments (`argc` and `argv[]`) the RGM passes to the callback method, obviating the need for you to write a command-line parsing function.
- Sets up internal data structures for use by other DSDL functions. For example, the convenience functions that retrieve property values from the RGM store the values in these structures. Likewise, values from the command-line, which take precedence over values retrieved from the RGM, are stored in these data structures.

Note – For the `Validate` method, scds_initialize parses the property values that are passed on the command line, obviating the need to write a parse function for `Validate`.

The `scds_initialize` function also initializes the logging environment and validates fault monitor probe settings.

The DSDL provides sets of functions to retrieve resource, resource type, and resource group properties as well as commonly-used extension properties. These functions standardize access to properties by using the following conventions.

- Each function takes only a handle argument (returned by `scds_initialize`).
- Each function corresponds to a particular property. The return value type of the function matches the type of the property value it retrieves.
- Functions do not return errors as the values have been precomputed by `scds_initialize`. Functions retrieve values from the RGM unless a new value is passed on the command line.

Starting and Stopping a Data Service

A Start method is expected to perform the actions required to start a data service on a cluster node. Typically, this includes retrieving the resource properties, locating application-specific executables and configuration files, and launching the application with the appropriate command-line arguments.

The scds_initialize function retrieves the resource configuration. The Start method can use property convenience functions to retrieve values for specific properties, such as Confdir_list, that identify the configuration directories and files for the application to launch.

A Start method can call scds_pmf_start to launch an application under control of the Process Monitor Facility (PMF). PMF enables you to specify the level of monitoring to apply to the process and provides the ability to restart the process in case of failure. See "xfnts_start Method" on page 134 for an example of a Start method implemented with the DSDL.

A Stop method must be idempotent such that it exits with success even if it is called on a node when the application is not running. If the Stop method fails, the resource being stopped is set to the STOP_FAILED state, which can lead to a hard reboot of the cluster.

To avoid putting the resource in STOP_FAILED state the Stop method must make every effort to stop the resource. The scds_pmf_stop function provides a phased attempt to stop the resource. It first attempts to stop the resource using SIGTERM signal, and if this fails, uses a SIGKILL signal. See scds_pmf_stop(3HA) for details.

Implementing a Fault Monitor

The DSDL absorbs much of the complexity of implementing a fault monitor by providing a predetermined model. A Monitor_start method launches the fault monitor, under the control of PMF, when the resource starts on a node. The fault monitor runs in loop as long as the resource is running on the node. The high-level logic of a DSDL fault monitor is as follows.

- The scds_fm_sleep function uses the Thorough_probe_interval property to determine the amount of time between probes. Any application process failures determined by PMF during this interval lead to a restart of the resource.
- The probe itself returns a value indicating the severity of failures, from 0, no failure, to 100 complete failure.

- The probe return value is sent to the `scds_action` function, which maintains a cumulative failure history within the interval of the `Retry_interval` property.
- The `scds_action` function determines what to do in the event of failure, as follows.
  - If the cumulative failure is below `100`, do nothing.
  - If the cumulative failure reaches `100` (complete failure) restart the data service. If `Retry_interval` is exceeded, reset the history.
  - If the number of restarts exceeds the value of the `Retry_count` property, within the time specified by `Retry_interval`, failover the data service.

Accessing Network Address Information

The DSDL provides convenience functions to return network address information for resources and resource groups. For example, the `scds_get_netaddr_list` retrieves the network-address resources used by a resource, enabling a fault monitor to probe the application.

The DSDL also provides a set of functions for TCP-based monitoring. Typically, these functions establish a simple socket connection to a service, read and write data to the service, and then disconnect from the service. The result of the probe can be sent to the DSDL `scds_fm_action` function to determine the action to take.

See “`xfnts_validate` Method” on page 148 for an example of TCP-based fault monitoring.

Debugging the Resource Type Implementation

The DSDL has built-in features to help you debug your data service.

The DSDL utility `scds_syslog_debug()` provides a basic framework for adding debugging statements to the resource type implementation. The debugging *level* (a number between 1-9) can be dynamically set per resource type implementation per cluster node. A file named `/var/cluster/rgm/rt/`*rtname*`/loglevel`, which contains only an integer between 1 and 9, is read by all resource type callback methods. The DSDL routine `scds_initialize()` reads this file and sets the debug level internally to the specified level. The default debug level 0, specifies that the data service log no debugging messages.

The `scds_syslog_debug()` function uses the facility returned by the `scha_cluster_getlogfacility()` function at a priority of `LOG_DEBUG`. You can configure these debug messages in `/etc/syslog.conf`.

You can turn some debugging messages into informational messages for regular operation of the resource type (perhaps at `LOG_INFO` priority) using the `scds_syslog` utility. If you look at the sample DSDL application in Chapter 8 you will notice that it makes liberal use of `scds_syslog_debug` and `scds_syslog` functions.

Enabling Highly Available Local File Systems

You can use the `HAStoragePlus` resource type to make a local file system highly available within a Sun Cluster environment. The local file system partitions must be located on global disk groups. Affinity switchovers must be enabled and the Sun Cluster environment must be configured for failover. This set up enables the user to make any file system on multi-host disks accessible from any host directly connected to those multi-host disks. Using a highly available local file system is strongly recommended for some I/O intensive data services. “Enabling Highly Available Local File Systems” in *Sun Cluster 3.1 Data Service Planning and Administration Guide* contains information about configuring the `HAStoragePlus` resource type.

CHAPTER 7

Designing Resource Types

This chapter explains the typical usage of the DSDL in designing and implementing resource types. This chapter also focuses on designing the resource type to validate the resource configuration, and to start, stop, and monitor the resource. This chapter finally describes how to use the DSDL to implement the resource type callback methods.

Refer to the `rt_callbacks`(1HA) man page for additional information.

You need access to the resource's property settings to complete these tasks. The DSDL utility `scds_initialize()` gives you a uniform way to access the resource properties. This function is designed to be called at the beginning of each callback method. This utility function retrieves all the properties for a resource from the cluster framework and makes it available to the family of `scds_get`*name*`()` functions.

This chapter covers the following topics:

The RTR File

The Resource Type Registration (RTR) file is an important component of a resource type. This file specifies the details about the resource type to Sun Cluster. These details include information such as the properties that are needed by the implementation, the data types of those properties, the default values of those properties, the file system path for the callback methods for the resource type implementation, and various settings for the system-defined properties.

The sample RTR file that is shipped with the DSDL should suffice for most resource type implementations. All you need to do is edit some basic elements such as the resource type name and the pathname of the resource type callback methods. If a new property is needed to implement the resource type, you can declare it as an extension property in the Resource Type Registration (RTR) file of the resource type implementation, and then access the new property using the DSDL `scds_get_ext_property()` utility.

The `Validate` Method

The `Validate` method of a resource type implementation is called by the RGM in two scenarios: 1) when a new resource of the resource type is being created, and 2) when a property of the resource or resource group is being updated. These two scenarios can be distinguished by the presence of the command line option `-c` (creation) or `-u` (update) passed to the `Validate` method of the resource.

The `Validate` method is called on each node of a set of nodes, where the set of nodes is defined by the value of the resource type property `INIT_NODES`. If `INIT_NODES` is set to `RG_PRIMARIES`, `Validate` is called on each node that can host (be a primary of) the resource group containing the resource. If `INIT_NODES` is set to `RT_INSTALLED_NODES`, `Validate` is called on each node where the resource type software is installed, typically all nodes in the cluster. The default value of `INIT_NODES` is `RG_PRIMARIES` (see `rt_reg`(4). At the point the `Validate` method is called, the RGM has not yet created the resource (in the case of creation callback) or has not yet applied the updated value(s) of the properties being updated (in the case of update callback). The purpose of the `Validate` callback method of a resource type implementation is to check that the proposed resource settings (as specified by the proposed property settings on the resource) are acceptable to the resource type.

Note – If you are using local file systems managed by `HAStoragePlus`, you use the `scds_hasp_check` to check the state of the `HAStoragePlus` resource, This information is obtained from the state (online or otherwise) of all `SUNW.HAStoragePlus`(5) resources that the resource depends upon using `Resource_dependencies` or `Resource_dependencies_weak` system properties defined for the resource. .See `scds_hasp_check`(3HA) for a complete list of status codes returned from the `scds_hasp_check` call.

The DSDL function `scds_initialize()` takes care of these situations in the following manner:

- In the case of resource creation, it parses the proposed resource properties, as passed on the command line. The proposed values of resource properties are thus available to the resource type developer as if the the resource were already created in the system.
- In the case of resource or resource group update, the proposed values of the properties being updated by the administrator are read in from the command line, and the remaining properties (whose values are not being updated) are read in from Sun Cluster using the Resource Management API. A resource type developer using the DSDL need not concern himself with all these housekeeping tasks. The validation of a resource can be done as if all the properties of the resource were available to the developer.

Suppose the function that implements the validation of a resource's properties is called `svc_validate()` which uses the `scds_get_`*name*`()` family of functions to look at the property it is interested in validating. Assuming that an acceptable resource setting is represented by a 0 return code from this function, the `Validate` method of the resource type can thus be represented by the following code fragment:

```
in
tmain(int argc, char *argv[])
{
   scds_handle_t handle;
   int rc;

   if (scds_initialize(&handle, argc, argv)!= SCHA_ERR_NOERR) {
   return (1);   /* Initialization Error */
   }
   rc = svc_validate(handle);
   scds_close(&handle);
   return (rc);
}
```

The the validation function should also log the reason for the failure of the validation of resource. Leaving out that detail (see the next chapter for a more realistic treatment of a validation function), a simple example `svc_validate()` function can then be implemented as:

```
int
svc_validate(scds_handle_t handle)
{
   scha_str_array_t *confdirs;
   struct stat    statbuf;
   confdirs = scds_get_confdir_list(handle);
   if (stat(confdirs->str_array[0], &statbuf) == -1) {
   return (1);   /* Invalid resource property setting */
   }
   return (0);   /* Acceptable setting */
}
```

The resource type developer thus has to concern himself with only the implementation of the `svc_validate()` function. A typical example for a resource type implementation could be to ensure that an application configuration file named app.conf exists under the `Confdir_list` property. That can be conveniently implemented by a `stat()` system call on the appropriate pathname derived from the `Confdir_list` property.

The `Start` Method

The `Start` callback method of a resource type implementation is called by the RGM on a chosen cluster node to start the resource. The resource group name, the resource name, and resource type name are passed on the command line. The `Start` method is expected to perform the actions needed to start up a data service resource on the cluster node. Typically this involves retrieving the resource properties, locating the application specific executables and/or configuration files, and launching the application with appropriate command line arguments.

With the DSDL, the resource configuration is already retrieved by the `scds_initialize()` utility. The startup action for the application can be contained in a function `svc_start()`. Another function, `svc_wait()`, can be called to verify that the application actually starts. The simplified code for the `Start` method becomes:

```
int
main(int argc, char *argv[])
{
   scds_handle_t handle;

   if (scds_initialize(&handle, argc, argv)!= SCHA_ERR_NOERR) {
   return (1);   /* Initialization Error */
   }
   if (svc_validate(handle) != 0) {
   return (1);   /* Invalid settings */
   }
   if (svc_start(handle) != 0) {
```

```
   return (1);   /* Start failed */
   }
   return (svc_wait(handle));
}
```

This start method implementation calls `svc_validate()` to validate the resource configuration. If it fails, either the resource configuration and application configuration do not match, or there is currently a problem on this cluster node with regard to the system. For example, a global file system needed by the resource may currently not be available on this cluster node. In this case, it is futile to even attempt to start the resource on this cluster node. It is better to let the RGM attempt to start the resource on a different node. Note however that the above assumes `svc_validate()` is sufficiently conservative (so that it checks only for resources on the cluster node that are absolutely needed by the application) or else the resource might fail to start up on all cluster nodes and thus land in `START_FAILED` state. See `scswitch`(1M) and the *Sun Cluster 3.1 Data Service Planning and Administration Guide* for an explanation of this state.

The `svc_start()` function must return 0 for a successful startup of the resource on the node. If the startup function encountered a problem, it must return non-zero. Upon failure of this function, the RGM attempts to start the resource on a different cluster node.

To leverage the DSDL as much as possible, the `svc_start()` function can use the `scds_pmf_start()` utility to start the application under the Process Management Facility (PMF). This utility also leverages the failure callback action feature of PMF (see the `-a` action flag in `pmfadm`(1M)) to implement process failure detection.

The `Stop` Method

The `Stop` callback method of a resource type implementation is called by the RGM on a cluster node to stop the application. The callback semantics for the `Stop` method demands that

- The `Stop` method must be *idempotent* because the `Stop` method can be called by the RGM even if the `Start` method did not complete successfully on the node. Thus the `Stop` method must succeed (exit zero) even if the application is not currently running on the cluster node and there is no work for it to do.
- If the `Stop` method of the resource type fails (exits non-zero) on a cluster node, the resource being stopped would end up in the `STO_FAILED` state. Depending upon the `Failover_mode` setting on the resource, this may lead to a hard rebooting of the cluster node by the RGM. Thus it is important to design the `Stop` method so that it tries very hard to really stop the application, even by a hard and abrupt killing of the application (for example, using `SIGKILL`) if the application otherwise fails to terminate. It should also make sure that it does so in a timely fashion,

because the framework treats expiry of `Stop_timeout` as a stop failure, and puts the resource in `STOP_FAILED` state.

The DSDL utility `scds_pmf_stop()` should suffice for most applications as it first attempts to softly (via `SIGTERM`) stop the application (it assumes that it was started under PMF via `scds_pmf_start()`) followed by a delivering a `SIGKILL` to the process. See "PMF Functions" on page 196 for details about this utility.

Following the model of the code we have been using so far, assuming that the application specific function to stop the application is called `svc_stop()` (whether the implementation of `svc_stop()` uses the `scds_pmf_stop()` is besides the point here, and would depend upon whether or not the application was started under PMF via the `Start` method)) the `Stop` method can be implemented as

```
if (scds_initialize(&handle, argc, argv)!= SCHA_ERR_NOERR)
{
   return (1);   /* Initialization Error */
}
return (svc_stop(handle));
```

The `svc_validate()` method is not used in the implementation of the `Stop` method, because even if the system currently has a problem, the `Stop` method should attempt to stop the application on this node.

The `Monitor_start` Method

The RGM calls the `Monitor_start` method to start a fault monitor for the resource. Fault monitors monitor the health of the application being managed by the resource. Resource type implementations typically implement a fault monitor as a separate daemon which runs in the background. The `Monitor_start` callback method is used to launch this daemon with the appropriate arguments.

Because the monitor daemon itself is prone to failures (for example, it could die, leaving the application unmonitored) you should use the PMF to start the monitor daemon. The DSDL utility `scds_pmf_start()` has built in support for starting fault monitors. This utility uses the relative pathname (relative to the `RT_basedir` for the location of the resource type callback method implementations) of the monitor daemon program. It uses the `Monitor_retry_interval` and `Monitor_retry_count` extension properties managed by the DSDL to prevent unlimited restarts of the daemon. It imposes the same command line syntax as defined for all callback methods (that is, `-R` *resource* `-G` *resource_group* `-T` *resource_type*) onto the monitor daemon, although the monitor daemon is never called directly by the RGM. It allows the monitor daemon implementation itself to leverage the `scds_initialize()` utility to set up its own environment. The main effort is in designing the monitor daemon itself.

The `Monitor_stop` Method

The RGM calls the `Monitor_stop` method to stop the fault monitor daemon that was started via the `Monitor_start` method. Failure of this callback method is treated in exactly the same fashion as failure of the `Stop` method; therefore the `Monitor_stop` method must be idempotent and robust like the `Stop` method.

If you use the `scds_pmf_start()` utility to start the fault monitor daemon, use the `scds_pmf_stop()` utility to stop it.

The `Monitor_check` Method

The `Monitor_check` callback method on a resource is invoked on a node for the specified resource to ascertain whether the cluster node is capable of mastering the resource (that is, can the application(s) being managed by the resource be run successfully on the node?). Typically this situation involves making sure that all the system resources needed by the application are indeed available on the cluster node. As discussed in "The `Validate` Method" on page 120, the function `svc_validate()` implemented by the developer is intended to ascertain at least that.

Depending upon the specific application being managed by the resource type implementation, the `Monitor_check` method can be written to do some additional tasks. The `Monitor_check` method must be implemented so that it does not conflict with other methods running concurrently. For developers using the DSDL it is recommended that the `Monitor_check` method leverage the `svc_validate()` function written for the purpose of implementing application specific validation of resource properties.

The `Update` Method

The RGM calls the `Update` method of a resource type implementation to apply any changes that were made by the system administrator to the configuration of the active resource. The `Update` method is only called on nodes (if any) where the resource is currently online.

The changes that have just been made to the resource configuration are guaranteed to be acceptable to the resource type implementation because the RGM runs the `Validate` method of the resource type before it runs the `Update` method. The

`Validate` method is called before the resource or resource group properties are changed and the `Validate` method can veto the proposed changes. The `Update` method is called after the changes have been applied to give the active (online) resource the opportunity to take notice of the new settings.

As a resource type developer, you need to cautiously decide the properties that you want to be able to update dynamically and mark those with the `TUNABLE = ANYTIME` setting in the RTR file. Typically, you can specify that you want to be able to dynamically update any property of a resource type implementation that the fault monitor daemon uses, provided that the `Update` method implementation at least restarts the monitor daemon.

Possible candidates are as follows:

- `Thorough_Probe_Interval`
- `Retry_Count`
- `Retry_Interval`
- `Monitor_retry_count`
- `Monitor_retry_interval`
- `Probe_timeout`

These properties affect the way a fault monitor daemon does health checking of the service, how often it does it, what history interval it uses to keep track of the errors, and what are the restart thresholds set on it by PMF. To implement updates of these properties the utility `scds_pmf_restart()` is provided in the DSDL.

If you need to be able to dynamically update a resource property, but the modification of that property might affect the running application, you need to implement the appropriate actions so that the updates to that property are correctly applied to any running instances of the application. Currently there is no way to facilitate this via the DSDL. `Update` is not passed the modified properties on the command line (as is `Validate`).

The `Init`, `Fini`, and `Boot` Methods

These are *one time action* methods as defined by the Resource Management API specifications. The sample implementation included with the DSDL does not illustrate the use of these methods. However, all the facilities in the DSDL are available to these methods as well, should a resource type developer have a need for these methods. Typically, the `Init` and the `Boot` methods would be exactly the same for a resource type implementation to implement a *one time action*. The `Fini` method typically would perform an action which *undoes* the action of the `Init` or `Boot` methods.

Designing the Fault Monitor Daemon

Resource type implementations using the DSDL typically have a fault monitor daemon with the following responsibilities.

- Periodically monitoring the health of the application being managed. This particular aspect of a monitor daemon is heavily application dependent and could vary widely from resource type to resource type. The DSDL has some built in utility functions to perform health checks for simple TCP based services. Applications implementing ASCII based protocols such as HTTP, NNTP, IMAP, and POP3 can be implemented using these utilities.
- Keeping track of the problems encountered by the application using the resource properties `Retry_interval` and `Retry_count`. Upon complete failures of the application, deciding whether the PMF action script should restart the service or whether the application failures have accumulated so rapidly that a failover could be considered. The DSDL utilities `scds_fm_action()` and `scds_fm_sleep()` are intended to aid you in implementing this mechanism.
- Taking appropriate actions (typically either restarting the application or attempting a failover of the containing resource group). The DSDL utility `scds_fm_action()` implements such an algorithm. It computes the current accumulation of probe failures in the past Retry_interval seconds for this purpose.
- Updating the resource state so that application health state is available to the `scstat` command as well as to the cluster management GUI.

The DSDL utilities are designed so the main loop of the fault monitor daemon can be represented by the following pseudo code.

For fault monitors implemented using the DSDL,

- The detection of application process death by `scds_fm_sleep()` is fairly rapid because the process death notification via PMF is asynchronous. Contrast that with a case where a fault monitor wakes up every so often to check on service health and finds the application dead. The fault detection time is reduced significantly, thereby increasing the availability of the service.
- If the RGM rejects the attempt to fail over the service via the `scha_control (3HA)` API, `scds_fm_action()` *resets* (forgets) its current failure history. The reason is that the failure history is already above `Retry_count`, and if the monitor daemon wakes up in the next iteration and is unable to successfully complete its health check of the daemon, it would again attempt to invoke the `scha_control()` call, which would probably still be rejected, as the situation which led to its rejection in the last iteration is still valid. Resetting the history ensures that the fault monitor at least attempts to correct the situation locally (for example, via application restart) in the next iteration.

- scds_fm_action() does *not* reset application failure history in case of restart failures, as one would typically like to try scha_control() soon if the situation doesn't correct itself.
- The utility scds_fm_action() updates the resource status to SCHA_RSSTATUS_OK, SCHA_RSSTATUS_DEGRADED or SCHA_RSSTATUS_FAULTED depending upon the failure history. This status is thus available to cluster system management.

In most cases, the application specific health check action can be implemented in a separate stand-alone utility (svc_probe(), for example) and integrated with this generic main loop.

```
for (;;) {

   / * sleep for a duration of thorough_probe_interval between
   *  successive probes. */
   (void) scds_fm_sleep(scds_handle,
   scds_get_rs_thorough_probe_interval(scds_handle));

   /* Now probe all ipaddress we use. Loop over
   * 1. All net resources we use.
   * 2. All ipaddresses in a given resource.
   * For each of the ipaddress that is probed,
   * compute the failure history. */
   probe_result = 0;
   /* Iterate through the all resources to get each
    * IP address to use for calling svc_probe() */
   for (ip = 0; ip < netaddr->num_netaddrs; ip++) {
   /* Grab the hostname and port on which the
   * health has to be monitored.
   */
   hostname = netaddr->netaddrs[ip].hostname;
   port = netaddr->netaddrs[ip].port_proto.port;
   /*
   * HA-XFS supports only one port and
   * hence obtaint the port value from the
   * first entry in the array of ports.
   */
   ht1 = gethrtime(); /* Latch probe start time */
   probe_result = svc_probe(scds_handle,

   hostname, port, timeout);
   /*
   * Update service probe history,
   * take action if necessary.
   * Latch probe end time.
   */
   ht2 = gethrtime();
   /* Convert to milliseconds */
   dt = (ulong_t)((ht2 - ht1) / 1e6);

   /*
   * Compute failure history and take
   * action if needed
   */
   (void) scds_fm_action(scds_handle,
   probe_result, (long)dt);
   }       /* Each net resource */
   }       /* Keep probing forever */
```

CHAPTER 8

Sample DSDL Resource Type Implementation

This chapter describes a sample resource type, SUNW.xfnts, implemented with the DSDL. The data service is written in C. The underlying application is the X Font Server, a TCP/IP-based service.

The information in this chapter includes.

X Font Server

The X Font Server is a simple TCP/IP-based service that serves font files to its clients. Clients connect to the server to request a font set, and the server reads the font files off the disk and serves them to the clients. The X Font Server daemon consists of a server binary /usr/openwin/bin/xfs. The daemon is normally started from inetd, however, for the current sample, assume that the appropriate entry in the /etc/inetd.conf file has been disabled (for example, by the fsadmin -d command) so the daemon is under sole control of Sun Cluster.

X Font Server Configuration File

By default, the X Font Server reads its configuration information from the file `/usr/openwin/lib/X11/fontserver.cfg`. The catalog entry in this file contains a list of font directories available to the daemon for serving. The cluster administrator can locate the font directories on the global file system (to optimize the use of the X Font Server on Sun Cluster by maintaining a single copy of the font's database on the system). If so, the administrator must edit `fontserver.cfg` to reflect the new paths for the font directories.

For ease of configuration, the administrator can also place the configuration file itself on the global file system. The `xfs` daemon provides command line arguments to override the default, built-in location of this file. The `SUNW.xfnts` resource type uses the following command to start the daemon under control of Sun Cluster.

```
/usr/openwin/bin/xfs -config <location_of_cfg_file>/fontserver.cfg \
-port <portnumber>
```

In the `SUNW.xfnts` resource type implementation, you can use the `Confdir_list` property to manage the location of the `fontserver.cfg` configuration file.

TCP Port Number

The TCP port number on which the `xfs` server daemon listens is normally the "fs" port (typically defined as `7100` in the `/etc/services` file). However, the `-port` option on the `xfs` command line enables the system administrator to override the default setting. You can use the `Port_list` property in the `SUNW.xfnts` resource type to set the default value and to support the use of the `-port` option on the `xfs` command line. You define the default value of this property as `7100/tcp` in the RTR file. In the `SUNW.xfnts` `Start` method, you pass `Port_list` to the `-port` option on the `xfs` command line. Consequently, a user of this resource type isn't required to specify a port number—the port defaults to `7100/tcp`—but does have the option of specifying a different port if they wish when configuring the resource type, by specifying a different value for the `Port_list` property.

Naming Conventions

You can identify the various pieces of the sample code by keeping the following conventions in mind.

- RMAPI functions begin with `scha_`.
- DSDL functions begin with `scds_`.
- Callback methods begin with `xfnts_`.

- User-written functions begin with svc_.

SUNW.xfnts RTR File

This section describes several key properties in the SUNW.xfnts RTR file. It does not describe the purpose of each property in the file. For such a description, see "Setting Resource and Resource Type Properties" on page 30.

The Confdir_list extension property identifies the configuration directory (or a list of directories), as follows.

```
{
        PROPERTY = Confdir_list;
        EXTENSION;
        STRINGARRAY;
        TUNABLE = AT_CREATION;
        DESCRIPTION = "The Configuration Directory Path(s)";
}
```

The Confdir_list property does not specify a default value. The cluster administrator must specify a directory at the time of resource creation. This value cannot be changed later because tunability is limited to AT_CREATION.

The Port_list property identifies the port on which the server daemon listens, as follows.

```
{
        PROPERTY = Port_list;
        DEFAULT = 7100/tcp;
        TUNABLE = AT_CREATION;
}
```

Because the property declares a default value, the cluster administrator has a choice of specifying a new value or accepting the default at the time of resource creation. This value cannot be changed later because tunability is limited to AT_CREATION.

scds_initialize() Function

The DSDL requires that each callback method call the scds_initialize(3HA) function at the beginning of the method. This function performs the following operations:

- Checks and processes the command line arguments (argc and argv) that the framework passes to the data service method. The method does not have to do any additional processing of the command-line arguments.
- Sets up internal data structures for use by the other functions in the DSDL.
- Initializes the logging environment.
- Validates fault monitor probe settings.

Use the scds_close() function to reclaim the resources allocated by scds_initialize().

xfnts_start Method

The RGM invokes the Start method on a cluster node when the resource group containing the data service resource is brought online on that node or when the resource is enabled. In the SUNW.xfnts sample resource type, the xfnts_start method activates the xfs daemon on that node.

The xfnts_start method calls scds_pmf_start() to start the daemon under PMF. PMF provides automatic failure notification and restart features, as well as integration with the fault monitor.

Note – The first call in xfnts_start is to scds_initialize(), which performs some necessary *house-keeping* functions (the "scds_initialize() Function" on page 133 and the scds_initialize(3HA) man page contain more detail).

Validating the Service Before Starting

Before it attempts to start the X Font Server, the xfnts_start method calls svc_validate() to verify that a proper configuration is in place to support the xfs daemon (see "xfnts_validate Method" on page 148 for details), as follows.

```
rc = svc_validate(scds_handle);
   if (rc != 0) {
      scds_syslog(LOG_ERR,
          "Failed to validate configuration.");
      return (rc);
   }
```

Starting the Service

The `xfnts_start` method calls the `svc_start()` method, defined in `xfnts.c` to start the `xfs` daemon. This section describes `svc_start()`.

The command to launch the `xfs` daemon is as follows.

```
xfs -config config_directory/fontserver.cfg -port port_number
```

The `Confdir_list` extension property identifies the *config_directory* while the `Port_list` system property identifies the *port_number*. When the cluster administrator configures the data service, he provides specific values for these properties.

The `xfnts_start` method declares these properties as string arrays and obtains the values the administrator sets using the `scds_get_ext_confdir_list()` and `scds_get_port_list()` functions (described in `scds_property_functions`(3HA)), as follows.

```
scha_str_array_t *confdirs;
scds_port_list_t    *portlist;
scha_err_t   err;

   /* get the configuration directory from the confdir_list property */
   confdirs = scds_get_ext_confdir_list(scds_handle);

   (void) sprintf(xfnts_conf, "%s/fontserver.cfg", confdirs->str_array[0]);

   /* obtain the port to be used by XFS from the Port_list property */
   err = scds_get_port_list(scds_handle, &portlist);
   if (err != SCHA_ERR_NOERR) {
      scds_syslog(LOG_ERR,
          "Could not access property Port_list.");
      return (1);
   }
```

Note that the `confdirs` variable points to the first element (0) of the array.

The `xfnts_start` method uses `sprintf` to form the command line for `xfs` as follows.

```
/* Construct the command to start the xfs daemon. */
   (void) sprintf(cmd,
       "/usr/openwin/bin/xfs -config %s -port %d 2>/dev/null",
       xfnts_conf, portlist->ports[0].port);
```

Note that he output is redirected to `dev/null` to suppress messages generated by the daemon.

The `xfnts_start` method passes the `xfs` command line to `scds_pmf_start()` to start the data service under control of PMF, as follows.

```
scds_syslog(LOG_INFO, "Issuing a start request.");
   err = scds_pmf_start(scds_handle, SCDS_PMF_TYPE_SVC,
      SCDS_PMF_SINGLE_INSTANCE, cmd, -1);

   if (err == SCHA_ERR_NOERR) {
      scds_syslog(LOG_INFO,
          "Start command completed successfully.");
   } else {
      scds_syslog(LOG_ERR,
          "Failed to start HA-XFS ");
   }
```

Note the following points about the call to `scds_pmf_start()`.

- The `SCDS_PMF_TYPE_SVC` parameter identifies the program to start as a data service application—this method can also start a fault monitor or some other type of application.
- The `SCDS_PMF_SINGLE_INSTANCE` parameter identifies this as a single-instance resource.
- The `cmd` parameter is the command line generated previously.
- The final parameter, `-1`, specifies the child monitoring level. The -1 specifies that PMF monitor all children as well as the original process.

Before returning, `svc_pmf_start()` frees the memory allocated for the `portlist` structure, as follows.

```
scds_free_port_list(portlist);
return (err);
```

Returning From `svc_start()`

Even when `svc_start()` returns successfully, it is possible the underlying application failed to start. Therefore, `svc_start()` must probe the application to verify that it is running before returning a success message. The probe must also take into account that the application might not be immediately available because it takes some time to start up. The `svc_start()` method calls `svc_wait()`, which is defined in `xfnts.c`, to verify the application is running, as follows.

```
/* Wait for the service to start up fully */
   scds_syslog_debug(DBG_LEVEL_HIGH,
       "Calling svc_wait to verify that service has started.");

   rc = svc_wait(scds_handle);

   scds_syslog_debug(DBG_LEVEL_HIGH,
       "Returned from svc_wait");

   if (rc == 0) {
      scds_syslog(LOG_INFO, "Successfully started the service.");
   } else {
      scds_syslog(LOG_ERR, "Failed to start the service.");
   }
```

The `svc_wait()` function calls `scds_get_netaddr_list`(3HA) to obtain the network-address resources needed to probe the application, as follows.

```
/* obtain the network resource to use for probing */
   if (scds_get_netaddr_list(scds_handle, &netaddr)) {
      scds_syslog(LOG_ERR,
          "No network address resources found in resource group.");
      return (1);
   }

   /* Return an error if there are no network resources */
   if (netaddr == NULL || netaddr->num_netaddrs == 0) {
      scds_syslog(LOG_ERR,
          "No network address resource in resource group.");
      return (1);
   }
```

Then `svc_wait()` obtains the `start_timeout` and `stop_timeout` values, as follows.

```
svc_start_timeout = scds_get_rs_start_timeout(scds_handle)
   probe_timeout = scds_get_ext_probe_timeout(scds_handle)
```

To account for the time the server might take to start up, `svc_wait()` calls `scds_svc_wait()` and passes a timeout value equivalent to three percent of the `start_timeout` value. Then `svc_wait()` calls `svc_probe()` to verify that the application has started. The `svc_probe()` method makes a simple socket connection to the server on the specified port. If fails to connect to the port, `svc_probe()` returns a value of 100, indicating total failure. If the connection goes through but the disconnect to the port fails, then `svc_probe()` returns a value of 50.

On failure or partial failure of `svc_probe()`, `svc_wait()` calls `scds_svc_wait()` with a timeout value of 5. The `scds_svc_wait()` method limits the frequency of the probes to every five seconds. This method also counts the number of attempts to start the service. If the number of attempts exceeds the value of the `Retry_count` property of the resource within the period specified by the `Retry_interval` property of the resource, the `scds_svc_wait()` function returns failure. In this case, the `svc_start()` function also returns failure.

```
#define     SVC_CONNECT_TIMEOUT_PCT     95
#define     SVC_WAIT_PCT        3
   if (scds_svc_wait(scds_handle, (svc_start_timeout * SVC_WAIT_PCT)/100)
      != SCHA_ERR_NOERR) {

      scds_syslog(LOG_ERR, "Service failed to start.");
      return (1);
   }
```

```
do {
   /*
    * probe the data service on the IP address of the
    * network resource and the portname
    */
   rc = svc_probe(scds_handle,
       netaddr->netaddrs[0].hostname,
       netaddr->netaddrs[0].port_proto.port, probe_timeout);
   if (rc == SCHA_ERR_NOERR) {
      /* Success. Free up resources and return */
      scds_free_netaddr_list(netaddr);
      return (0);
   }

    /* Call scds_svc_wait() so that if service fails too
   if (scds_svc_wait(scds_handle, SVC_WAIT_TIME)
      != SCHA_ERR_NOERR) {
      scds_syslog(LOG_ERR, "Service failed to start.");
      return (1);
   }

/* Rely on RGM to timeout and terminate the program */
} while (1);
```

Note – Before it exits, the `xfnts_start` method calls `scds_close()` to reclaim resources allocated by `scds_initialize()`. See “`scds_initialize()` Function” on page 133 and the `scds_close`(3HA) man page for details.

`xfnts_stop` Method

Because the `xfnts_start` method uses `scds_pmf_start()` to start the service under PMF, `xfnts_stop` uses `scds_pmf_stop()` to stop the service.

Note – The first call in `xfnts_stop` is to `scds_initialize()`, which performs some necessary *house-keeping* functions (the “`scds_initialize()` Function” on page 133 and the `scds_initialize`(3HA) man page contain more detail.

The `xfnts_stop` method calls the `svc_stop()` method, which is defined in `xfnts.c` as follows.

```
scds_syslog(LOG_ERR, "Issuing a stop request.");
   err = scds_pmf_stop(scds_handle,
       SCDS_PMF_TYPE_SVC, SCDS_PMF_SINGLE_INSTANCE, SIGTERM,
       scds_get_rs_stop_timeout(scds_handle));

   if (err != SCHA_ERR_NOERR) {
      scds_syslog(LOG_ERR,
          "Failed to stop HA-XFS.");
      return (1);
   }

   scds_syslog(LOG_INFO,
       "Successfully stopped HA-XFS.");
   return (SCHA_ERR_NOERR); /* Successfully stopped */
```

Note the following about the call in `svc_stop()` to the `scds_pmf_stop()` function.

- `SCDS_PMF_TYPE_SVC` parameter identifies the program to stop as a data service application—this method can also stop a fault monitor or some other type of application.
- The `SCDS_PMF_SINGLE_INSTANCE` parameter identifies the signal.
- The `SIGTERM` parameter identifies the signal to use to stop the resource instance. If this signal fails to stop the instance, `scds_pmf_stop()` sends `SIGKILL` to stop the instance, and if that fails, returns with a timeout error. See the `scds_pmf_stop`(3HA) man page for details.
- The timeout value is that of the `Stop_timeout` property of the resource.

Note – Before it exits, the `xfnts_stop` method calls `scds_close()` to reclaim resources allocated by `scds_initialize()`. See "`scds_initialize()` Function" on page 133 and the `scds_close`(3HA) man page for details.

`xfnts_monitor_start` Method

The RGM calls the `Monitor_start` method on a node to start the fault monitor after a resource is started on the node. The `xfnts_monitor_start` method uses `scds_pmf_start()` to start the monitor daemon under PMF.

Note – The first call in `xfnts_monitor_start` is to `scds_initialize()`, which performs some necessary *house-keeping* functions (the "`scds_initialize()` Function" on page 133 and the `scds_initialize`(3HA) man page contain more detail.

The xfnts_monitor_start method calls the mon_start method, which is defined in xfnts.c as follows.

```
scds_syslog_debug(DBG_LEVEL_HIGH,
      "Calling Monitor_start method for resource <%s>.",
      scds_get_resource_name(scds_handle));

    /* Call scds_pmf_start and pass the name of the probe. */
   err = scds_pmf_start(scds_handle, SCDS_PMF_TYPE_MON,
       SCDS_PMF_SINGLE_INSTANCE, "xfnts_probe", 0);

   if (err != SCHA_ERR_NOERR) {
      scds_syslog(LOG_ERR,
          "Failed to start fault monitor.");
      return (1);
   }

   scds_syslog(LOG_INFO,
       "Started the fault monitor.");

   return (SCHA_ERR_NOERR); /* Successfully started Monitor */
}
```

Note the following about the call in svc_mon_start() to the scds_pmf_start() function.

- SCDS_PMF_TYPE_MON parameter identifies the program to start as a fault monitor—this method can also start a data service or some other type of application.
- The SCDS_PMF_SINGLE_INSTANCE parameter identifies this as a single-instance resource.
- The xfnts_probe parameter identifies the monitor daemon to start. The assumption is that the monitor daemon is in the same directory as the other callback programs.
- The final parameter, 0, specifies the child monitoring level—in this case, monitor the monitor daemon only.

Note – Before it exits, the xfnts_monitor_start method calls scds_close() to reclaim resources allocated by scds_initialize(). See "scds_initialize() Function" on page 133 and the scds_close(3HA) man page for details.

---

xfnts_monitor_stop Method

Because the xfnts_monitor_start method uses scds_pmf_start() to start the monitor daemon under PMF, xfnts_monitor_stop uses scds_pmf_stop() to stop the monitor daemon.

Note – The first call in xfnts_monitor_stop is to scds_initialize(), which performs some necessary *house-keeping* functions (the "scds_initialize() Function" on page 133 and the scds_initialize(3HA) man page contain more detail.

The xfnts_monitor_stop() method calls the mon_stop method, which is defined in xfnts.c as follows.

```
scds_syslog_debug(DBG_LEVEL_HIGH,
      "Calling scds_pmf_stop method");

   err = scds_pmf_stop(scds_handle, SCDS_PMF_TYPE_MON,
       SCDS_PMF_SINGLE_INSTANCE, SIGKILL,
       scds_get_rs_monitor_stop_timeout(scds_handle));

   if (err != SCHA_ERR_NOERR) {
      scds_syslog(LOG_ERR,
          "Failed to stop fault monitor.");
      return (1);
   }

   scds_syslog(LOG_INFO,
       "Stopped the fault monitor.");

   return (SCHA_ERR_NOERR); /* Successfully stopped monitor */
}
```

Note the following about the call in svc_mon_stop() to the scds_pmf_stop() function.

- SCDS_PMF_TYPE_MON parameter identifies the program to stop as a fault monitor—this method can also stop a data service or some other type of application.
- The SCDS_PMF_SINGLE_INSTANCE parameter identifies this as a single-instance resource.
- The SIGKILL parameter identifies the signal to use to stop the resource instance. If this signal fails to stop the instance, scds_pmf_stop() returns with a timeout error. See the scds_pmf_stop(3HA)) man page for details.

- The timeout value is that of the `Monitor_stop_timeout` property of the resource.

Note – Before it exits, the `xfnts_monitor_stop` method calls `scds_close()` to reclaim resources allocated by `scds_initialize()`. See "`scds_initialize()` Function" on page 133 and the `scds_close`(3HA) man page for details.

`xfnts_monitor_check` Method

The RGM calls the `Monitor_check` method whenever the fault monitor attempts to fail the resource group containing the resource over to another node. The `xfnts_monitor_check` method calls the `svc_validate()` method to verify that a proper configuration is in place to support the `xfs` daemon (see "`xfnts_validate` Method" on page 148 for details). The code for `xfnts_monitor_check` is as follows.

```
   /* Process the arguments passed by RGM and initialize syslog */
   if (scds_initialize(&scds_handle, argc, argv) != SCHA_ERR_NOERR)
{
      scds_syslog(LOG_ERR, "Failed to initialize the handle.");
      return (1);
   }

   rc =  svc_validate(scds_handle);
   scds_syslog_debug(DBG_LEVEL_HIGH,
       "monitor_check method "
       "was called and returned <%d>.", rc);

   /* Free up all the memory allocated by scds_initialize */
   scds_close(&scds_handle);

   /* Return the result of validate method run as part of monitor check */
   return (rc);
}
```

`SUNW.xfnts` Fault Monitor

The RGM does not directly call the `PROBE` method but rather calls the `Monitor_start` method to start the monitor after a resource is started on a node. The `xfnts_monitor_start` method starts the fault monitor under the control of PMF. The `xfnts_monitor_stop` method stops the fault monitor.

The SUNW.xfnts fault monitor performs the following operations:

- Periodically monitors the health of the xfs server daemon using utilities specifically designed to check simple TCP-based services, such as xfs.
- Tracks problems the application encounters within a time window (using the Retry_count and Retry_interval properties) and decides whether to restart or failover the data service in case of complete application failure. The scds_fm_action() and scds_fm_sleep() functions provide built-in support for this tracking and decision mechanism.
- Implements the failover or restart decision using scds_fm_action().
- Updates the resource state and makes it available to administrative tools and graphics user interfaces.

xfonts_probe Main Loop

The xfonts_probe method implements a loop. Before implementing the loop, xfonts_probe

- Retrieves the network-address resources for the xfnts resource, as follows.

```
/* Get the ip addresses available for this resource */
   if (scds_get_netaddr_list(scds_handle, &netaddr)) {
      scds_syslog(LOG_ERR,
          "No network address resource in resource group.");
      scds_close(&scds_handle);
      return (1);
   }

   /* Return an error if there are no network resources */
   if (netaddr == NULL || netaddr->num_netaddrs == 0) {
      scds_syslog(LOG_ERR,
          "No network address resource in resource group.");
      return (1);
   }
```

- Calls scds_fm_sleep() and passes the value of Thorough_probe_interval as the timeout value. The probe sleeps for the value of Thorough_probe_interval between probes.

```
timeout = scds_get_ext_probe_timeout(scds_handle);

   for (;;) {
      /*
       * sleep for a duration of thorough_probe_interval between
       *  successive probes.
       */
      (void) scds_fm_sleep(scds_handle,
          scds_get_rs_thorough_probe_interval(scds_handle));
```

The xfnts_probe method implements the loop as follows.

```
for (ip = 0; ip < netaddr->num_netaddrs; ip++) {
         /*
          * Grab the hostname and port on which the
          * health has to be monitored.
          */
         hostname = netaddr->netaddrs[ip].hostname;
         port = netaddr->netaddrs[ip].port_proto.port;
         /*
          * HA-XFS supports only one port and
          * hence obtain the port value from the
          * first entry in the array of ports.
          */
         ht1 = gethrtime(); /* Latch probe start time */
         scds_syslog(LOG_INFO, "Probing the service on port: %d.", port);

         probe_result =
         svc_probe(scds_handle, hostname, port, timeout);

         /*
          * Update service probe history,
          * take action if necessary.
          * Latch probe end time.
          */
         ht2 = gethrtime();

         /* Convert to milliseconds */
         dt = (ulong_t)((ht2 - ht1) / 1e6);

         /*
          * Compute failure history and take
          * action if needed
          */
         (void) scds_fm_action(scds_handle,
             probe_result, (long)dt);
      }   /* Each net resource */
   }    /* Keep probing forever */
```

The svc_probe() function implements the probe logic. The return value from svc_probe() is passed to scds_fm_action(), which determines whether to restart the application, failover the resource group, or do nothing.

svc_probe() Function

The svc_probe() function makes a simple socket connection to the specified port by calling scds_fm_tcp_connect(). If the connection fails, svc_probe() returns a value of 100 indicating a complete failure. If the connection succeeds, but the disconnect fails, svc_probe() returns a value of 50 indicating a partial failure. If the connection and disconnection both succeed, svc_probe() returns a value of 0, indicating success.

The code for `svc_probe()` is as follows.

```
int svc_probe(scds_handle_t scds_handle,
char *hostname, int port, int timeout)
{
   int  rc;
   hrtime_t   t1, t2;
   int    sock;
   char   testcmd[2048];
   int    time_used, time_remaining;
   time_t      connect_timeout;


   /*
    * probe the data service by doing a socket connection to the port */
    * specified in the port_list property to the host that is
    * serving the XFS data service. If the XFS service which is configured
    * to listen on the specified port, replies to the connection, then
    * the probe is successful. Else we will wait for a time period set
    * in probe_timeout property before concluding that the probe failed.
    */

   /*
    * Use the SVC_CONNECT_TIMEOUT_PCT percentage of timeout
    * to connect to the port
    */
   connect_timeout = (SVC_CONNECT_TIMEOUT_PCT * timeout)/100;
   t1 = (hrtime_t)(gethrtime()/1E9);

   /*
    * the probe makes a connection to the specified hostname and port.
    * The connection is timed for 95% of the actual probe_timeout.
    */
   rc = scds_fm_tcp_connect(scds_handle, &sock, hostname, port,
       connect_timeout);
   if (rc) {
      scds_syslog(LOG_ERR,
          "Failed to connect to port <%d> of resource <%s>.",
          port, scds_get_resource_name(scds_handle));
      /* this is a complete failure */
      return (SCDS_PROBE_COMPLETE_FAILURE);
   }

   t2 = (hrtime_t)(gethrtime()/1E9);

   /*
    * Compute the actual time it took to connect. This should be less than
    * or equal to connect_timeout, the time allocated to connect.
    * If the connect uses all the time that is allocated for it,
    * then the remaining value from the probe_timeout that is passed to
    * this function will be used as disconnect timeout. Otherwise, the
    * the remaining time from the connect call will also be added to
    * the disconnect timeout.
    *
    */
```

```
time_used = (int)(t2 - t1);

/*
 * Use the remaining time(timeout - time_took_to_connect) to disconnect
 */

time_remaining = timeout - (int)time_used;

/*
 * If all the time is used up, use a small hardcoded timeout
 * to still try to disconnect. This will avoid the fd leak.
 */
if (time_remaining <= 0) {
   scds_syslog_debug(DBG_LEVEL_LOW,
       "svc_probe used entire timeout of "
       "%d seconds during connect operation and exceeded the "
       "timeout by %d seconds. Attempting disconnect with timeout"
       " %d ",
       connect_timeout,
       abs(time_used),
       SVC_DISCONNECT_TIMEOUT_SECONDS);

   time_remaining = SVC_DISCONNECT_TIMEOUT_SECONDS;
}

/*
 * Return partial failure in case of disconnection failure.
 * Reason: The connect call is successful, which means
 * the application is alive. A disconnection failure
 * could happen due to a hung application or heavy load.
 * If it is the later case, don't declare the application
 * as dead by returning complete failure. Instead, declare
 * it as partial failure. If this situation persists, the
 * disconnect call will fail again and the application will be
 * restarted.
 */
rc = scds_fm_tcp_disconnect(scds_handle, sock, time_remaining);
if (rc != SCHA_ERR_NOERR) {
   scds_syslog(LOG_ERR,
       "Failed to disconnect to port %d of resource %s.",
       port, scds_get_resource_name(scds_handle));
   /* this is a partial failure */
   return (SCDS_PROBE_COMPLETE_FAILURE/2);
}

t2 = (hrtime_t)(gethrtime()/1E9);
time_used = (int)(t2 - t1);
time_remaining = timeout - time_used;

/*
 * If there is no time left, don't do the full test with
 * fsinfo. Return SCDS_PROBE_COMPLETE_FAILURE/2
 * instead. This will make sure that if this timeout
 * persists, server will be restarted.
```

```
    */
   if (time_remaining <= 0) {
      scds_syslog(LOG_ERR, "Probe timed out.");
      return (SCDS_PROBE_COMPLETE_FAILURE/2);
   }

   /*
    * The connection and disconnection to port is successful,
    * Run the fsinfo command to perform a full check of
    * server health.
    * Redirect stdout, otherwise the output from fsinfo
    * ends up on the console.
    */
   (void) sprintf(testcmd,
       "/usr/openwin/bin/fsinfo -server %s:%d > /dev/null",
       hostname, port);
   scds_syslog_debug(DBG_LEVEL_HIGH,
       "Checking the server status with %s.", testcmd);
   if (scds_timerun(scds_handle, testcmd, time_remaining,
      SIGKILL, &rc) != SCHA_ERR_NOERR || rc != 0) {

      scds_syslog(LOG_ERR,
         "Failed to check server status with command <%s>",
         testcmd);
      return (SCDS_PROBE_COMPLETE_FAILURE/2);
   }
   return (0);
}
```

When finished, `svc_probe()` returns a success (`0`), partial failure (`50`), or complete failure (`100`) value. The `xfnts_probe` method passes this value to `scds_fm_action()`.

Determining the Fault Monitor Action

The `xfnts_probe` method calls `scds_fm_action()` to determine the action to take. The logic in `scds_fm_action()` is as follows:

- Maintain a cumulative failure history within the value of the `Retry_interval` property.
- If the cumulative failure reaches 100 (complete failure) restart the data service. If `Retry_interval` is exceeded, reset the history.
- If the number of restarts exceeds the value of the `Retry_count` property, within the time specified by `Retry_interval`, failover the data service.

For example, suppose the probe makes a connection to the xfs server, but fails to disconnect. This indicates that the server is running, but could be hung or just under a temporary load. The failure to disconnect sends a partial (`50`) failure to `scds_fm_action()`. This value is below the threshold for restarting the data service, but the value is maintained in the failure history.

If during the next probe the server again fails to disconnect, a value of `50` is added to the failure history maintained by `scds_fm_action()`. The cumulative failure value is now `100`, so `scds_fm_action()` restarts the data service.

`xfnts_validate` Method

The RGM calls the `Validate` method when a resource is created and when administrative action updates the properties of the resource or its containing group. The RGM calls `Validate` before the creation or update is applied, and a failure exit code from the method on any node causes the creation or update to be canceled.

The RGM calls `Validate` only when resource or group properties are changed through administrative action, not when the RGM sets properties, or when a monitor sets the resource properties `Status` and `Status_msg`.

Note – The `Monitor_check` method also explicitly calls the `Validate` method whenever the `PROBE` method attempts to fail the data service over to a new node.

The RGM calls `Validate` with additional arguments to those passed to other methods, including the properties and values being updated. The call to `scds_initialize()` at the beginning of `xfnts_validate` parses all the arguments the RGM passes to `xfnts_validate` and stores the information in the `scds_handle` parameter. The subroutines that `xfnts_validate` calls make use of this information.

The `xfnts_validate` method calls `svc_validate()`, which verifies the following.

- The `Confdir_list` property has been set for the resource and defines a single directory.

```
scha_str_array_t *confdirs;
   confdirs = scds_get_ext_confdir_list(scds_handle);

/* Return error if there is no confdir_list extension property */
   if (confdirs == NULL || confdirs->array_cnt != 1) {
      scds_syslog(LOG_ERR,
          "Property Confdir_list is not set properly.");
      return (1); /* Validation failure */
   }
```

- The directory specified by `Confdir_list` contains the `fontserver.cfg` file.

```
(void) sprintf(xfnts_conf, "%s/fontserver.cfg", confdirs->str_array[0]);

   if (stat(xfnts_conf, &statbuf) != 0) {
      /*
       * suppress lint error because errno.h prototype
       * is missing void arg
       */
      scds_syslog(LOG_ERR,
          "Failed to access file <%s> : <%s>",
          xfnts_conf, strerror(errno));   /*lint !e746 */
      return (1);
   }
```

- The server daemon binary is accessible on the cluster node.

```
if (stat("/usr/openwin/bin/xfs", &statbuf) != 0) {
      scds_syslog(LOG_ERR,
          "Cannot access XFS binary : <%s> ", strerror(errno));
      return (1);
   }
```

- The Port_list property specifies a single port.

```
scds_port_list_t   *portlist;
   err = scds_get_port_list(scds_handle, &portlist);
   if (err != SCHA_ERR_NOERR) {
      scds_syslog(LOG_ERR,
          "Could not access property Port_list: %s.",
         scds_error_string(err));
      return (1); /* Validation Failure */
   }

#ifdef TEST
   if (portlist->num_ports != 1) {
      scds_syslog(LOG_ERR,
          "Property Port_list must have only one value.");
      scds_free_port_list(portlist);
      return (1); /* Validation Failure */
   }
#endif
```

- The resource group containing the data service also contains at least one network-address resource.

```
scds_net_resource_list_t *snrlp;
   if ((err = scds_get_rs_hostnames(scds_handle, &snrlp))
      != SCHA_ERR_NOERR) {
      scds_syslog(LOG_ERR,
          "No network address resource in resource group: %s.",
         scds_error_string(err));
      return (1); /* Validation Failure */
   }

   /* Return an error if there are no network address resources */
   if (snrlp == NULL || snrlp->num_netresources == 0) {
      scds_syslog(LOG_ERR,
          "No network address resource in resource group.");
      rc = 1;
      goto finished;
   }
```

Before it returns, `svc_validate()` frees all allocated resources.

```
finished:
   scds_free_net_list(snrlp);
   scds_free_port_list(portlist);

   return (rc); /* return result of validation */
```

Note – Before it exits, the `xfnts_validate` method calls `scds_close()` to reclaim resources allocated by `scds_initialize()`. See "`scds_initialize()` Function" on page 133 and the `scds_close`(3HA) man page for details.

`xfnts_update` Method

The RGM calls the `Update` method to notify a running resource that its properties have changed. The only properties that can be changed for the `xfnts` data service pertain to the fault monitor. Therefore, whenever a property is updated, the `xfnts_update` method calls `scds_pmf_restart_fm()` to restart the fault monitor.

```
* check if the Fault monitor is already running and if so stop
   * and restart it. The second parameter to scds_pmf_restart_fm()
   * uniquely identifies the instance of the fault monitor that needs
   * to be restarted.
   */

   scds_syslog(LOG_INFO, "Restarting the fault monitor.");
   result = scds_pmf_restart_fm(scds_handle, 0);
   if (result != SCHA_ERR_NOERR) {
      scds_syslog(LOG_ERR,
          "Failed to restart fault monitor.");
      /* Free up all the memory allocated by scds_initialize */
      scds_close(&scds_handle);
      return (1);
   }

   scds_syslog(LOG_INFO,
   "Completed successfully.");
```

Note – The second parameter to `scds_pmf_restart_fm()` uniquely identifies the instance of the fault monitor to be restarted if there are multiple instances. The value `0` in the example indicates there is only one instance of the fault monitor.

CHAPTER 9

SunPlex Agent Builder

This chapter describes SunPlex™ Agent Builder and the Cluster Agent module for Agent Builder, which are tools that automate the creation of resource types, or data services, to be run under the Resource Group Manager (RGM). A resource type essentially is a wrapper around an application to enable the application to run in a clustered environment under control of the RGM.

Agent Builder provides a screen-based interface for entering simple information about your application and the kind of resource type that you want to create. Based on the information you enter, Agent Builder generates the following software:

- A set of source files—C, Korn shell (`ksh`), or GDS (generic data service)—for a failover or scalable resource type, corresponding to the resource type's method callbacks
- A customized Resource Type Registration (RTR) file (if you generate C or Korn shell source)
- Customized utility scripts for starting, stopping, and removing an instance (resource) of the resource type, as well as customized man pages documenting how to use each of these files
- A Solaris package that includes the binaries (if you generate C source), an RTR file (if you generate C or Korn shell source), and the utility scripts

Agent Builder supports network-aware applications-applications that use the network to communicate with clients—as well as non network-aware (or stand-alone) applications. Agent Builder also enables you to generate a resource type for an application that has multiple independent process trees that the Process Monitor Facility (PMF) must monitor and restart individually (see "Creating Resource Types With Multiple Independent Process Trees" on page 162.

Topics covered in this chapter include:

- "Using Agent Builder" on page 154
- "Directory Structure" on page 165
- "Output" on page 165

- “Navigating Agent Builder” on page 169
- “Cluster Agent Module for Agent Builder” on page 172

Using Agent Builder

This section describes how to use Agent Builder, including tasks you must complete before you can use Agent Builder. This section also explains ways you can leverage Agent Builder after you have generated your resource type code.

Analyzing the Application

Before using Agent Builder you must determine if your application meets the criteria to be made highly available or scalable. Agent Builder cannot perform this analysis, which is based solely on the runtime characteristics of the application. “Analyzing the Application for Suitability” on page 25 provides more information about this topic.

Agent Builder may not always be able to create a complete resource type for your application, though in most cases Agent Builder provides at least a partial solution. For example, more sophisticated applications might require additional code that Agent Builder does not generate by default, such as code to add validation checks for additional properties or to tune parameters that Agent Builder does not expose. In these cases, you must make changes to the generated source code or to the RTR file. Agent Builder is designed to provide just this sort of flexibility.

Agent Builder places comments at certain points in the generated source code where you can add your own specific resource type code. After making changes to the source code, you can use the makefile that Agent Builder generates to recompile the source code and regenerate the resource type package.

Even if you write your entire resource type code without using any code generated by Agent Builder, you can leverage the makefile and structure that Agent Builder provides to create the Solaris package for your resource type.

Installing and Configuring Agent Builder

Agent Builder requires no special installation. Agent Builder is included in the `SUNWscdev` package, which is installed by default as part of a standard Sun Cluster software installation (the *Sun Cluster 3.1 10/03 Software Installation Guide* contains more information). Before you use Agent Builder, verify the following information:

- Java is included in your `$PATH` variable Agent Builder depends on Java (Java Development Kit version 1.3.1 or higher) and if Java is not in your `$PATH`, `scdsbuilder` returns with an error message.

- You have installed the "Developer System Support" software group of Solaris 8 or higher.
- The `cc` compiler is included in your `$PATH` variable Agent Builder uses the first occurrence of `cc` in your `$PATH` variable to identify the compiler with which to generate C binary code for the resource type. If `cc` is not included in `$PATH`, Agent Builder disables the option to generate C code (see "Using the Create Screen" on page 157.

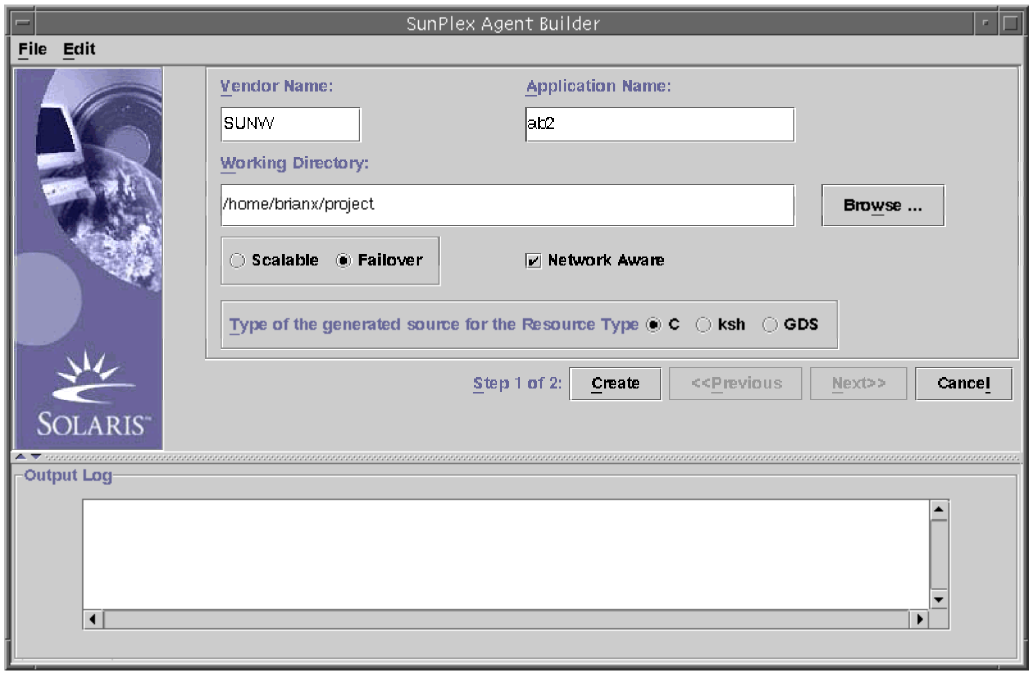
Note – You can use a different compiler with Agent Builder than the standard `cc` compiler. One way to do this is to create a symbolic link in `$PATH` from `cc` to a different compiler, such as `gcc`. Another way is to change the compiler specification in the makefile (currently, `CC=cc`) to the complete path for a different compiler. For example, in the makefile generated by Agent Builder, change `CC=cc` to `CC=`*pathname*`/gcc`. In this case you cannot run Agent Builder directly but must use the `make` and `make pkg` commands to generate data service code and a package.

Launching Agent Builder

Launch Agent Builder by entering the following command:

```
% /usr/cluster/bin/scdsbuilder
```

The initial Sun Builder screen, as shown in the following figure, appears.



Vendor Name: SUNW

Application Name: ab2

Working Directory: /home/brianx/project

○ Scalable [● Failover]

[✓ Network Aware]

Type of the generated source for the Resource Type [● C] ○ ksh ○ GDS

FIGURE 9–1 Initial Screen

Note – You can access Agent Builder through a command-line interface (see "Using the Command-Line Version of Agent Builder" on page 164) if the GUI version is not accessible.

Agent Builder provides two screens to guide you through the process of creating a new resource type:

1. **Create—**On this screen you provide basic information about the resource type to create, such as its name and the working directory (that is, the directory where you create and configure the resource type template) for the generated files. You also identify the kind of resource to create (scalable or failover), whether the base application is network aware (that is, if it uses the network to communicate with its clients), and the type of code (C, `ksh`, or GDS) to generate. For information on GDS (generic data service), see Chapter 10. You must complete the information in this screen, and select **Create** to generate the corresponding output, before you can display the Configure screen.
2. **Configure—**On this screen, you are required to provide a command to start the application. Optionally, you can provide commands to stop and probe the application. If you do not specify these commands, the generated output uses signals to stop the application and provides a default probe mechanism (see the

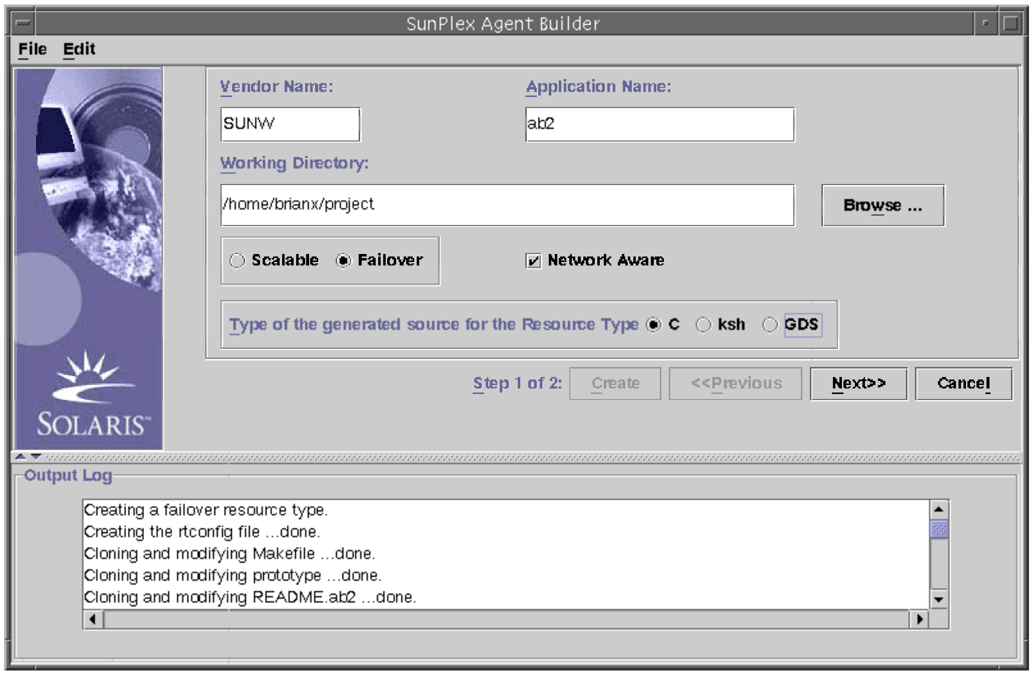
description of the probe command in “Using the Configure Screen” on page 159). This screen also enables you to change the timeout values for each of these three commands.

Note – If you launch Agent Builder from the working directory for an existing resource type, Agent Builder initializes the Create and Configure screens to the values of the existing resource type.

See “Navigating Agent Builder” on page 169 if you have questions about how to use any of the buttons or menu commands on either of the Agent Builder screens.

Using the Create Screen

The first step in creating a resource type is to fill out the Create screen, which appears when you launch Agent Builder. The following figure shows the Create screen after you enter information in the fields.



Vendor Name: SUNW

Application Name: ab2

Working Directory: /home/brianx/project

( ) Scalable [✓ Failover]

[✓] Network Aware

Type of the generated source for the Resource Type [✓ C] ( ) ksh ( ) GDS

```
Creating a failover resource type.
Creating the rtconfig file ...done.
Cloning and modifying Makefile ...done.
Cloning and modifying prototype ...done.
Cloning and modifying README.ab2 ...done.
```

FIGURE 9–2 Create Screen

The Create screen contains the following fields, radio buttons, and check box:

- **Vendor Name —** A name to identify the vendor of the resource type. Typically, you specify the stock symbol of the vendor, but any name that uniquely identifies the vendor is valid. Use alphanumeric characters only.
- **Application Name —** The name of the resource type. Use alphanumeric characters only.

Note – Together, the vendor name and application name make up the full name of the resource type. The full name must not exceed nine characters.

- **Working Directory —** The directory under which Agent Builder creates a directory structure to contain all the files created for the target resource type. You can create only one resource type in any one working directory. Agent Builder initializes this field to the path of the directory from which you launched Agent Builder, though you can type a different name or use the **Browse** button to locate a different directory.

  Under the working directory, Agent Builder creates a subdirectory with the resource-type name. For example, if `SUNW` is the vendor name and `ftp` is the application name, then Agent Builder names this subdirectory `SUNWftp`.

  Agent Builder places all the directories and files for the target resource type under this subdirectory (see "Directory Structure" on page 165).
- **Scalable or Failover —** Specify whether the target resource type will be failover or scalable.
- **Network Aware —** Specify whether the base application is network aware; that is, if it uses the network to communicate with its clients. Check the box to specify network aware; leave it blank to specify non-network aware. Korn shell code requires that the application be network aware. Therefore, Agent Builder checks this box, and grays it out if you check the **ksh** or the **GDS** button.
- **C, ksh —** Specify the language of the generated source code. Although these options are mutually exclusive, with Agent Builder you can create a resource type with `ksh` generated code and then reuse the same information to create C generated code (see "Cloning an Existing Resource Type" on page 163).
- **GDS —** Specifies that this service is a generic data service. See Chapter 10 for information about creating and configuring a generic data service.

Note – If the `cc` compiler is not in your `$PATH`, Agent Builder grays out the C option button and puts a check in the **ksh** button. To specify a different compiler, see the note at the end of "Installing and Configuring Agent Builder" on page 154.

After you have entered the required information, click the **Create** button. The Output Log at the bottom of the screen shows the actions that Agent Builder is taking. You can use the **Save Output Log** command in the Edit menu to save the information in the output log.

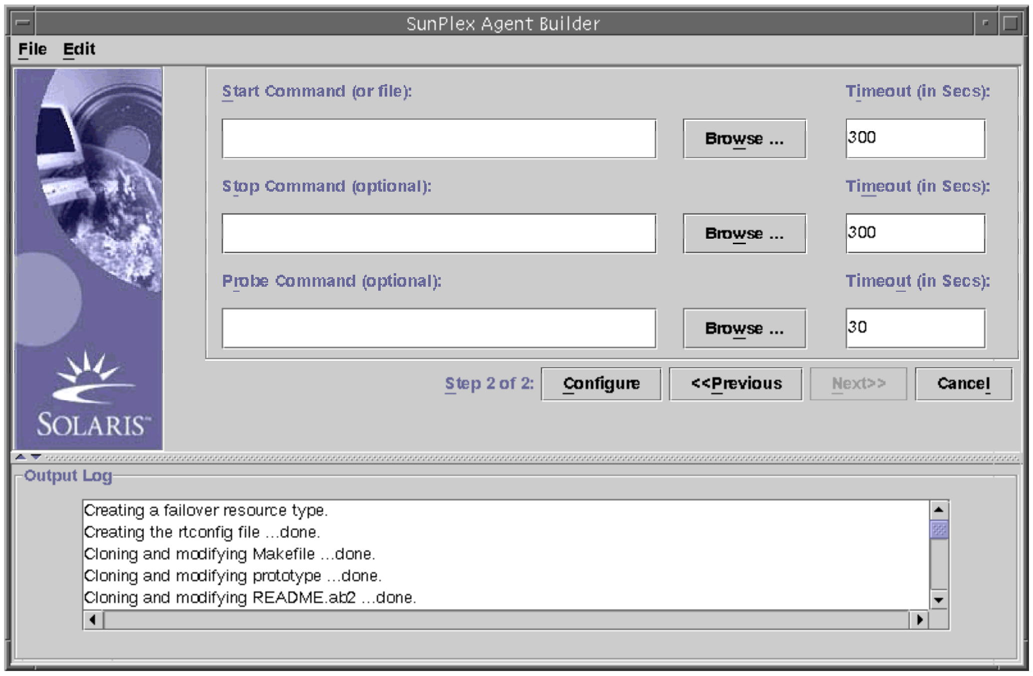
When finished, Agent Builder displays either a success message or a warning message that it was unable to complete this step, and you should check the output log for details.

If Agent Builder completes successfully, you can Click the **Next** button to bring up the Configure screen, which enables you to finish generating the resource type.

Note – Although generation of a complete resource type is a two-step process, you can exit Agent Builder after completing the first step (create) without losing the information you have entered or the work that Agent Builder has completed (see "Reusing Completed Work" on page 163).

Using the Configure Screen

The Configure screen, shown in the following figure, appears after Agent Builder finishes creating the resource type and you select the **Next** button on the Create screen. You cannot access the Configure screen before the resource type has been created.



300
300
30

```
Creating a failover resource type.
Creating the rtconfig file ...done.
Cloning and modifying Makefile ...done.
Cloning and modifying prototype ...done.
Cloning and modifying README.ab2 ...done.
```

FIGURE 9–3 Configure Screen

The Configure screen contains the following fields:

- **Start Command —** The full command line that can be passed to any UNIX shell to start the base application. It is required that you specify this command. You can type the command in the field provided or use the **Browse** button to locate a file containing the command to start the application.

  The complete command line must include everything necessary to start the application, such as hostnames, port numbers, a path to configuration files, and so on. If your application requires a hostname to be specified on the command line, you can use the `$hostnames` variable that Agent Builder defines (see "Using the Agent Builder `$hostnames` Variable" on page 161).

  Do not enclose the command in double quotes ("").

  Note – If the base application has multiple independent process trees, each of which is started with its own tag under PMF control, you cannot specify a single command. Rather, you must create a text file with individual commands to start each process tree, and specify the path to this file in the Start Command text field. See "Creating Resource Types With Multiple Independent Process Trees" on page 162, which lists some special characteristics this file requires to work properly.

- **Stop Command —** The full command line that can be passed to any UNIX shell to stop the base application. You can type the command in the field provided or use the Browse button to locate a file containing the command to stop the application. If your application requires a hostname to be specified on the command line, you can use the `$hostnames` variable defined by Agent Builder (see "Using the Agent Builder `$hostnames` Variable" on page 161).

  This command is optional. If you do not specify a stop command, the generated code uses signals (in the `Stop` method) to stop the application, as follows.

  - The `Stop` method sends `SIGTERM` to stop the application and waits for 80% of the timeout value for the application to exit.
  - If the `SIGTERM` signal is unsuccessful, the `Stop` method sends `SIGKILL` to stop the application and waits for 15% of the timeout value for the application to exit.
  - If `SIGKILL` is unsuccessful the `Stop` method exits unsuccessfully (the remaining 5% of the timeout value is considered overhead).

Caution – Be certain the stop command does not return before the application has stopped completely.

- **Probe Command —** A command that can be run periodically to check the health of the application and return an appropriate exit status between 0 (success) and 100 (complete failure). This command is optional. You can type the complete path to the command or use the Browse button to locate a file that contains the commands to probe the application.

  Typically, you specify a simple client of the base application. If you do not specify a probe command, the generated code simply connects to and disconnects from the port used by the resource, and if that succeeds, declares the application healthy. You can only use a probe command with network aware applications. Agent Builder always generates a probe command, but disables it for non-network aware applications.

  If your application requires that you specify a hostname on the probe command line, you can use the `$hostnames` variable that Agent Builder defines (see "Using the Agent Builder `$hostnames` Variable" on page 161).
- **Timeout —** (for each command)—A timeout value (in seconds) for each command. You can specify a new value or accept the default value Agent Builder provides (300 seconds for start and stop, 30 seconds for probe).

Using the Agent Builder `$hostnames` Variable

For many applications, specifically network-aware applications, the hostname on which the application listens and services customer requests must be passed to the application on the command line. Therefore, in many cases, hostname is a parameter you must specify for start, stop, and probe commands for the target resource type (on the Configure screen). However, the hostname on which an application listens is cluster specific—it is determined when the resource is run on a cluster and cannot be determined when Agent Builder generates your resource type code.

To solve this problem, Agent Builder provides the `$hostnames` variable that you can specify on the command line for the start, stop, and probe commands. You specify the `$hostnames` variable exactly as you would an actual hostname, for example:

```
/opt/network_aware/echo_server -p port_no -l $hostnames
```

When a resource of the target resource type is run on a cluster, the LogicalHostname or SharedAddress hostname configured for that resource (in the `Network_resources_used` resource property of the resource) is substituted for the value of the `$hostnames` variable.

If you configure the `Network_resources_used` property with multiple hostnames, the `$hostnames` variable contains all of them separated by commas.

Creating Resource Types With Multiple Independent Process Trees

Agent Builder can create resource types for applications that have more than one independent process tree. These process trees are independent in the sense that PMF monitors and starts them individually. PMF starts each process tree with its own tag.

Note – Agent Builder enables you to create resource types with multiple independent process trees only if the generated source code that you specify is C. You cannot use Agent Builder to create these resource types for `ksh` or for GDS. To create these resource types for `ksh` or for GDS, you must write the code by hand.

In the case of a base application with multiple independent process trees, you cannot specify a single command line to start the application. Rather, you must create a text file, with each line specifying the full path to a command to start one of the application's process trees. This file must not contain any blank lines. You specify this text file in the Start Command text field in the Configure screen.

You must also make certain this text file does not have execute permissions. This enables Agent Builder to distinguish this file, whose purpose is to start multiple process trees, from a simple executable script containing multiple commands. If this text file is given execute permissions, the resources would come up fine on a cluster, but all the commands would be started under one PMF tag, precluding the possibility of monitoring and restarting the process trees individually by PMF.

Reusing Completed Work

Agent Builder enables you leverage completed work in several ways.

- You can clone an existing resource type created with Agent Builder.
- You can edit the source code Agent Builder generates and then recompile the code to create a new package.

Cloning an Existing Resource Type

Follow this procedure to clone an existing resource type generated by Agent Builder.

1. **Load an existing resource type into Agent Builder. You can do this in either of two ways:**

   a. **Launch Agent Builder from the working directory (which contains the `rtconfig` file) for an existing resource type (created with Agent Builder), and Agent Builder loads the values for that resource type in the Create and Configure screens.**

   b. **Use the Load Resource Type command in the File menu.**

2. **Change the working directory on the Create screen.**

   You must use the **Browse** button to select a directory—typing a new directory name is not sufficient. After you select a directory, Agent Builder re-enables the **Create** button.

3. **Make changes.**

   You might use this procedure to change the type of code generated for the resource type. For example, if you initially create a `ksh` version of a resource type but find over time that you require a C version, you can load the existing `ksh` resource type, change the language for the output to C, and then have Agent Builder build a C version of the resource type.

4. **Create the cloned resource type.**

   Select **Create** to create the resource type. Select **Next** to bring up the Configure screen. Select **Configure** to configure the resource type and then **Cancel** to finish.

Editing the Generated Source Code

To keep the process of creating a resource type simple, Agent Builder limits the number of inputs, which necessarily limits the scope of the generated resource type. Therefore, to add more sophisticated features, such as validation checks for additional properties, or to tune parameters Agent Builder does not expose, you need to modify the generated source code or the RTR file.

The source files are in the *install_directory*/*rt_name*/`src` directory. Agent Builder embeds comments in the source code at places you can add code. These comments are of the form (for C code):

```
/* User added code -- BEGIN vvvvvvvvvvvvvvv */
/* User added code -- END   ^^^^^^^^^^^^^^^ */
```

Note – These comments are identical in Korn shell code, except they use the pound sign (#) to begin the comment line.

For example, *rt_name*`.h` declares all the utility routines that the different programs use. At the end of the list of declarations are comments that enable you to declare additional routines you might have added to any of your code.

Agent Builder also generates the makefile in the *install_directory*/*rt_name*/`src` directory, with appropriate targets. Use the `make` command to recompile the source code, and the `make pkg` command to regenerate the resource type package.

The RTR file is in the *install_directory*/*rt_name*/`etc` directory. You can edit the RTR file with a standard text editor (see “Setting Resource and Resource Type Properties” on page 30 for more information about the RTR file and Appendix A for information about properties).

Using the Command-Line Version of Agent Builder

The command-line version of Agent Builder has the same two-step process as the graphical user interface. However, instead of entering information in the graphical user interface, you pass parameters to the commands `scdscreate`(1HA) and `scdsconfig`(1HA).

Follow these steps to use the command-line version of Agent Builder:

1. **Use `scdscreate` to create a Sun Cluster resource type template for making an application highly available (HA) or scalable.**

2. **Use `scdsconfigure` to configure the resource type template that you created with `scdscreate`.**

3. **Change directories to the `pkg` subdirectory in the working directory.**

4. **Use the `pkgadd`(1M) command to install the packages that you created with `scdscreate`.**

5. **If you want, edit the generated source code.**

6. **Run the start script.**

Directory Structure

Agent Builder creates a directory structure to hold all the files it generates for the target resource type. You specify (on the **Create** screen) the working directory. You must specify separate install directories for any additional resource types you develop. Under the working directory, Agent Builder creates a subdirectory whose name is a concatenation of the vendor name and the resource-type name (from the **Create** screen). For example, if you specify `SUNW` as the vendor name and create a resource type called `ftp`, Agent Builder creates a directory called `SUNWftp` under the working directory.

Under this subdirectory, Agent Builder creates and populates the directories listed in the following table.

Directory Name	Contents
`bin`	For C output, contains the binary files compiled from the source files. For `ksh` output, contains the same files as the `src` directory.
`etc`	Contains the RTR file. Agent Builder concatenates the vendor name and application name, separated by a period (.), to form the RTR filename. For example, if the vendor name is `SUNW` and the name of the resource type is `ftp`, the name of the RTR file is `SUNW.ftp`.
`man`	Contains customized (man1m) man pages for the `start`, `stop`, and `remove` utility scripts. For example, `startftp`(1M), `stopftp`(1M), and `removeftp`(1M). To view these man pages, specify the path with the `man -M` option. For example, `man -M` *install_directory*`/SUNWftp/man removeftp`.
`pkg`	Contains the final package.
`src`	Contains the source files that Agent Builder generates.
`util`	Contains the `start`, `stop`, and `remove` utility scripts that Agent Builder generates. See "Utility Scripts and man Pages" on page 167. Agent Builder appends the application name to each of these script names; for example, `startftp`, `stopftp`, `removeftp`.

Output

This section describes the output that Agent Builder generates.

Source and Binary Files

The Resource Group Manager (RGM)—which manages resource groups and ultimately, resources on a cluster—works on a callback model. When specific events happen, such as a node failure, the RGM calls the resource type's methods for each of the resources running on the affected node. For example, the RGM calls the `Stop` method to stop a resource running on the affected node and then calls the resource's `Start` method to start the resource on a different node. (See "RGM Model" on page 19, "Callback Methods" on page 21 and the `rt_callbacks`(1HA) man page for more information on this model).

To support this model, Agent Builder generates (in the *install_directory*/*rt_name*/`bin` directory) eight executable programs (C) or scripts (`ksh`) that serve as callback methods.

Note – Strictly speaking, the *rt_name*`_probe` program, which implements a fault monitor, is not a callback program. The RGM does not directly call *rt_name*`_probe` but rather calls *rt_name*`_monitor_start` and *rt_name*`_monitor_stop`, which start and stop the fault monitor by calling *rt_name*`_probe`.

The eight methods that Agent Builder generates are:

- *rt_name*`_monitor_check`
- *rt_name*`_monitor_start`
- *rt_name*`_monitor_stop`
- *rt_name*`_probe`
- *rt_name*`_svc_start`
- *rt_name*`_svc_stop`
- *rt_name*`_update`
- *rt_name*`_validate`

Refer to the `rt_callbacks`(1HA) man page for specific information on each of these methods.

In the *install_directory*/*rt_name*/`src` directory (C output), Agent Builder generates the following files:

- A header file (*rt_name*`.h`).
- A source file (*rt_name*`.c`) containing code common to all methods.
- An object file (*rt_name*`.o`) for the common code.
- Source files (`*.c`) for each of the methods.
- Object files (`*.o`) for each of the methods.

Agent Builder links the *rt_name*`.o` file to each of the method `.o` files to create the executables in the *install_directory*/*rt_name*/`bin` directory.

For `ksh` output, the *install_directory*/*rt_name*/`bin` and *install_directory*/*rt_name*/`src` directories are identical—each contains the eight executable scripts corresponding to the seven callback methods and the `PROBE` method.

Note – The `ksh` output includes two compiled utility programs (`gettime` and `gethostnames`) that certain of the callback methods require for getting the time and probing.

You can edit the source code, run the `make` command to recompile the code, and when you are finished, run the `make pkg` command to generate a new package. To support making changes to the source code, Agent Builder embeds comments in the source code at appropriate locations to add code. See "Editing the Generated Source Code" on page 163.

Utility Scripts and man Pages

Once you have generated a resource type and installed its package on a cluster, you must still get an instance (resource) of the resource type running on a cluster, generally by using administrative commands or SunPlex Manager. However, as a convenience, Agent Builder generates a customized utility script for this purpose (the start script) as well as scripts for stopping and removing a resource of the target resource type. These three scripts, located in the *install_directory*/*rt_name*/`util` directory, do the following:

- **Start script**—registers the resource type, and creates the necessary resource groups and resources. It also creates the network address resources (LogicalHostname or SharedAddress) that enable the application to communicate with the clients on the network.
- **Stop script**—stops and disables the resource.
- **Remove script**—undoes the work of the start script, that is, it stops and removes the resources, resource groups, and the target resource type from the system.

Note – You can only use the remove script with a resource started by the corresponding start script because these scripts use internal conventions to name resources and resource groups.

Agent Builder names these scripts by appending the application name to the script names. For example, if the application name is `ftp`, the scripts are called `startftp`, `stopftp`, and `removeftp`.

Agent Builder provides man pages in the *install_directory*/*rt_name*/`man/man1m` directory for each of the utility scripts. You should read these man pages before you launch these scripts because they document the parameters you need to pass to the script.

To view these man pages, specify the path to this man directory using the `-M` option with the `man` command. For example, if `SUNW` is the vendor and `ftp` is the application name, use the following command to view the `startftp`(1M) man page:

```
man -M install_directory/SUNWftp/man startftp
```

The man page utility scripts are also available to the cluster administrator. When an Agent Builder-generated package is installed on a cluster, the man pages for the utility scripts are placed in the `/opt/`*rt_name*`/man` directory. For example, use the following command to view the `startftp`(1M) man page:

```
man -M /opt/SUNWftp/man startftp
```

Support Files

Agent Builder places support files, such as `pkginfo`, `postinstall`, `postremove`, and `preremove`, in the *install_directory*/*rt_name*/`etc` directory. This directory also contains the resource type registration (RTR) file, which declares resource and resource type properties available for the target resource type and initializes property values at the time a resource is registered with a cluster (see "Setting Resource and Resource Type Properties" on page 30 for more information). The RTR file is named as *vendor_name*.*resource_type_name*—for example, `SUNW.ftp`.

You can edit this file with a standard text editor and make changes without recompiling your source code. However, you must rebuild the package with the `make pkg` command.

Package Directory

The *install_directory*/*rt_name*/`pkg` directory contains a Solaris package. The name of the package is a concatenation of the vendor name and the application name, for example, `SUNWftp`. The `Makefile` in the *install_directory*/*rt_name*/`src` directory supports creation of a new package. For example, if you make changes to the source files and recompile the code, or make changes to the package utility scripts, use the `make pkg` command to create a new package.

When you remove a package from a cluster, the `pkgrm` command can fail if you attempt to run the command from more than one node simultaneously. You can solve this problem in one of two ways:

- Run the `remove`*rt_name* script from one node of the cluster before running `pkgrm` from any node.

- Run `pkgrm` from one node of the cluster, which takes care of all necessary clean up, then run `pkgrm` from the remaining nodes, simultaneously if necessary.

If `pkgrm` fails because you attempt to run it simultaneously from multiple nodes, run it again from one node then run it from the remaining nodes.

The `rtconfig` File

If you generate C or `ksh` source code, in the working directory, Agent Builder generates a configuration file `rtconfig`, which contains the information that you entered on the Create and Configure screens. If you launch Agent Builder from the working directory for an existing resource type (or load an existing resource type using the File menu **Load Resource Type** command), Agent Builder reads the `rtconfig` file and fills in the Create and Configure screens with the information that you provided for the existing resource type. This feature is useful if you want to clone an existing resource type (see "Cloning an Existing Resource Type" on page 163.

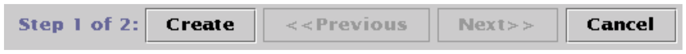
Navigating Agent Builder

Navigating Agent Builder is simple and intuitive. Agent Builder is a two-step wizard with a corresponding screen for each step (Create and Configure screens). You enter information in each screen by:

- Typing information in a field.
- Browsing your directory structure and selecting a file or directory.
- Checking one of a set of mutually exclusive radio buttons—for example, **Scalable** or **Failover**.
- Checking an on/off box. For example, checking **Network Aware** identifies the base application as network aware, while leaving this box blank identifies a non-network aware application.

The buttons at the bottom of each screen enable you to complete the task, move to the next or previous screen, or exit Agent Builder. Agent Builder highlights or grays out these buttons as appropriate.

For example, when you have filled in the fields and checked the desired options on the Create screen, click the **Create** button at the bottom of the screen. The **Previous** and **Next** buttons are grayed out because no previous screen exists and you cannot go to the next step before you complete this one.

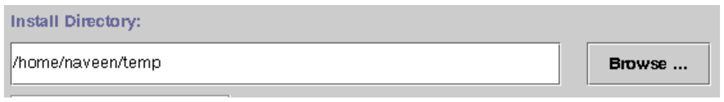


Agent Builder displays progress messages in the output log area at the bottom of the screen. When Agent Builder finishes, it displays a success message, or a warning to look at the output log. The **Next** button is highlighted, or if this is the last screen, only the **Cancel** button is highlighted.

You can select **Cancel** at any time to exit Agent Builder.

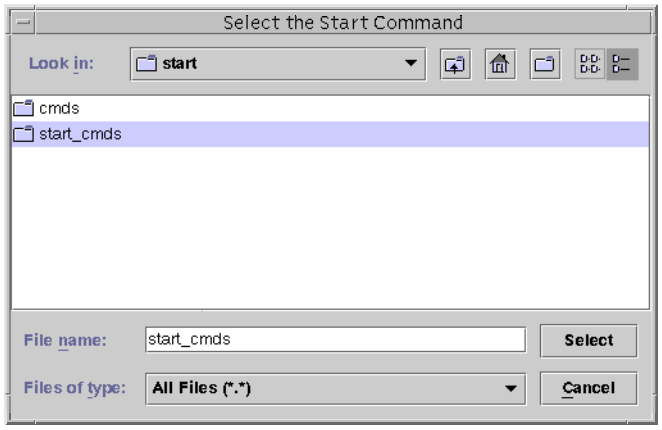
Browse Button

Particular Agent Builder fields enable you to type information or to click the **Browse** button to browse your directory structure and select a file or directory.


Install Directory:

/home/naveen/temp

When you click **Browse**, a screen similar to the following screen appears:



File name: start_cmds

Files of type: All Files (*.*)

Double click on a folder to open it. When you highlight a file, its name appears in the **File name** box. Click **Select** when you have located and highlighted the appropriate file.

Note – If you are browsing for a directory, highlight it and select the **Open** button. If there are no subdirectories, Agent Builder closes the browse window and places the name of the directory you highlighted in the appropriate field. If this directory has subdirectories, click the close button to close the browse window and return to the previous screen. Agent Builder places the name of the directory you highlighted in the appropriate field.

The icons in the upper right corner of the screen do the following:

This icon moves you up one level in the directory tree.

This icon returns you to the home folder.

This icon creates a new folder under the currently selected folder.

This icon, for toggling between different views, is reserved for future use.

Menus

Agent Builder provides File and Edit menus.

File Menu

The File men has two commands:

- **Load Resource Type —** Load an existing resource type. Agent Builder provides a browse screen from which you select the working directory for an existing resource type. If a resource type exists in the directory from which you launch Agent Builder, Agent Builder automatically loads the resource type. The **Load Resource Type** command allows you to launch Agent Builder from any directory and select an existing resource type to use as a template for creating a new resource type (see "Cloning an Existing Resource Type" on page 163).

- **Exit —** Exit Agent Builder. You can also exit by clicking **Cancel** on the Create or Configure screen.

Edit Menu

The Edit menu has commands to clear and save the output log:

- **Clear Output Log —** Clears the information from the output log. Each time you select Create or Configure, Agent Builder appends status messages to the output log. If you are engaged in an iterative process of making changes to your source code and regenerating output in Agent Builder and want to segregate the status messages, you can save and clear the log file before each use.
- **Save Log File —** Save the log output to a file. Agent Builder provides a browse screen that enables you to choose the directory and specify a filename.

Cluster Agent Module for Agent Builder

The Cluster Agent module for Agent Builder is a NetBeans™ module. The Cluster Agent module enables users of the Sun™ ONE Studio product to create resource types, or data services, for the Sun Cluster software through an integrated development environment. The Cluster Agent module provides a screen-based interface for describing the kind of resource type that you want to create.

Note – The Sun ONE Studio documentation contains information about how to set up, install, and use the Sun ONE Studio product.

▼ Installing and Setting Up the Cluster Agent Module

The Cluster Agent module is installed when you install the Sun Cluster software. The Sun Cluster installation tool places the Cluster Agent module file `scdsbuilder.jar` in `/usr/cluster/lib/scdsbuilder`. To use the Cluster Agent module with the Sun ONE Studio software, you need to create a symbolic link to this file.

Note – The Sun Cluster and Sun ONE Studio products and Java™ 1.4 must be installed and available to the system on which you intend to run the Cluster Agent module.

---

1. **Do you want to enable all users or only yourself to use the Cluster Agent module?**

   - To enable all users, become superuser or assume an equivalent role and create the symbolic link in the global module directory:

     ```
     # cd /opt/s1studio/ee/modules
     # ln -s /usr/cluster/lib/scdsbuilder/scdsbuilder.jar
     ```

     Note – If you installed the Sun ONE Studio software in a directory other than `/opt/s1studio/ee`, substitute this directory path with the path that you used.

   - To enable only yourself, create the symbolic link in your `modules` subdirectory:

     ```
     % cd ~your-home-dir/ffjuser40ee/modules
     % ln -s /usr/cluster/lib/scdsbuilder/scdsbuilder.jar
     ```

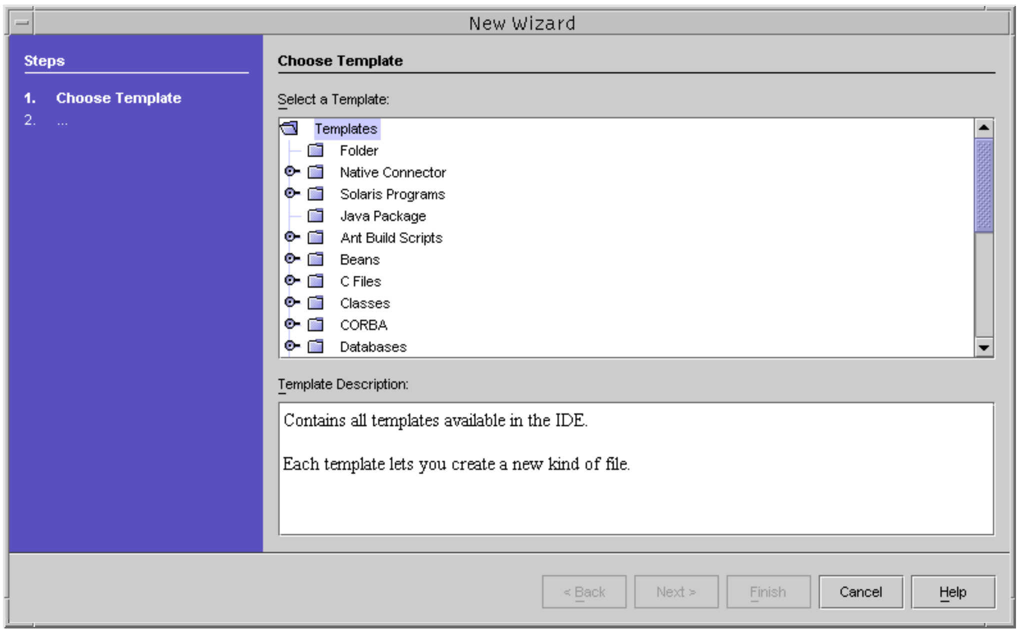
2. **Stop and restart the Sun ONE Studio software.**

▼ Starting the Cluster Agent Module

The following steps describe how to start the Cluster Agent module from the Sun ONE Studio software.

1. **From the Sun ONE Studio File menu, select New, or click this icon on the toolbar:**

   The New Wizard screen appears.

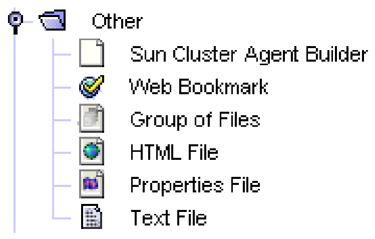


Contains all templates available in the IDE.

Each template lets you create a new kind of file.

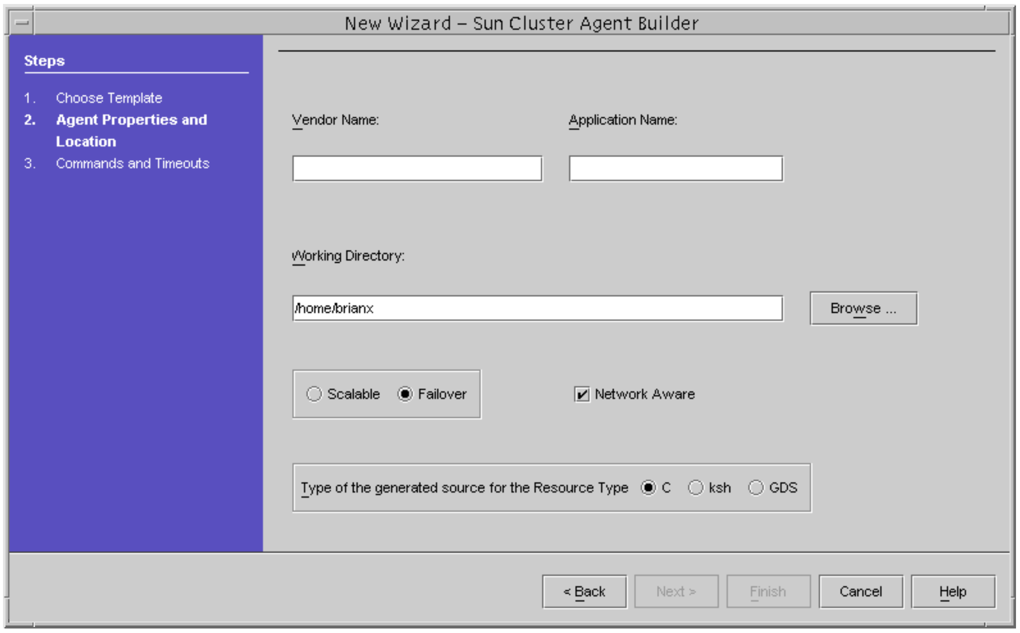
2. **In the Select a Template window, scroll down (if necessary) and click the key next to the Other folder:**

The Other menu opens.



3. **From the Other menu, select Sun Cluster Agent Builder and click Next.**

   The Cluster Agent module for Sun One Studio starts. The first New Wizard - Sun Cluster Agent Builder screen appears.



Vendor Name:

Application Name:

Working Directory: /home/brianx

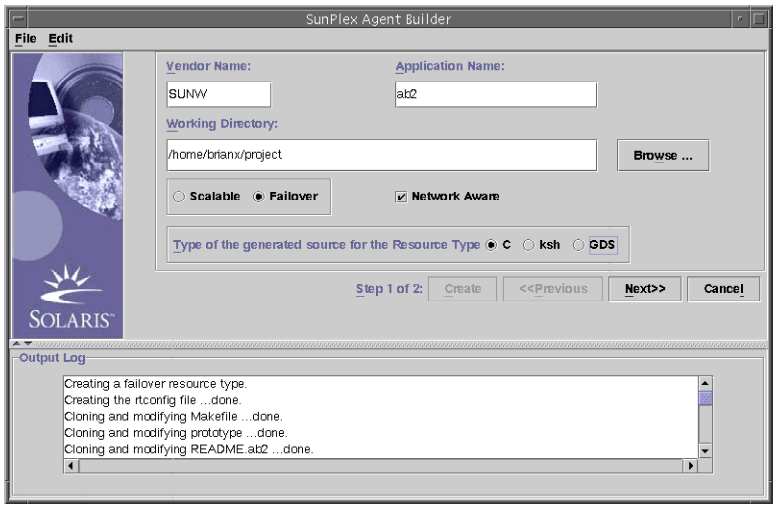
( ) Scalable [✓ Failover]

[✓ Network Aware]

Type of the generated source for the Resource Type [✓ C] ( ) ksh ( ) GDS

Using the Cluster Agent Module

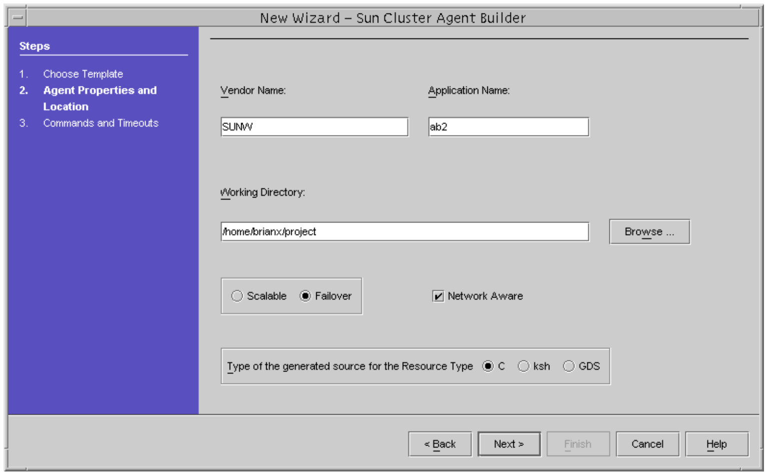
Use the Cluster Agent module as you would the Agent Builder software. The interfaces are identical. For example, the following figures show that the Create screen in the Agent Builder software and the first New Wizard - Sun Cluster Agent Builder screen in the Cluster Agent module contain the same fields and selections.



Vendor Name: SUNW
Application Name: ab2
Working Directory: /home/brianx/project
Scalable [✓ Failover]
[✓ Network Aware]
Type of the generated source for the Resource Type [✓ C] ksh GDS

```
Creating a failover resource type.
Creating the rtconfig file ...done.
Cloning and modifying Makefile ...done.
Cloning and modifying prototype ...done.
Cloning and modifying README.ab2 ...done.
```

FIGURE 9–4 Create Screen in the Agent Builder Software



Vendor Name: SUNW
Application Name: ab2
Working Directory: /home/brianx/project
Scalable [✓ Failover]
[✓ Network Aware]
Type of the generated source for the Resource Type [✓ C] ksh GDS

FIGURE 9–5 New Wizard - Sun Cluster Agent Builder Screen in the Cluster Agent Module

Differences Between the Cluster Agent Module and Agent Builder

Despite the similarities between the Cluster Agent module and Agent Builder, minor differences exist:

- In the Cluster Agent module, the resource type is created and configured only after you click Finish on the second New Wizard - Sun Cluster Agent Builder screen. The resource type is *not* created when you click Next on the first New Wizard - Sun Cluster Agent Builder screen.

  In Agent Builder, the resource type is immediately created when you click Create on the Create screen and configured when you click Configure on the Configure screen.
- The information that appears in the Output Log window in Agent Builder appears in a separate output window in the Sun ONE Studio product.

CHAPTER **10**

Generic Data Services

This chapter provides information on the generic data service (GDS) and shows you how to create a service that uses the GDS using either the SunPlex Agent Builder or the standard Sun Cluster administration commands.

Overview of GDS

The GDS is a mechanism for making simple network-aware applications highly available or scalable by plugging them into the Sun Cluster Resource Group Management framework. This mechanism does not require the coding of an agent which is the typical approach for making an application highly available or scalable.

The GDS is a single, precompiled data service. You cannot modify the precompiled data service and its components, the callback method (`rt_callbacks`(1HA)) implementations and the resource type registration file (`rt_reg`(4)).

Precompiled Resource Type

The generic data service resource type `SUNW.gds` is included in the `SUNWscgds` package. The `scinstall`(1M) utility installs this package during cluster installation. The `SUNWscgds` package includes the following files:

```
# pkgchk -v SUNWscgds
```

```
/opt/SUNWscgds
/opt/SUNWscgds/bin
/opt/SUNWscgds/bin/gds_monitor_check
/opt/SUNWscgds/bin/gds_monitor_start
/opt/SUNWscgds/bin/gds_monitor_stop
/opt/SUNWscgds/bin/gds_probe
/opt/SUNWscgds/bin/gds_svc_start
/opt/SUNWscgds/bin/gds_svc_stop
/opt/SUNWscgds/bin/gds_update
/opt/SUNWscgds/bin/gds_validate
/opt/SUNWscgds/etc
/opt/SUNWscgds/etc/SUNW.gds
```

Why Use GDS

The GDS has the following advantages over using either the SunPlex Agent Builder generated source code model (see `scdscreate`(1HA)) or the standard Sun Cluster administration commands:

- The GDS is easy to use.
- The GDS and its methods are precompiled and are therefore not modifiable.
- The SunPlex Agent Builder can be used to generate driving scripts for your application and these scripts are packaged in a Solaris-installable package that can be reused across multiple clusters.

Ways to Create a Service That Uses GDS

There are two ways to create a service that uses the GDS:

- Using the SunPlex Agent Builder
- Using the standard Sun Cluster administration commands

GDS and the SunPlex Agent Builder

Use the SunPlex Agent Builder and select GDS as the type of generated source code. The user input is used to generate a set of driving scripts that configure resources for the given application.

GDS and the Standard Sun Cluster Administration Commands

This method uses the precompiled data service code in `SUNWscgds` but requires that the system administrator use the standard Sun Cluster administration commands (`scrgadm`(1M) and `scswitch`(1M)) to create and configure the resource.

Selecting the Method to Use to Create a GDS-Based Service

As shown in the procedures "How to Use Sun Cluster Administration Commands to Create a Highly Available Service Using GDS" on page 189 and "Standard Sun Cluster Administration Commands to Create a Scalable Service Using GDS" on page 190, a significant amount of typing is required to issue the appropriate `scrgadm` and `scswitch` commands.

Using the GDS with SunPlex Agent Builder simplifies the process because it generates the driving scripts that issue the `scrgadm` and `scswitch` commands for you.

When Is GDS Not Appropriate

While using the GDS has many advantages, there are instances when it is not appropriate to use the GDS. The GDS is not appropriate:

- When more control is required than is available using the precompiled resource type. such as when you need to add extension properties or change the defaults.
- When the source code needs to be modified to add special functions.
- When you want to use multiple process trees.
- When you want to use non-network-aware applications.

Required Properties for GDS

The following properties must be provided:

- `Start_command` (extension property)
- `Port_list`

`Start_command` Extension Property

The start command, which you specify in the `Start_command` extension property, launches the application. It must be a UNIX command complete with its arguments that can be passed directly to a shell to start the application.

`Port_list` Property

The `Port_list` property identifies the list of ports that the application listens on. The `Port_list` property must be specified on the start script created by the SunPlex Agent Builder or on the `scrgadm` command if you are using the standard Sun Cluster administration commands.

Optional Properties for GDS

Optional GDS properties include:

- `Network_resources_used`
- `Stop_command` (extension property)
- `Probe_command`(extension property)
- `Start_timeout`
- `Stop_timeout`
- `Probe_timeout` (extension property)
- `Child_mon_level` (extension property only used with the standard administration commands)
- `Failover_enabled` (extension property)
- `Stop_signal` (extension property)

`Network_resources_used` Property

The default value for this property is null. This property must be specified if the application needs to bind to one or more specific addresses. If this property is omitted or is specified as Null, the application is assumed to listen on all addresses.

Before creating the GDS resource, a `LogicalHostname` or `SharedAddress` resource must already have been configured. See the *Sun Cluster 3.1 Data Service Planning and Administration Guide* for information about how to configure a `LogicalHostname` or `SharedAddress` resource.

To specify a value, specify one or more resource names; each resource name can contain one or more `LogicalHostname` or one or more `SharedAddress`. See `r_properties`(5) for details.

`Stop_command` Property

The stop command must stop the application and only return after the application has been completely stopped. It must be a complete UNIX command that can be passed directly to a shell to stop the application.

If the `Stop_command` is provided, the GDS stop method launches the stop command with 80% of the stop timeout. Regardless of the outcome of launching the stop command, the GDS stop method sends `SIGKILL` with 15% of the stop timeout. The remaining 5% of the time is reserved for housekeeping overhead.

If the stop command is omitted, the GDS tries to stop the application using the signal specified in `Stop_signal`.

`Probe_command` Property

The probe command periodically checks the health of the given application. It must be a UNIX command complete with its arguments that can be passed directly to a shell to probe the application. The probe command returns with an exit status of 0 if the application is OK.

The exit status of the probe command is used to determine the severity of the failure of the application. This exit status, called probe status, must be an integer between 0 (for success) and 100 (for complete failure). The probe status can also be a special value of 201 which results in immediate failover of the application unless `Failover_enabled` is set to false. The probe status is used within the GDS probing algorithm (see `scds_fm_action`(3HA) to make the decision about restarting the application locally versus failing it over to another node; if the exit status is 201, the application is immediately failed over.

If the probe command is omitted, the GDS provides its own simple probe that connects to the application on the set of IP addresses derived from the `Network_resources_used` property or the output of `scds_get_netaddr_list`(3HA). If the connect succeeds, it disconnects immediately. If both connect and disconnect succeed, the application is deemed to be running healthily.

Note – The probe provided with the GDS is only intended to be a simple substitute for the fully functioning application-specific probe.

`Start_timeout` Property

This property specifies the start timeout for the start command (see "`Start_command` Extension Property" on page 181 for additional information). The default for `Start_timeout` is 300 seconds.

`Stop_timeout` Property

This property specifies the stop timeout for the stop command (see "`Stop_command` Property" on page 182 for the additional information. The default for `Stop_timeout` is 300 seconds.

`Probe_timeout` Property

This property specifies the timeout value for the probe command (see "`Probe_command` Property" on page 183 for additional information. The default for `Probe_timeout` is 30 seconds.

`Child_mon_level` Property

This property provides control over which processes get monitored through PMF. It denotes the level up to which the forked children processes are monitored. This is similar to the `-C` argument to the `pmfadm`(1M) command.

Omitting this property, or setting it to the default value of `-1`, has the same effect as omitting the `-C` option on the `pmfadm` command; that is, all children (and their descendents) will be monitored.

Note – This option can only be specified using the standard Sun Cluster administration commands. This option cannot be specified if you are using the SunPlex Agent Builder.

`Failover_enabled` Property

This boolean extension property controls the failover behavior of the resource. If this extension property is set to `true`, the application fails over when the number of restarts exceeds the `retry_count` within the `retry_interval` number of seconds.

If this extension property is set to `false`, the application does not restart or fail over to another node when the number of restarts exceed the `retry_count` within the `retry_interval` number of seconds.

This extension property can be used to prevent the application resource from initiating a failover of the resource group. The default is `true`.

`Stop_signal` Property

The GDS uses the value of this integer extension property to determine the signal used for stopping the application through PMF. See `signal`(3HEAD) for a list of the integer values that can be specified. The default is 15 (`SIGTERM`).

Using the SunPlex Agent Builder to Create a Service Using GDS

You can use the SunPlex Agent Builder to create the service that uses the GDS. The SunPlex Agent Builder is described in more detail in Chapter 9.

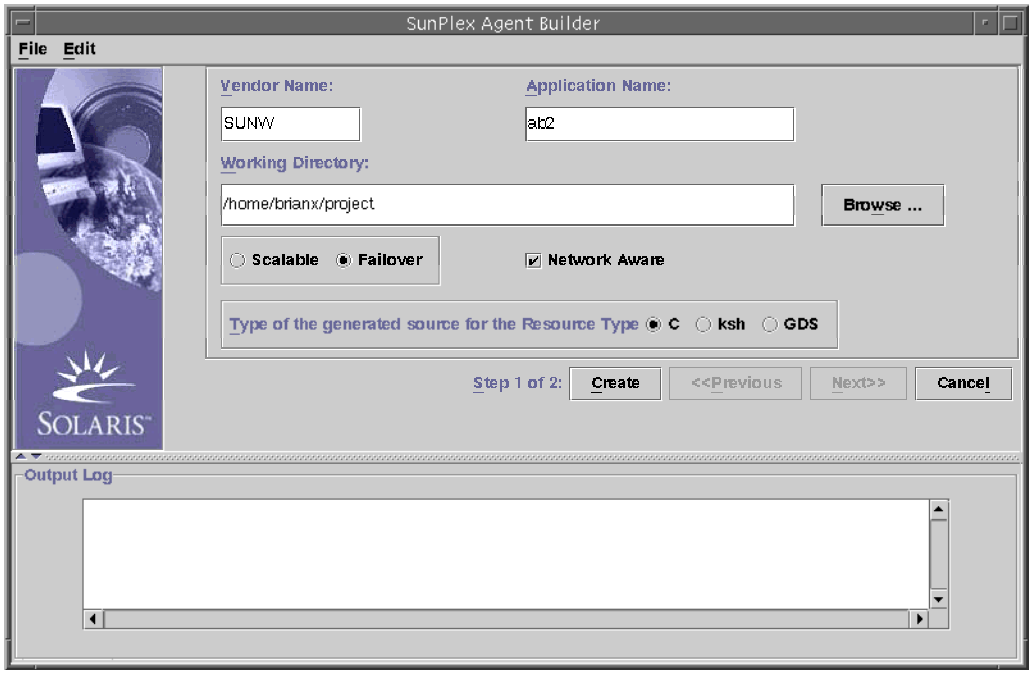
Create a Service Using GDS in the SunPlex Agent Builder

▼ Creating a Service Using GDS in the Agent Builder

1. **Start the SunPlex Agent Builder.**

   ```
   # /usr/cluster/bin/scdsbuilder
   ```

2. **The SunPlex Agent Builder panel appears.**



SunPlex Agent Builder

File Edit

Vendor Name: SUNW

Application Name: ab2

Working Directory: /home/brianx/project

Browse ...

Scalable [✓ Failover]

[✓ Network Aware]

Type of the generated source for the Resource Type [✓ C] ksh GDS

Step 1 of 2: Create <<Previous Next>> Cancel

Output Log

3. **Enter the Vendor Name.**

4. **Enter the Application Name.**

   Note – The combination of Vendor and Application Name may not contain more than nine characters. It is used as the name of the package for the driving scripts.

   ---

5. **Go to the working directory.**

You can use the Browse pulldown to select the directory rather than typing the path.

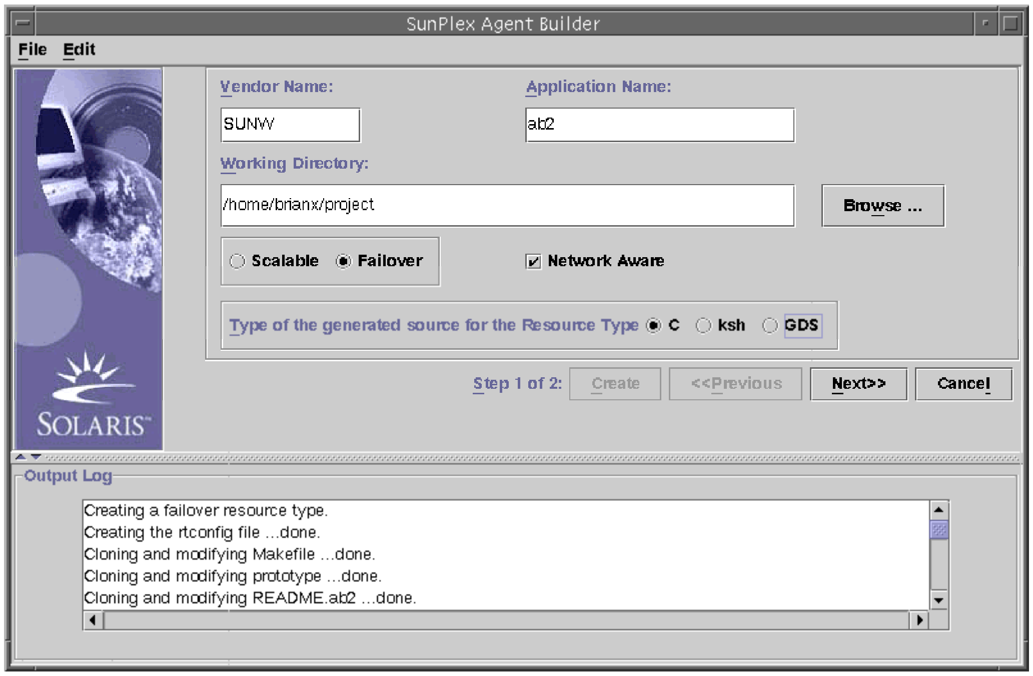
6. **Select whether the data service is scalable or failover.**

   You do not need to select Network Aware since that is the default when creating the GDS.

7. **Select GDS.**

8. **Click the Create button to create the driving scripts.**

9. **The SunPlex Agent Builder panel displays the results of the creation of the service. The Create button is grayed out and you can now use the Next button.**



Vendor Name: SUNW
Application Name: ab2
Working Directory: /home/brianx/project
Scalable [✓ Failover]
[✓ Network Aware]
Type of the generated source for the Resource Type [✓ C] ksh GDS

Output Log

```
Creating a failover resource type.
Creating the rtconfig file ...done.
Cloning and modifying Makefile ...done.
Cloning and modifying prototype ...done.
Cloning and modifying README.ab2 ...done.
```

▼ Configuring the Driving Scripts

After creating the driving scripts, you need to use the SunPlex Agent Builder to configure the new service.

1. **Click the Next button and the configuration panel appears.**

2. **Either enter the location of the Start command or use the browse button to locate the Start command.**

3. **(Optional) Enter the Stop command or use the browse button to locate the Stop command.**

4. **(Optional) Enter the Probe command or use the browse button to locate the Probe command.**

5. **(Optional) Specify the timeout values for the Start, Stop, and Probe commands.**

6. **Click Configure to start the configuration of the driving scripts.**

Note – The package name will consist of a concatenation of the Vendor Name and Application Name.

A package for driving scripts will be created and placed in:

<working-dir>/*<vendor_name><application>*/pkg
For example, /export/wdir/NETapp/pkg

7. **Install the completed package on all nodes of the cluster.**

```
# cd /export/wdir/NETapp/pkg
# pkgadd -d . NETapp
```

8. **The following files will be installed during the pkgadd:**

```
/opt/NETapp
/opt/NETapp/README.app
/opt/NETapp/man
/opt/NETapp/man/man1m
/opt/NETapp/man/man1m/removeapp.1m
/opt/NETapp/man/man1m/startapp.1m
/opt/NETapp/man/man1m/stopapp.1m
/opt/NETapp/man/man1m/app_config.1m
/opt/NETapp/util
/opt/NETapp/util/removeapp
/opt/NETapp/util/startapp
/opt/NETapp/util/stopapp
/opt/NETapp/util/app_config
```

Note – The man pages and script names will correspond to the Application Name you entered above preceded by the script name; for example, startapp.

To view the man pages, you need to specify the path to the man page. For example, to view the startapp man pages, use:

```
# man -M /opt/NETapp/man startapp
```

9. **On one node of the cluster, configure the resources and start the application.**

```
# /opt/NETapp/util/startapp -h <logichostname> -p <port and protocol list>
```

The arguments to the start script will vary according to the type of resource: failover or scalable. Check the customized man page or run the start script without any argument to get a usage statement.

```
# /opt/NETapp/util/startapp
 The resource name of LogicalHostname or SharedAddress must be specified.
 For failover services:
 Usage: startapp -h <logical host name>
          -p <port and protocol list>
          [-n <ipmpgroup/adapter list>]
 For scalable services:
 Usage: startapp
          -h <shared address name>
          -p <port and protocol list>
          [-l <load balancing policy>]
          [-n <ipmpgroup/adapter list>]
          [-w <load balancing weights>]
```

Output From SunPlex Agent Builder

The SunPlex Agent Builder generates three driving scripts and a configuration file based on input you provide during package creation. The configuration file specify the names of the resource group and resource type.

The driving scripts are:

- Start script: Used to configure the resources and start the application under RGM control.
- Stop script: Used to stop the application and take down resources and resource groups.
- Remove script: Used to remove the resources and resource groups created by the start script.

These driving scripts have the same interface and behavior as the utility scripts generated by the SunPlex Agent Builder for non-GDS-based agents. The scripts are packaged in a Solaris-installable package that can be reused across multiple clusters.

You can customize the configuration file to provide your own names for resource groups or other parameters that are normally given as inputs to the `scrgadm` command. If you do not customize the scripts, the SunPlex Agent Builder provides reasonable defaults for the `scrgadm` parameters.

Using the Standard Sun Cluster Administration Commands to Create a Service Using GDS

In this section we describe how these parameters can actually be input to the GDS. The GDS is used and administered using the existing Sun Cluster administration commands such as `scrgadm` and `scswitch`.

Then there is no need to enter the lower level administration commands shown in this section if the driving scripts provide adequate functionality. However, you can do so if you need to have finer control over the GDS-based resource. These are the commands actually executed by the driving scripts.

▼ How to Use Sun Cluster Administration Commands to Create a Highly Available Service Using GDS

1. **Register the resource type `SUNW.gds`**

```
# scrgadm -a -t SUNW.gds
```

2. **Create the resource group containing the LogicalHostname resource and the failover service itself.**

```
# scrgadm -a -g haapp_rg
```

3. **Create the resource for the LogicalHostname resource.**

```
# scrgadm -a -L -g haapp_rs -l hhead
```

4. **Create the resource for the failover service itself.**

```
# scrgadm -a -j haapp_rs -g haapp_rg -t SUNW.gds \
         -y Scalable=false -y Start_timeout=120 \
         -y Stop_timeout=120 -x Probe_timeout=120 \
         -y Port_list="2222/tcp" \
         -x Start_command="/export/ha/appctl/start" \
         -x Stop_command="/export/ha/appctl/stop" \
         -x Probe_command="/export/app/bin/probe" \
         -x Child_mon_level=0 -y Network_resources_used=hhead \
         -x Failover_enabled=true -x Stop_signal=9
```

5. **Bring the resource group `haapp_rg` online.**

```
# scswitch -Z -g haapp_rg
```

▼ Standard Sun Cluster Administration Commands to Create a Scalable Service Using GDS

1. **Register the resource type SUNW.gds.**

```
# scrgadm -a -t SUNW.gds
```

2. **Create the resource group for the SharedAddress resource.**

```
# scrgadm -a -g sa_rg
```

3. **Create the SharedAddress resource on `sa_rg`.**

```
# scrgadm -a -S -g sa_rg -l hhead
```

4. **Create the resource group for the scalable service.**

```
# scrgadm -a -g app_rg -y Maximum_primaries=2 \
      -y Desired_primaries=2 -y RG_dependencies=sa_rg
```

5. **Create the resource group for the scalable service itself.**

```
# scrgadm -a -j app_rs -g app_rg -t SUNW.gds \
       -y Scalable=true -y Start_timeout=120 \
       -y Stop_timeout=120 -x Probe_timeout=120 \
       -y Port_list="2222/tcp" \
       -x Start_command="/export/app/bin/start" \
       -x Stop_command="/export/app/bin/stop" \
       -x Probe_command="/export/app/bin/probe" \
       -x Child_mon_level=0 -y Network_resource_used=hhead \
       -x Failover_enabled=true -x Stop_signal=9
```

6. **Bring the resource group containing the network resources online.**

```
# scswitch -Z -g sa_rg
```

7. **Bring the resource group `app_rg` online.**

```
# scswitch -Z -g app_rg
```

Command-Line Interface to the SunPlex Agent Builder

The SunPlex Agent Builder has a command-line interface that has equivalent functionality to the GUI interface. This interface consists of the commands `scdscreate`(1HA) and `scdsconfig`(1HA). The following section performs the same function as the GUI-based procedure “Creating a Service That Uses GDS With the Command-Line Version of Agent Builder” on page 191 but uses the non-GUI interface.

▼ Creating a Service That Uses GDS With the Command-Line Version of Agent Builder

1. **Create the service.**

   For a failover service, use:

   ```
   # scdscreate -g -V NET -T app -d /export/wdir
   ```

   For a scalable service, use:

   ```
   # scdscreate -g -s -V NET -T app -d /export/wdir
   ```

   Note – The *–d* parameters are optional. If it is not specified, the working directory defaults to the current directory.

   ---

2. **Configure the service.**

   ```
   # scdsconfig -s "/export/app/bin/start’ -t "/export/app/bin/stop" \
   -m "/export/app/bin/probe" -d /export/wdir
   ```

   Note – Only the start command is required. All other parameters are optional.

   ---

3. **Install the completed package on all nodes of the cluster.**

   ```
   # cd /export/wdir/NETapp/pkg
   # pkgadd -d . NETapp
   ```

4. **The following files will be installed during the pkgadd:**

   ```
   /opt/NETapp
   /opt/NETapp/README.app
   /opt/NETapp/man
   /opt/NETapp/man/man1m
   /opt/NETapp/man/man1m/removeapp.1m
   /opt/NETapp/man/man1m/startapp.1m
   /opt/NETapp/man/man1m/stopapp.1m
   /opt/NETapp/man/man1m/app_config.1m
   /opt/NETapp/util
   /opt/NETapp/util/removeapp
   /opt/NETapp/util/startapp
   /opt/NETapp/util/stopapp
   /opt/NETapp/util/app_config
   ```

   Note – The man pages and script names will correspond to the Application Name you entered above preceded by the script name; for example, `startapp`.

To view the man pages, you need to specify the path to the man page. For example, to view the `startapp` man pages, use:

```
# man -M /opt/NETapp/man startapp
```

5. **On one node of the cluster, configure the resources and start the application.**

   ```
   # /opt/NETapp/util/startapp -h <logichostname> -p <port and protocol list>
   ```

   The arguments to the start script will vary according to the type of resource: failover or scalable. Check the customized man page or run the start script without any argument to get a usage statement.

   ```
   # /opt/NETapp/util/startapp
    The resource name of LogicalHostname or SharedAddress must be specified.
    For failover services:
    Usage: startapp -h <logical host name>
             -p <port and protocol list>
             [-n <ipmpgroup/adapter list>]
    For scalable services:
    Usage: startapp
             -h <shared address name>
             -p <port and protocol list>
             [-l <load balancing policy>]
             [-n <ipmpgroup/adapter list>]
             [-w <load balancing weights>]
   ```

CHAPTER 11

Data Service Development Library Reference

This chapter lists and briefly describes the Data Service Development Library (DSDL) API functions. See the individual 3HA man pages for a complete description of each DSDL function. The DSDL defines a C interface only. There is no scriptable DSDL interface.

The DSDL provides functions in the following categories.

- "General Purpose Functions" on page 193
- "Property Functions" on page 195
- "Network Resource-Access Functions" on page 195
- "PMF Functions" on page 196
- "Fault Monitor Functions" on page 197
- "Utility Functions" on page 197

DSDL Functions

The following subsections provide a brief overview to each category of DSDL functions. However, the individual 3HA man pages are the definitive reference for DSDL functions.

General Purpose Functions

The functions in this section provide a broad range of functionality. These functions enable you to

- Initialize the DSDL environment
- Retrieve resource, resource type, and resource group names, and extension property values

- Failover and restart a resource group and restart a resource
- Convert error strings to error messages
- Execute a command under a timeout

The following functions initialize the calling method.

- `scds_initialize` – allocate resources and initialize the DSDL environment.
- `scds_close` – free resources allocated by `scds_initialize`.

The following functions retrieve information about resources, resource types, resource groups, and extension properties.

- `scds_get_resource_name` – retrieve the name of the resource for the calling program.
- `scds_get_resource_type_name` – retrieve the name of the resource type for the calling program.
- `scds_get_resource_group_name` – retrieve the name of the resource group for the calling program.
- `scds_get_ext_property` – retrieve the value of the specified extension property.
- `scds_free_ext_property` – free the memory allocated by `scds_get_ext_property`.

The following function retrieves status information about the SUNW.HAStoragePlus resources used by a resource.

- `scds_hasp_check` – retrieves status information about `SUNW.HAStoragePlus` resources used by a resource. This information is obtained from the state (online or otherwise) of all `SUNW.HAStoragePlus` resources that the resource depends upon using the `Resource_dependencies` or `Resource_dependencies_weak` system properties defined for the resource.

  See `SUNW.HAStoragePlus`(5) for more information about `SUNW.HAStoragePlus`.

The following functions fail over or restart a resource or resource group.

- `scds_failover_rg` – fail over a resource group.
- `scds_restart_rg` – restart a resource group.
- `scds_restart_resource` – restart a resource.

The following two functions execute a command under a timeout and convert an error code to an error message.

- `scds_timerun` – execute a command under a timeout value.
- `scds_error_string` – translate an error code to an error string.

Property Functions

These functions provide convenience APIs for accessing specific properties of the relevant resource, resource group and resource type, including some commonly-used extension properties. The DSDL provides the `scds_initialize` function to parse the command line arguments. The library then *caches* the various properties of the relevant resource, resource group and resource type.

A single man page, `scds_property_functions`(3HA) describes all of these functions. This section contains the following functions

- `scds_get_rs_`*property_name*
- `scds_get_rg_`*property_name*
- `scds_get_rt_`*property_name*
- `scds_get_ext_`*property_name*

Network Resource-Access Functions

The functions listed in this section retrieve, print, and free network resources used by resources and resource groups. The `scds_get_*` functions in this section provide a convenient way of retrieving network resources without querying specific properties such as `Network_resources_used`, and `Port_list` using the RMAPI functions. The `scds_print_`*name*`()` functions print values from the data structures returned by the `scds_get_`*name*`()` functions. The `scds_free_`*name*`()` functions free the memory allocated by the `scds_get_`*name*`()` functions.

The following functions are concerned with hostnames.

- `scds_get_rg_hostnames` – retrieve a list of hostnames used by the network resources in a resource group.
- `scds_get_rs_hostnames` – retrieve a list of hostnames used by the resource.
- `scds_print_net_list` – print the contents of the list of hostnames returned by `scds_get_rg_hostnames` or `scds_get_rs_hostnames`.
- `scds_free_net_list` – free the memory allocated by `scds_get_rg_hostnames` or `scds_get_rs_hostnames`.

The following functions are concerned with port lists.

- `scds_get_port_list` – retrieve a list of port-protocol pairs used by a resource.
- `scds_print_port_list` – print the contents of the list of port-protocol pairs returned by `scds_get_port_list`.
- `scds_free_port_list` – free the memory allocated by `scds_get_port_list`.

The following functions are concerned with network addresses.

- `scds_get_netaddr_list` – retrieve a list of network addresses used by a resource.

- `scds_print_netaddr_list` – print the contents of the list of network addresses returned by `scds_get_netaddr_list`.
- `scds_free_netaddr_list` – free the memory allocated by `scds_get_netaddr_list`.

Fault Monitoring Using TCP Connections

The functions in this section enable TCP-based monitoring. Typically, a fault monitor uses these functions to establish a simple socket connection to a service, read and write data to the service to ascertain its status, and then disconnect from the service.

This section contains the following functions.

- `scds_tcp_connect` – establish a TCP connection to a process.
- `scds_tcp_read` – use a TCP connection to read data from the process being monitored.
- `scds_tcp_write` – use a TCP connection to write data to a process being monitored.
- `scds_simple_probe` – probe a process by establishing and terminating a TCP connection to the process.
- `scds_tcp_disconnect` – terminate the connection to a process being monitored.

PMF Functions

These functions encapsulate the PMF functionality. The DSDL model for monitoring through PMF creates and uses implicit *tag* values for `pmfadm`(1M). The PMF facility also uses implicit values for the `Restart_interval`, `Retry_count` and `action_script` (the `-t`, `-n` and `-a` options to `pmfadm`). Most importantly, the DSDL ties the process death history, as discovered by PMF, into the application failure history as detected by the fault monitor to compute the restart or failover decision.

This section contains the following functions.

- `scds_pmf_get_status` – determine if the specified instance is being monitored under PMF control.
- `scds_pmf_restart_fm` – restarts the fault monitor using PMF.
- `scds_pmf_signal` – send the specified signal to a process tree running under PMF control.
- `scds_pmf_start` – execute a specified program (including a fault monitor) under PMF control.
- `scds_pmf_stop` – terminate a process running under PMF control.
- `scds_stop_monitoring` — stop monitoring a process running under PMF control.

Fault Monitor Functions

The functions in this section provide a predetermined model of fault-monitoring by keeping the failure history and evaluating it in conjunction with the `Retry_count` and `Retry_interval` properties.

This section contains the following functions.

- `scds_fm_sleep` – wait for a message on a fault monitor control socket.
- `scds_fm_action` – take action after completion of a probe.
- `scds_fm_print_probes` – write probe status information to the system log.

Utility Functions

The functions in this section enable you to write messages and debugging messages to the system log. This section contains the following two functions.

- `scds_syslog` – write messages to the system log.
- `scds_syslog_debug` – write a debugging message to the system log.

CHAPTER 12

CRNP

This chapter provides information about the Cluster Reconfiguration Notification Protocol (CRNP). CRNP enables failover and scalable applications to be "cluster aware." More specifically, CRNP provides a mechanism that enables applications to register for, and receive subsequent asynchronous notification of, Sun Cluster reconfiguration events. Data services that run within the cluster and applications that run outside the cluster can register for notification of events. Events are generated when membership in a cluster changes and when the state of a resource group or a resource changes.

Overview of CRNP

CRNP provides mechanisms and daemons that generate cluster reconfiguration events, route them through the cluster, and send them to interested clients.

The `cl_apid` daemon interacts with the clients. The Sun Cluster Resource Group Manager (RGM) generates cluster reconfiguration events. These daemons use `syseventd`(1M) to transmit events on each local node. The `cl_apid` daemon uses Extensible Markup Language (XML) over TCP/IP to communicate with interested clients.

The following diagram presents an overview of the flow of events between the CRNP components. In this diagram, one client is running on cluster node 2, and the other client is running on a computer that is not part of the cluster.

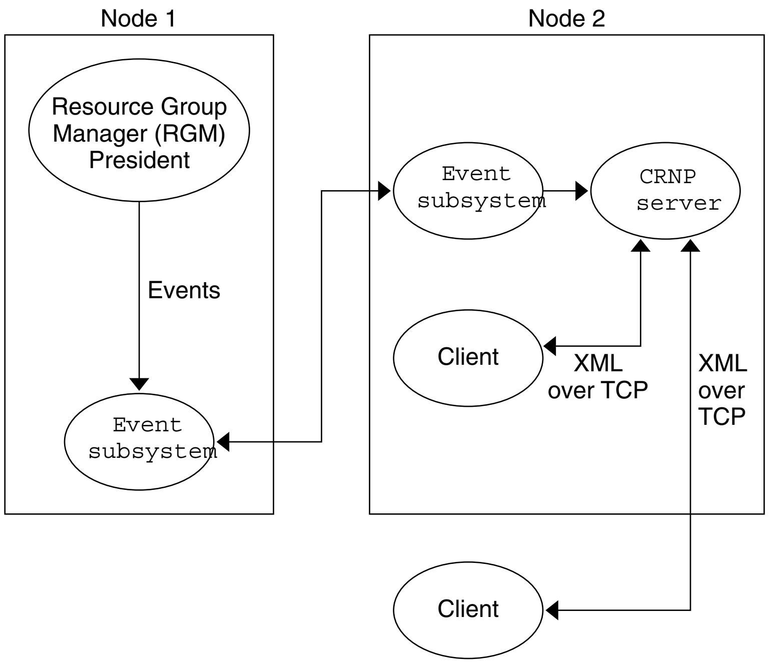


FIGURE 12–1 How CRNP Works

Overview of the CRNP Protocol

The CRNP defines the Application, Presentation, and Session layers of the standard seven layer Open System Interconnect (OSI) protocol stack. The Transport layer must be TCP and the Network layer must be IP. The CRNP is independent of the Data Link and Physical layers. All Application layer messages that are exchanged in the CRNP are based on XML 1.0.

Semantics of the CRNP Protocol

Clients initiate communication by sending a registration message (`SC_CALLBACK_RG`) to the server. This registration message specifies the event types for which the clients want to receive notification as well as a port to which the events can be delivered. The source IP of the registration connection and the specified port, taken together, form the callback address.

Whenever an event of interest to a client is generated within the cluster, the server contacts the client on its callback address (IP and port) and delivers the event (SC_EVENT) to the client. The server is highly available, running within the cluster itself. The server stores client registrations in storage that persists even after the cluster is rebooted.

Clients unregister by sending a registration message (SC_CALLBACK_RG, which contains a REMOVE_CLIENT message) to the server. After the client receives an SC_REPLY message from the server, the client closes the connection.

The following diagram shows the flow of communication between a client and a server.

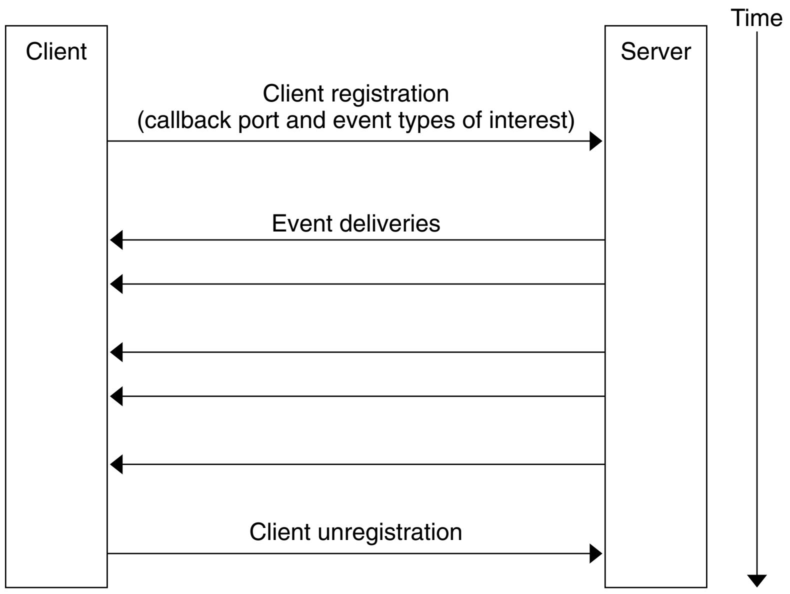


FIGURE 12–2 Flow of Communication Between a Client and a Server

Message Types That the CRNP Uses

The CRNP uses three types of messages, all of which are XML-based, as described in the following table. These message types are described in more detail later in this chapter. Usage is also described in more detail later in this chapter.

Type of Message	Description
`SC_CALLBACK_REG`	This message takes four forms: `ADD_CLIENT`, `REMOVE_CLIENT`, `ADD_EVENTS`, and `REMOVE_EVENTS`. Each of these forms contains the following information: ■ Protocol version ■ Callback port in ASCII format (not binary format) The `ADD_CLIENT`, `ADD_EVENTS`, and `REMOVE_EVENTS` forms also contain an unbounded list of event types, each of which includes the following information: ■ Event class ■ Event subclass (optional) ■ List of the name and value pairs (optional) Together, the event class and event subclass define a unique "event type." The DTD (document type definition) from which the classes of `SC_CALLBACK_REG` are generated is `SC_CALLBACK_REG`. This DTD is described in more detail in Appendix F.
`SC_EVENT`	This message contains the following information: ■ Protocol version ■ Event class ■ Event subclass ■ Vendor ■ Publisher ■ Name and value pairs list (0 or more name and value pair data structures) ■ Name (string) ■ Value (string or string array) The values in an `SC_EVENT` are not typed. The DTD (document type definition) from which the classes of `SC_EVENT` are generated is `SC_EVENT`. This DTD is described in more detail in Appendix F.
`SC_REPLY`	This message contains the following information: ■ Protocol version ■ Error code ■ Error message The DTD (document type definition) from which the classes of `SC_REPLY` are generated is `SC_REPLY`. This DTD is described in more detail in Appendix F.

How a Client Registers With the Server

This section describes how an administrator will set up the server, how clients are identified, how information is sent over the Application and Session layers, and error conditions.

Assumptions About How Administrators Will Set Up the Server

The system administrator must configure the server with a highly available IP address (that is, an IP address that is not tied to a particular machine in the cluster) and a port number. The administrator must publish this network address to prospective clients. The CRNP does not define how this server name is made available to clients. Administrators will either use a naming service, which will enable clients to find the network address of the server dynamically, or will add the network name to a configuration file for the client to read. The server will run within the cluster as a failover resource type.

How the Server Identifies a Client

Each client is uniquely identified by its callback address, that is, its IP address and port number. The port is specified in the `SC_CALLBACK_REG` messages, and the IP address is obtained from the TCP registration connection. CRNP assumes that subsequent `SC_CALLBACK_REG` messages with the same callback address come from the same client, even if the source port from which the messages are sent is different.

How `SC_CALLBACK_REG` Messages Are Passed Between a Client and the Server

A client initiates a registration by opening a TCP connection to the server's IP address and port number. After the TCP connection is established and ready for writing, the client must send its registration message. The registration message must be one correctly formatted `SC_CALLBACK_REG` message that does not contain extra bytes either before or after the message.

After all the bytes have been written to the stream, the client must keep its connection open to receive the reply from the server. If the client does not format the message correctly, the server does not register the client, and sends an error reply to the client. If the client closes the socket connection before the server sends a reply, the server registers the client as normal.

A client can contact the server at any time. Every time a client contacts the server, the client must send an SC_CALLBACK_REG message. If the server receives a message that is malformed, out of order, or invalid, the server sends an error reply to the client.

A client cannot send an ADD_EVENTS, REMOVE_EVENTS, or REMOVE_CLIENT message before that client sends an ADD_CLIENT message. A client cannot send a REMOVE_CLIENT message before that client sends an ADD_CLIENT message.

If a client sends an ADD_CLIENT message and the client is already registered, the server might tolerate this message. In this situation, the server silently replaces the old client registration with the new client registration that is specified in the second ADD_CLIENT message.

In most situations, a client registers with the server once, when the client starts, by sending an ADD_CLIENT message. And a client unregisters once by sending a REMOVE_CLIENT message to the server. However, the CRNP provides more flexibility for those clients that need to modify their event type list dynamically.

Contents of an SC_CALLBACK_REG Message

Each ADD_CLIENT, ADD_EVENTS, and REMOVE_EVENTS message contains a list of events. The following table describes the event types that the CRNP accepts, including the required name and value pairs.

If a client either:

- Sends a REMOVE_EVENTS message that specifies one or more event types for which the client has not previously registered, or
- Registers for the same event type twice

the server silently ignores these messages.

Class and Subclass	Name and Value Pairs	Description
EC_Cluster ESC_cluster_membership	Required: none Optional: none	Registers for all cluster membership change events (node death or join)
EC_Cluster ESC_cluster_rg_state	One required, as follows: rg_name Value type: string Optional: none	Registers for all state change events for resource group *name*

Class and Subclass	Name and Value Pairs	Description
`EC_Cluster` `ESC_cluster_r_state`	One required, as follows: `r_name` Value type: string Optional: none	Registers for all state change events for resource *name*
`EC_Cluster` None	Required: none Optional: none	Registers for all Sun Cluster events

How the Server Replies to a Client

After processing the registration, the server sends the `SC_REPLY` message. The server sends this message on the open TCP connection from the client on which the server received the registration request. The server then closes the connection. The client must keep the TCP connection open until it receives the `SC_REPLY` message from the server.

For example, the client carries out the following actions:

1. Opens a TCP connection to the server
2. Waits for a connection to be "writeable"
3. Sends an `SC_CALLBACK_REG` message (which contains an `ADD_CLIENT` message)
4. Waits for an `SC_REPLY` message
5. Receives an `SC_REPLY` message
6. Receives an indicator that the server has closed the connection (reads 0 bytes from the socket)
7. Closes the connection

At a later point in time, the client then carries out the following actions:

1. Opens a TCP connection to the server
2. Waits for a connection to be "writeable"
3. Sends an `SC_CALLBACK_REG` message (which contains a `REMOVE_CLIENT` message)
4. Waits for an `SC_REPLY` message
5. Receives an `SC_REPLY` message
6. Receives an indicator that the server has closed the connection (reads 0 bytes from the socket)

7. Closes the connection

Each time that the server receives an SC_CALLBACK_REG message from a client, the server sends an SC_REPLY message on the same open connection. This message specifies whether the operation succeeded or failed. "SC_REPLY XML DTD" on page 314 contains the XML document type definition of an SC_REPLY message, and the possible error messages that this message can include.

Contents of an SC_REPLY Message

An SC_REPLY message specifies whether an operation succeeded or failed. This message contains the version of the CRNP protocol message, a status code, and a status message, which describes the status code in more detail. The following table describes the possible values for the status code.

Status Code	Description
OK	The message was processed successfully.
RETRY	The registration of the client was rejected by the server due to a transient error (the client should try to register again, with different parameters).
LOW_RESOURCE	Cluster resources are low, and the client can only try again at a later time (the system administrator for the cluster can also increase the resources on the cluster).
SYSTEM_ERROR	A serious problem occurred. Contact the system administrator for the cluster.
FAIL	Authorization failed or another problem caused the registration to fail.
MALFORMED	The XML request was malformed and could not be parsed.
INVALID	The XML request was invalid (does not meet the XML specification).
VERSION_TOO_HIGH	The version of the message was too high to process the message successfully.
VERSION_TOO_LOW	The version of the message was too low to process the message successfully.

How a Client Is to Handle Error Conditions

Under normal conditions, a client that sends an SC_CALLBACK_REG message receives a reply that indicates that the registration succeeded or failed.

However, the server can experience an error condition when a client is registering that prohibits the server from sending an `SC_REPLY` message to the client. In this case, the registration could either have succeeded before the error condition occurred, could have failed, or could not yet have been processed.

Because the server must function as a failover, or highly available, server on the cluster, this error condition does not mean an end to the service. In fact, the server could soon begin sending events to the newly registered client.

To remedy these conditions, your client should both:

- Impose an application-level time-out on a registration connection that is waiting for an `SC_REPLY` message, after which the client needs to retry registering.
- Begin listening on its callback IP address and port number for event deliveries before it registers for the event callbacks. The client should wait for a registration confirmation message and for event deliveries in parallel. If the client begins to receive events before the client receives a confirmation message, the client should silently close the registration connection.

How the Server Delivers Events to a Client

As events are generated within the cluster, the CRNP server delivers them to all clients who requested events of those types. The delivery consists of sending an `SC_EVENT` message to the client's callback address. The delivery of each event occurs on a new TCP connection.

Immediately after a client registers for an event type, through an `SC_CALLBACK_REG` message that contains an `ADD_CLIENT` message or an `ADD_EVENT` message, the server sends the most recent event of that type to the client. The client can then discover the current state of the system from which the subsequent events come.

When the server initiates a TCP connection to the client, the server sends exactly one `SC_EVENT` message on the connection. The server then issues a full-duplex close.

For example, the client carries out the following actions:

1. Waits for the server to initiate a TCP connection
2. Accepts the incoming connection from the server
3. Waits for an `SC_EVENT` message
4. Reads an `SC_EVENT` message
5. Receives an indicator that the server has closed the connection (reads 0 bytes from the socket)

6. Closes the connection

When all clients have registered, they must listen at their callback address (the IP address and port number) at all times for an incoming event delivery connection.

If the server fails to contact the client to deliver an event, the server tries again to deliver the event the number of times and at the interval that you define. If all attempts fail, the client is removed from the server's list of clients. The client also needs to re-register by sending another `SC_CALLBACK_REG` message that contains an `ADD_CLIENT` message before the client can receive more events.

How the Delivery of Events Is Guaranteed

There is a total ordering of event generation within the cluster that is preserved in the order of delivery to each client. In other words, if event A is generated within the cluster before event B, then client X receives event A before that client receives event B. However, the total ordering of event delivery to *all* clients is *not* preserved. That is, client Y could receive both events A and B before client X receives event A. In this way, slow clients do not hold up delivery to all clients.

All events that the server delivers (except the first event for a subclass and events that follow server errors) occur in response to the actual events that the cluster generates, except if the server experiences an error that causes it to miss cluster-generated events. In this case, the server generates an event for each event type that represents the current state of the system for that type. Each event is sent to clients that registered interest in that event type.

Event delivery follows the "at least once" semantics. That is, the server is allowed to send the same event to a client more than once. This allowance is necessary in cases in which the server goes down temporarily, and when it comes back up, cannot determine if the client has received the latest information.

Contents of an `SC_EVENT` Message

The `SC_EVENT` message contains the actual message that is generated within the cluster, translated to fit into the `SC_EVENT` XML message format. The following table describes the event types that the CRNP delivers, including the name and value pairs, publisher, and vendor.

Class and Subclass	Publisher and Vendor	Name and Value Pairs	Notes
`EC_Cluster` `ESC_cluster_membership`	Publisher: rgm Vendor: SUNW	Name: `node_list` Value type: string array Name: `state_list` Value type: string array	The positions of the array elements for `state_list` are synchronized with those of the `node_list`. That is, the state for the node listed first in the `node_list` array is first in the `state_list` array. The `state_list` contains only numbers represented in ASCII. Each number represents the current incarnation number for that node in the cluster. If the number is the same as the number that was received in a previous message, the node has not changed its relationship to the cluster (departed, joined, or rejoined). If the incarnation number is –1, the node is not a member of the cluster. If the incarnation number is a number other than a negative number, the node is a member of the cluster. Additional names starting with `ev_` and their associated values might be present, but are not intended for client use.

Class and Subclass	Publisher and Vendor	Name and Value Pairs	Notes

`EC_Cluster`
 	
`ESC_cluster_rg_state`
	Publisher: rgm
	
	Vendor: SUNW
		Name: `rg_name`
		
		Value type: string
		
		Name: `node_list`
		
		Value type: string array
		
		Name: `state_list`
		
		Value type: string array
			The positions of the array elements for `state_list` are synchronized with those of the `node_list`. That is, the state for the node listed first in the `node_list` array is first in the `state_list` array.
			
			The `state_list` contains string representations of the state of the resource group. Valid values are those values that you can retrieve with the `scha_cmds`(1HA) commands.
			
			Additional names starting with `ev_` and their associated values might be present, but are not intended for client use.

`EC_Cluster`
 	
`ESC_cluster_r_state`
	Publisher: rgm
	
	Vendor: SUNW
		Three required, as follows:
		
		Name: `r_name`
		
		Value type: string
		
		Name: `node_list`
		
		Value type: string array
		
		Name: `state_list`
		
		Value type: string array
			The positions of the array elements for `state_list` are synchronized with those of the `node_list`. That is, the state for the node listed first in the `node_list` array is first in the `state_list` array.
			
			The `state_list` contains string representations of the state of the resource. Valid values are those values that you can retrieve with the `scha_cmds`(1HA) commands.
			
			Additional names starting with `ev_` and their associated values might be present, but are not intended for client use.

How the CRNP Authenticates Clients and the Server

The server authenticates a client by using a form of TCP wrappers. The source IP address of the registration message (which is also used as the callback IP address on which events are delivered) must be in the list of allowed clients on the server. The source IP address and registration message cannot be in the denied clients list. If the source IP address and registration are not in the list, the server rejects the request and issues an error reply to the client.

When the server receives an `SC_CALLBACK_REG` `ADD_CLIENT` message, subsequent `SC_CALLBACK_REG` messages for that client must contain a source IP address that is the same as the source IP address in the first message. If the CRNP server receives an `SC_CALLBACK_REG` that does not meet this requirement, the server either:

- Ignores the request and sends an error reply to the client, or
- Assumes that the request comes from a new client (depending on the contents of the `SC_CALLBACK_REG` message)

This security mechanism helps to prevent denial of service attacks, where someone attempts to unregister a legitimate client.

Clients should also similarly authenticate the server. Clients need only accept event deliveries from a server whose source IP address and port number are the same as the registration IP address and port number that the client used.

Because it is expected that clients of the CRNP service are located inside a firewall that protects the cluster, CRNP does not include additional security mechanisms.

Creating a Java Application That Uses CRNP

The following example illustrates how to develop a simple Java application named `CrnpClient` that uses the CRNP. The application registers for event callbacks with the CRNP server on the cluster, listens for the event callbacks, and processes the events by printing their contents. Before terminating, the application unregisters its request for event callbacks.

Keep the following points in mind when reviewing this example.

- The sample application performs XML generation and parsing with the JAXP (Java API for XML Processing). This example does not teach you how to use the JAXP. JAXP is described in more detail at `http://java.sun.com/xml/jaxp/index.html`.
- This example presents pieces of a complete application, which can be found in its entirety in Appendix G. To illustrate particular concepts more effectively, the example presented in this chapter differs slightly from the complete application that is presented in Appendix G.
- For the sake of brevity, comments are excluded from the sample code in the example in this chapter. The complete application in Appendix G includes comments.
- The application that is shown in this example handles most error conditions by simply exiting the application. Your actual application needs to handle errors more robustly.

▼ Set Up Your Environment

First, you need to set up your environment.

1. **Download and install JAXP and the correct version of the Java compiler and virtual machine.**

   You can find instructions at `http://java.sun.com/xml/jaxp/index.html`.

   Note – This example requires Java 1.3.1 or a later version of Java.

   ---

2. **Ensure that you specify a `classpath` in your compilation command line so that the compiler can find the JAXP classes. From the directory in which your source file is located, type:**

   ```
   % javac -classpath JAXP_ROOT/dom.jar:JAXP_ROOTjaxp-api. \
   jar:JAXP_ROOTsax.jar:JAXP_ROOTxalan.jar:JAXP_ROOT/xercesImpl \
   .jar:JAXP_ROOT/xsltc.jar -sourcepath . SOURCE_FILENAME.java
   ```

   where *JAXP_ROOT* is the absolute or relative path to the directory in which the JAXP jar files are located and *SOURCE_FILENAME* is the name of your Java source file.

3. **When you run the application, specify the `classpath` so that the application can load the proper JAXP class files (note that the first path in the `classpath` is the current directory):**

   ```
   java -cp .:JAXP_ROOT/dom.jar:JAXP_ROOTjaxp-api. \
   jar:JAXP_ROOTsax.jar:JAXP_ROOTxalan.jar:JAXP_ROOT/xercesImpl \
   .jar:JAXP_ROOT/xsltc.jar SOURCE_FILENAME ARGUMENTS
   ```

   Now that your environment is configured, you can develop your application.

▼ Get Started

In this part of the example, you create a basic class called `CrnpClient`, with a main method that parses the command line arguments and constructs a `CrnpClient` object. This object passes the command line arguments to the class), waits for the user to terminate the application, calls `shutdown` on the `CrnpClient`, and then exits.

The constructor of the `CrnpClient` class needs to execute the following tasks:

- Set up the XML processing objects.
- Create a thread that listens for event callbacks.
- Contact the CRNP server and register for event callbacks.

● **Create the Java code that implements the preceding logic.**

The following example shows the skeleton code for the `CrnpClient` class. The implementations of the four helper methods that are referenced in the constructor and shutdown methods are shown later. Note that the code that imports all the packages you need is shown.

```
import javax.xml.parsers.*;
import javax.xml.transform.*;
import javax.xml.transform.dom.*;
import javax.xml.transform.stream.*;
import org.xml.sax.*;
import org.xml.sax.helpers.*;
import org.w3c.dom.*;

import java.net.*;
import java.io.*;
import java.util.*;


class CrnpClient
{
        public static void main(String []args)
        {
                InetAddress regIp = null;
                int regPort = 0, localPort = 0;

                try {
                        regIp = InetAddress.getByName(args[0]);
                        regPort = (new Integer(args[1])).intValue();
                        localPort = (new Integer(args[2])).intValue();
                } catch (UnknownHostException e) {
                        System.out.println(e);
                        System.exit(1);
                }

                CrnpClient client = new CrnpClient(regIp, regPort, localPort,
                    args);
                System.out.println("Hit return to terminate demo...");
                try {
                        System.in.read();
                } catch (IOException e) {
                        System.out.println(e.toString());
                }
                client.shutdown();
                System.exit(0);
        }

        public CrnpClient(InetAddress regIpIn, int regPortIn, int localPortIn,
            String []clArgs)
        {
                try {
                        regIp = regIpIn;
                        regPort = regPortIn;
                        localPort = localPortIn;
                        regs = clArgs;

                        setupXmlProcessing();
                        createEvtRecepThr();
                        registerCallbacks();

                } catch (Exception e) {
                        System.out.println(e.toString());
                        System.exit(1);
                }
        }

        public void shutdown()
        {
                try {
                        unregister();
                } catch (Exception e) {
                        System.out.println(e);
                        System.exit(1);
                }
        }

        private InetAddress regIp;
        private int regPort;
        private EventReceptionThread evtThr;
        private String regs[];

        public int localPort;
        public DocumentBuilderFactory dbf;
}
```

Member variables are discussed in more detail later.

▼ Parse the Command Line Arguments

- **To see how to parse command line arguments, refer to the code in Appendix G.**

▼ Define the Event Reception Thread

In the code, you need to ensure that event reception is performed in a separate thread so that your application can continue to do other work while the event thread blocks and waits for event callbacks.

Note – Setting up the XML is discussed later.

---

1. **In your code, define a `Thread` subclass called `EventReceptionThread` that creates a `ServerSocket` and waits for events to arrive on the socket.**

   In this part of the example code, events are neither read nor processed. Reading and processing events are discussed later. The `EventReceptionThread` creates a `ServerSocket` on a wildcard internetworking protocol address. `EventReceptionThread` also keeps a reference to the `CrnpClient` object so that `EventReceptionThread` can send events to the `CrnpClient` object to process.

```
class EventReceptionThread extends Thread
{
        public EventReceptionThread(CrnpClient clientIn) throws IOException
        {
                client = clientIn;
                listeningSock = new ServerSocket(client.localPort, 50,
                    InetAddress.getLocalHost());
        }

        public void run()
        {
                try {
                        DocumentBuilder db = client.dbf.newDocumentBuilder();
                        db.setErrorHandler(new DefaultHandler());

                        while(true) {
                                Socket sock = listeningSock.accept();
                                // Construct event from the sock stream and process it
                                sock.close();
                        }
                        // UNREACHABLE

                } catch (Exception e) {
                        System.out.println(e);
                        System.exit(1);
                }
        }

        /* private member variables */
        private ServerSocket listeningSock;
        private CrnpClient client;
}
```

2. **Now that you see how the `EventReceptionThread` class works, construct an `createEvtRecepThr` object:**

```
private void createEvtRecepThr() throws Exception
{
        evtThr = new EventReceptionThread(this);
        evtThr.start();
}
```

▼ Register and Unregister Callbacks

The registration task consists of:

- Opening a basic TCP socket to the registration internetworking protocol and port
- Constructing the XML registration message
- Sending the XML registration message on the socket
- Reading the XML reply message off the socket
- Closing the socket

1. **Create the Java code that implements the preceding logic.**

   The following example shows the implementation of the `registerCallbacks` method of the `CrnpClient` class (which is called by the `CrnpClient` constructor). The calls to `createRegistrationString()` and `readRegistrationReply()` are described in more detail later.

   `regIp` and `regPort` are object members that are set up by the constructor.

```
private void registerCallbacks() throws Exception
{
        Socket sock = new Socket(regIp, regPort);
        String xmlStr = createRegistrationString();
        PrintStream ps = new
                PrintStream(sock.getOutputStream());
        ps.print(xmlStr);
        readRegistrationReply(sock.getInputStream();
        sock.close();
}
```

2. **Implement the `unregister` method. This method is called by the `shutdown` method of `CrnpClient`. The implementation of `createUnregistrationString` is described in more detail later.**

```
private void unregister() throws Exception
{
        Socket sock = new Socket(regIp, regPort);
        String xmlStr = createUnregistrationString();
        PrintStream ps = new PrintStream(sock.getOutputStream());
        ps.print(xmlStr);
        readRegistrationReply(sock.getInputStream());
        sock.close();
}
```

▼ Generate the XML

Now that you have set up the structure of the application and have written all the networking code, you write the code that generates and parses the XML. Start by writing the code that generates the `SC_CALLBACK_REG` XML registration message.

An `SC_CALLBACK_REG` message consists of a registration type (`ADD_CLIENT`, `REMOVE_CLIENT`, `ADD_EVENTS`, or `REMOVE_EVENTS`), a callback port, and a list of events of interest. Each event consists of a class and a subclass, followed by a list of name and value pairs.

In this part of the example, you write a `CallbackReg` class that stores the registration type, callback port, and list of registration events. This class also can serialize itself to an `SC_CALLBACK_REG` XML message.

An interesting method of this class is the `convertToXml` method, which creates an `SC_CALLBACK_REG` XML message string from the class members. The JAXP documentation at `http://java.sun.com/xml/jaxp/index.html` describes the code in this method in more detail.

The implementation of the `Event` class is shown below. Note that the `CallbackReg` class uses an `Event` class that stores one event and can convert that event to an XML `Element`.

1. **Create the Java code that implements the preceding logic.**

```
class CallbackReg
{
        public static final int ADD_CLIENT = 0;
        public static final int ADD_EVENTS = 1;
        public static final int REMOVE_EVENTS = 2;
        public static final int REMOVE_CLIENT = 3;

        public CallbackReg()
        {
                port = null;
                regType = null;
                regEvents = new Vector();
        }

        public void setPort(String portIn)
        {
                port = portIn;
        }

        public void setRegType(int regTypeIn)
        {
                switch (regTypeIn) {
                case ADD_CLIENT:
                        regType = "ADD_CLIENT";
                        break;
                case ADD_EVENTS:
                        regType = "ADD_EVENTS";
                        break;
                case REMOVE_CLIENT:
                        regType = "REMOVE_CLIENT";
                        break;
                case REMOVE_EVENTS:
                        regType = "REMOVE_EVENTS";
                        break;
                default:
                        System.out.println("Error, invalid regType " +
                            regTypeIn);
                        regType = "ADD_CLIENT";
                        break;
                }
        }

        public void addRegEvent(Event regEvent)
        {
                regEvents.add(regEvent);
        }

        public String convertToXml()
        {
                Document document = null;
                DocumentBuilderFactory factory =
                    DocumentBuilderFactory.newInstance();
                try {
                        DocumentBuilder builder = factory.newDocumentBuilder();
                        document = builder.newDocument();
                } catch (ParserConfigurationException pce) {
                        // Parser with specified options can't be built
                        pce.printStackTrace();
                        System.exit(1);
                }

                // Create the root element
                Element root = (Element) document.createElement(
                    "SC_CALLBACK_REG");

                // Add the attributes
                root.setAttribute("VERSION", "1.0");
                root.setAttribute("PORT", port);
                root.setAttribute("regType", regType);

                // Add the events
                for (int i = 0; i < regEvents.size(); i++) {
                        Event tempEvent = (Event)
                            (regEvents.elementAt(i));
                        root.appendChild(tempEvent.createXmlElement(
                            document));
                }
                document.appendChild(root);

                // Convert the whole thing to a string
                DOMSource domSource = new DOMSource(document);
                StringWriter strWrite = new StringWriter();
                StreamResult streamResult = new StreamResult(strWrite);
                TransformerFactory tf = TransformerFactory.newInstance();
                try {
                        Transformer transformer = tf.newTransformer();
                        transformer.transform(domSource, streamResult);
                } catch (TransformerException e) {
                        System.out.println(e.toString());
                        return ("");
                }
                return (strWrite.toString());
        }

        private String port;
        private String regType;
        private Vector regEvents;
}
```

2. **Implement the `Event` and `NVPair` classes.**

   Note that the `CallbackReg` class uses an `Event` class, which itself uses an `NVPair` class.

```
class Event
{

        public Event()
        {
                regClass = regSubclass = null;
                nvpairs = new Vector();
        }

        public void setClass(String classIn)
        {
                regClass = classIn;
        }

        public void setSubclass(String subclassIn)
        {
                regSubclass = subclassIn;
        }

        public void addNvpair(NVPair nvpair)
        {
                nvpairs.add(nvpair);
        }

        public Element createXmlElement(Document doc)
        {
                Element event = (Element)
                    doc.createElement("SC_EVENT_REG");
                event.setAttribute("CLASS", regClass);
                if (regSubclass != null) {
                        event.setAttribute("SUBCLASS", regSubclass);
                }
                for (int i = 0; i < nvpairs.size(); i++) {
                         NVPair tempNv = (NVPair)
```

```
                                (nvpairs.elementAt(i));
                            event.appendChild(tempNv.createXmlElement(
                                doc));
                }
                return (event);
        }

        private String regClass, regSubclass;
        private Vector nvpairs;
}

class NVPair
{
        public NVPair()
        {
                name = value = null;
        }

        public void setName(String nameIn)
        {
                name = nameIn;
        }

        public void setValue(String valueIn)
        {
                value = valueIn;
        }

        public Element createXmlElement(Document doc)
        {
                Element nvpair = (Element)
                    doc.createElement("NVPAIR");
                Element eName = doc.createElement("NAME");
                Node nameData = doc.createCDATASection(name);
                eName.appendChild(nameData);
                nvpair.appendChild(eName);
                Element eValue = doc.createElement("VALUE");
                Node valueData = doc.createCDATASection(value);
                eValue.appendChild(valueData);
                nvpair.appendChild(eValue);

                return (nvpair);
        }

        private String name, value;
}
```

▼ Create the Registration and Unregistration Messages

Now that you have created the helper classes that generate the XML messages, you can write the implementation of the `createRegistrationString` method. This method is called by the `registerCallbacks` method, which is described in "Register and Unregister Callbacks" on page 216.

`createRegistrationString` constructs a `CallbackReg` object and sets its registration type and port. Then `createRegistrationString` constructs various events, using the `createAllEvent`, `createMembershipEvent`, `createRgEvent`, and `createREvent` helper methods. Each event is added to the `CallbackReg` object after this object is created. Finally, `createRegistrationString` calls the `convertToXml` method on the `CallbackReg` object to retrieve the XML message in `String` form.

Note that the `regs` member variable stores the command line arguments that a user provides to the application. The fifth and subsequent arguments specify the events for which the application should register. The fourth argument specifies the type of registration, but is ignored in this example. The complete code in Appendix G shows how to use this fourth argument.

1. **Create the Java code that implements the preceding logic.**

```
private String createRegistrationString() throws Exception
{
        CallbackReg cbReg = new CallbackReg();
        cbReg.setPort("" + localPort);

        cbReg.setRegType(CallbackReg.ADD_CLIENT);

        // add the events
        for (int i = 4; i < regs.length; i++) {
                if (regs[i].equals("M")) {
                        cbReg.addRegEvent(
                            createMembershipEvent());
                } else if (regs[i].equals("A")) {
                        cbReg.addRegEvent(
                            createAllEvent());
                } else if (regs[i].substring(0,2).equals("RG")) {
                        cbReg.addRegEvent(createRgEvent(
                            regs[i].substring(3)));
                } else if (regs[i].substring(0,1).equals("R")) {
                        cbReg.addRegEvent(createREvent(
                            regs[i].substring(2)));
                }
        }

        String xmlStr = cbReg.convertToXml();
        return (xmlStr);
}
```

```
private Event createAllEvent()
{
        Event allEvent = new Event();
        allEvent.setClass("EC_Cluster");
        return (allEvent);
}

private Event createMembershipEvent()
{
        Event membershipEvent = new Event();
        membershipEvent.setClass("EC_Cluster");
        membershipEvent.setSubclass("ESC_cluster_membership");
        return (membershipEvent);
}

private Event createRgEvent(String rgname)
{
        Event rgStateEvent = new Event();
        rgStateEvent.setClass("EC_Cluster");
        rgStateEvent.setSubclass("ESC_cluster_rg_state");

        NVPair rgNvpair = new NVPair();
        rgNvpair.setName("rg_name");
        rgNvpair.setValue(rgname);
        rgStateEvent.addNvpair(rgNvpair);

        return (rgStateEvent);
}

private Event createREvent(String rname)
{
        Event rStateEvent = new Event();
        rStateEvent.setClass("EC_Cluster");
        rStateEvent.setSubclass("ESC_cluster_r_state");

        NVPair rNvpair = new NVPair();
        rNvpair.setName("r_name");
        rNvpair.setValue(rname);
        rStateEvent.addNvpair(rNvpair);

        return (rStateEvent);
}
```

2. **Create the unregistration string.**

   Creating the unregistration string is easier than creating the registration string because you don’t need to accommodate events:

```
private String createUnregistrationString() throws Exception
{
        CallbackReg cbReg = new CallbackReg();
        cbReg.setPort("" + localPort);
        cbReg.setRegType(CallbackReg.REMOVE_CLIENT);
        String xmlStr = cbReg.convertToXml();
        return (xmlStr);
}
```

▼ Set Up the XML Parser

You have now created the networking and XML generation code for the application. The final step is to parse and process the registration reply and event callbacks. The `CrnpClient` constructor calls a `setupXmlProcessing` method. This method creates a `DocumentBuilderFactory` object and sets various parsing properties on that object. The JAXP documentation at `http://java.sun.com/xml/jaxp/index.html` describes this method in more detail.

● **Create the Java code that implements the preceding logic.**

```
private void setupXmlProcessing() throws Exception
{
        dbf = DocumentBuilderFactory.newInstance();

        // We don't need to bother validating
        dbf.setValidating(false);
        dbf.setExpandEntityReferences(false);

        // We want to ignore comments and whitespace
        dbf.setIgnoringComments(true);
        dbf.setIgnoringElementContentWhitespace(true);

        // Coalesce CDATA sections into TEXT nodes.
        dbf.setCoalescing(true);
}
```

▼ Parse the Registration Reply

To parse the `SC_REPLY` XML message that the CRNP server sends in response to a registration or unregistration message, you need a `RegReply` helper class. You can construct this class from an XML document. This class provides accessors for the status code and status message. To parse the XML stream from the server, you need to create a new XML document and use that document's parse method (the JAXP documentation at `http://java.sun.com/xml/jaxp/index.html` describes this method in more detail).

1. **Create the Java code that implements the preceding logic.**

   Note that the `readRegistrationReply` method uses the new `RegReply` class.

```
private void readRegistrationReply(InputStream stream) throws Exception
{
        // Create the document builder
        DocumentBuilder db = dbf.newDocumentBuilder();
        db.setErrorHandler(new DefaultHandler());

        //parse the input file
        Document doc = db.parse(stream);
```

```
                RegReply reply = new RegReply(doc);
                reply.print(System.out);
        }
```

2. **Implement the `RegReply` class.**

   Note that the `retrieveValues` method walks the DOM tree in the XML document and pulls out the status code and status message. The JAXP documentation at `http://java.sun.com/xml/jaxp/index.html` contains more detail.

```
class RegReply
{
        public RegReply(Document doc)
        {
                retrieveValues(doc);
        }

        public String getStatusCode()
        {
                return (statusCode);
        }

        public String getStatusMsg()
        {
                return (statusMsg);
        }
        public void print(PrintStream out)
        {
                out.println(statusCode + ": " +
                    (statusMsg != null ? statusMsg : ""));
        }

        private void retrieveValues(Document doc)
        {
                Node n;
                NodeList nl;
                String nodeName;

                // Find the SC_REPLY element.
                nl = doc.getElementsByTagName("SC_REPLY");
                if (nl.getLength() != 1) {
                        System.out.println("Error in parsing: can't find "
                            + "SC_REPLY node.");
                        return;
                }

                n = nl.item(0);

                // Retrieve the value of the statusCode attribute
                statusCode = ((Element)n).getAttribute("STATUS_CODE");

                // Find the SC_STATUS_MSG element
                nl = ((Element)n).getElementsByTagName("SC_STATUS_MSG");
                if (nl.getLength() != 1) {
```

```
                System.out.println("Error in parsing: can't find "
                    + "SC_STATUS_MSG node.");
                return;
        }
        // Get the TEXT section, if there is one.
        n = nl.item(0).getFirstChild();
        if (n == null || n.getNodeType() != Node.TEXT_NODE) {
                // Not an error if there isn't one, so we just silently return.
                return;
        }

        // Retrieve the value
        statusMsg = n.getNodeValue();
    }

    private String statusCode;
    private String statusMsg;
}
```

▼ Parse the Callback Events

The final step is to parse and process the actual callback events. To aid in this task, you modify the `Event` class that you created in "Generate the XML" on page 217 so that this class can construct an `Event` from an XML document and create an XML `Element`. This change requires an additional constructor (that takes an XML document), a `retrieveValues` method, the addition of two member variables (`vendor` and `publisher`), accessor methods for all fields, and finally, a print method.

1. **Create the Java code that implements the preceding logic.**

   Note that this code is similar to the code for the `RegReply` class that is described in "Parse the Registration Reply" on page 223.

```
public Event(Document doc)
{
        nvpairs = new Vector();
        retrieveValues(doc);
}
public void print(PrintStream out)
{
        out.println("\tCLASS=" + regClass);
        out.println("\tSUBCLASS=" + regSubclass);
        out.println("\tVENDOR=" + vendor);
        out.println("\tPUBLISHER=" + publisher);
        for (int i = 0; i < nvpairs.size(); i++) {
                NVPair tempNv = (NVPair)
                    (nvpairs.elementAt(i));
                out.print("\t\t");
                tempNv.print(out);
        }
}
```

```
private void retrieveValues(Document doc)
{
        Node n;
        NodeList nl;
        String nodeName;

        // Find the SC_EVENT element.
        nl = doc.getElementsByTagName("SC_EVENT");
        if (nl.getLength() != 1) {
                System.out.println("Error in parsing: can't find "
                    + "SC_EVENT node.");
                return;
        }

        n = nl.item(0);

        //
        // Retrieve the values of the CLASS, SUBCLASS,
        // VENDOR and PUBLISHER attributes.
        //
        regClass = ((Element)n).getAttribute("CLASS");
        regSubclass = ((Element)n).getAttribute("SUBCLASS");
        publisher = ((Element)n).getAttribute("PUBLISHER");
        vendor = ((Element)n).getAttribute("VENDOR");

        // Retrieve all the nv pairs
        for (Node child = n.getFirstChild(); child != null;
            child = child.getNextSibling())
        {
               nvpairs.add(new NVPair((Element)child));
        }
}

public String getRegClass()
{
        return (regClass);
}

public String getSubclass()
{
        return (regSubclass);
}

public String getVendor()
{
        return (vendor);
}

public String getPublisher()
{
        return (publisher);
}

public Vector getNvpairs()
{
        return (nvpairs);
}

private String vendor, publisher;
```

2. **Implement the additional constructors and methods for the `NVPair` class that support the XML parsing.**

   The changes to the `Event` class that are shown in Step 1 require similar changes to the `NVPair` class.

```
public NVPair(Element elem)
{
        retrieveValues(elem);
}
public void print(PrintStream out)
{
        out.println("NAME=" + name + " VALUE=" + value);
}
private void retrieveValues(Element elem)
{
        Node n;
        NodeList nl;
        String nodeName;

        // Find the NAME element
        nl = elem.getElementsByTagName("NAME");
        if (nl.getLength() != 1) {
                System.out.println("Error in parsing: can't find "
                    + "NAME node.");
                return;
        }
        // Get the TEXT section
        n = nl.item(0).getFirstChild();
        if (n == null || n.getNodeType() != Node.TEXT_NODE) {
                System.out.println("Error in parsing: can't find "
                    + "TEXT section.");
                return;
        }

        // Retrieve the value
        name = n.getNodeValue();

        // Now get the value element
        nl = elem.getElementsByTagName("VALUE");
        if (nl.getLength() != 1) {
                System.out.println("Error in parsing: can't find "
                    + "VALUE node.");
                return;
        }
        // Get the TEXT section
        n = nl.item(0).getFirstChild();
        if (n == null || n.getNodeType() != Node.TEXT_NODE) {
        System.out.println("Error in parsing: can't find "
                    + "TEXT section.");
                return;
                }

                // Retrieve the value
                value = n.getNodeValue();
                }

        public String getName()
        {
                return (name);
        }

        public String getValue()
        {
                return (value);
        }
}
```

3. **Implement the `while` loop in `EventReceptionThread`, which waits for event callbacks (`EventReceptionThread` is described in "Define the Event Reception Thread" on page 215).**

```
while(true) {
                Socket sock = listeningSock.accept();
                Document doc = db.parse(sock.getInputStream());
                Event event = new Event(doc);
                client.processEvent(event);
                sock.close();
        }
```

▼ Run the Application

● **Run your application.**

# **`java CrnpClient`** *crnpHost crnpPort localPort* **...**

The complete code for the `CrnpClient` application is listed in Appendix G.

APPENDIX **A**

Standard Properties

This appendix describes the standard resource type, resource group, and resource properties. It also describes the resource property attributes that are available for changing system-defined properties and creating extension properties.

This appendix includes the following major sections:

Note – The property values, such as `True` and `False`, are *not* case sensitive.

Resource Type Properties

The following table describes the resource type properties defined by Sun Cluster. The property values are categorized as follows (in the Category column):

- **Required** — The property requires an explicit value in the Resource Type Registration (RTR) file or the object to which it belongs cannot be created. A blank or the empty string is not allowed as a value.
- **Conditional** — To exist, the property must be declared in the RTR file; otherwise, the RGM does not create it and it is not available to administrative utilities. A blank or the empty string is allowed. If the property is declared in the RTR file but no value is specified, the RGM supplies a default value.
- **Conditional/Explicit** — To exist, the property must be declared in the RTR file with an explicit value; otherwise, the RGM does not create it and it is not available to administrative utilities. A blank or the empty string is not allowed.

- **Optional** — The property can be declared in the RTR file. If the property is not, the RGM creates it and supplies a default value. If the property is declared in the RTR file but no value is specified, the RGM supplies the same default value as if the property were not declared in the RTR file.

Resource type properties cannot be updated by administrative utilities with the exception of `Installed_nodes`, which cannot be declared in the RTR file and must be set by the administrator.

TABLE A–1 Resource Type Properties

Property Name	Description	Can Be Updated?	Category
`Allow_hosts` (string array)	Controls the set of clients that are allowed to register with the `cl_apid` daemon to receive cluster reconfiguration events. The general form of this property is `ipaddress/masklength`, which defines a subnet from which the clients are allowed to register. For example, the setting `129.99.77.0/24` allows clients on the subnet `129.99.77` to register for events. As another example, `192.9.84.231/32` allows only the client `192.9.84.231` to register for events. This property provides security to the CRNP. The `cl_apid` daemon is described in `SUNW.Event`(5). In addition, the following special keywords are recognized. `LOCAL` refers to all clients that are located in directly connected subnets of the cluster. `ALL` allows all clients to register. Note that if a client matches an entry in both the `Allow_hosts` and the `Deny_hosts` property, that client is prevented from registering with the implementation. The default is `LOCAL`.	N	Optional
`API_version` (integer)	The version of the resource management API used by this resource type implementation. The default for SC 3.1 is 2.	N	Optional
`Boot` (string)	An optional callback method: the path to the program that the RGM invokes on a node, which joins or rejoins the cluster when a resource of this type is already managed. This method is expected to do initialization actions for resources of this type similar to the `Init` method.	N	Conditional/ Explicit

TABLE A–1 Resource Type Properties *(Continued)*

Property Name	Description	Can Be Updated?	Category
`Client_retry_count` (integer)	Controls the number of attempts made by the `cl_apid` daemon while communicating with external clients. If a client fails to respond within `Client_retry_count` attempts, the client times out. The client is subsequently removed from the list of registered clients that are eligible to receive cluster reconfiguration events. The client must re-register in order to start receiving events again. See the description of the `Client_retry_interval` property to learn more about how often these retries are made by the implementation. The `cl_apid` daemon is described in `SUNW.Event`(5). The default is 3.	Y	Optional
`Client_retry_interval` (integer)	Defines the time period (in seconds) used by the `cl_apid` daemon while communicating with unresponsive external clients. Up to `Client_retry_count` attempts are made during this interval to contact the client. The `cl_apid` daemon is described in `SUNW.Event`(5). The default is 1800.	Y	Optional
`Client_timeout` (integer)	The time-out value (in seconds) that is used by the `cl_apid` daemon while communicating with external clients. However, the `cl_apid` daemon continues to attempt to contact the client for a tunable number of times. See the descriptions of the `Client_retry_count` and `Client_retry_interval` properties to learn more about the means that you can use to tune this property. The `cl_apid` daemon is described in `SUNW.Event`(5). The default is 60.	Y	Optional
`Deny_hosts` (string array)	Controls the set of clients that are prevented from registering to receive cluster reconfiguration events. To determine access, the settings of this property take precedence over those in the `Allow_hosts` list. The format of this property is the same as the format that is defined in the `Allow_hosts` property. This property provides security to the CRNP. The default is `NULL`.	Y	Optional

TABLE A–1 Resource Type Properties *(Continued)*

Property Name	Description	Can Be Updated?	Category
`Failover` (Boolean)	`True` indicates that resources of this type cannot be configured in any group that can be online on multiple nodes at once. The default is `False`.	N	Optional
`Fini` (string)	An optional callback method: the path to the program that the RGM invokes when a resource of this type is removed from RGM management.	N	Conditional/ Explicit
`Init` (string)	An optional callback method: the path to the program that the RGM invokes when a resource of this type becomes managed by the RGM.	N	Conditional/ Explicit
`Init_nodes` (enum)	The values can be `RG_primaries` (just the nodes that can master the resource) or `RT_installed_nodes` (all nodes on which the resource type is installed). Indicates the nodes on which the RGM is to call the `Init`, `Fini`, `Boot` and `Validate` methods. The default value is `RG_primaries`.	N	Optional
`Installed_nodes` (string array)	A list of the cluster node names on which the resource type is allowed to be run. The RGM automatically creates this property. The cluster administrator can set the value. You cannot declare this property in the RTR file. The default is all cluster nodes.	Y	Can be configured by the cluster administrator
`Max_clients` (integer)	Controls the maximum number of clients that can register with the `cl_apid` daemon to receive notification of cluster events. Attempts by additional clients to register for events are rejected by your application. Since each client registration uses resources on the cluster, tuning this property allows users to control resource usage on the cluster by external clients. The `cl_apid` daemon is described in `SUNW.Event`(5). The default is 1000.	Y	Optional
`Monitor_check` (string)	An optional callback method: the path to the program that the RGM invokes before doing a monitor-requested failover of a resource of this type.	N	Conditional/ Explicit

TABLE A–1 Resource Type Properties *(Continued)*

Property Name	Description	Can Be Updated?	Category
`Monitor_start` (string)	An optional callback method: the path to the program that the RGM invokes to start a fault monitor for a resource of this type.	N	Conditional/ Explicit
`Monitor_stop` (string)	A callback method that is required if `Monitor_start` is set: the path to the program that the RGM invokes to stop a fault monitor for a resource of this type.	N	Conditional/ Explicit
`Num_resource_restarts` on each cluster node (integer)	This property is set by the RGM to the number of `scha_control RESTART` calls that have been made for this resource on this node within the past *n* seconds, where *n* is the value of the `Retry_interval` property of the resource. If a resource type does not declare the `Retry_interval` property, then the `Num_resource_restarts` property is not available for resources of that type.	N	Query-only
`Pkglist` (string array)	An optional list of packages that are included in the resource type installation.	N	Conditional/ Explicit
`Postnet_stop` (string)	An optional callback method: the path to the program that the RGM invokes after calling the `Stop` method of any network-address resources (`Network_resources_used`) on which a resource of this type depends. This method is expected to do `STOP` actions that must be done after the network interfaces are configured down.	N	Conditional/ Explicit
`Prenet_start` (string)	An optional callback method: the path to the program that the RGM invokes before calling the `Start` method of any network-address resources (`Network_resources_used`) that a resource of this type is dependent on. This method is expected to do `START` actions that must be done before network interfaces are configured up.	N	Conditional/ Explicit

TABLE A–1 Resource Type Properties *(Continued)*

Property Name	Description	Can Be Updated?	Category

`Resource_type` (string)	The name of the resource type. To view the names of the currently registered resource types, use:
	
	`scrgadm` `-p`
	Starting in Sun Cluster 3.1, a resource type name is of the form:
	
	`vendor_id.resource_type:version`
	The three components of the resource type name are properties specified in the RTR file as *Vendor_id*, *Resource_type*, and *RT_version*. The `scrgadm` command inserts the period and colon delimiters. The `RT_version` suffix of the resource type name is the same value as the `RT_version` property. To ensure that the *Vendor_id* is unique, the recommended approach is to use the stock symbol for the company creating the resource type. Resource type names created prior to Sun Cluster 3.1 continue to be of the form:
	
	`vendor_id.resource_type`
	The default is the empty string.
		N	Required

`RT_basedir` (string)	The directory path that is used to complete relative paths for callback methods. This path is expected to be set to the installation location for the resource type packages. It must be a complete path, that is, it must start with a forward slash (`/`). This property is not required if all the method path names are absolute.	N	Required unless all method path names are absolute
`RT_description` (string)	A brief description of the resource type. The default is the empty string.	N	Conditional
`RT_version` (string)	Starting with Sun Cluster 3.1, a required version string of this resource type implementation. The `RT_version` is the suffix component of the full resource type name.	N	Conditional/ Explicit
`Single_instance` (Boolean)	If `True`, indicates that only one resource of this type can exist in the cluster. The RGM allows only one resource of this type to run cluster-wide at one time. The default value is `False`.	N	Optional

TABLE A–1 Resource Type Properties *(Continued)*

Property Name	Description	Can Be Updated?	Category
`Start` (string)	A callback method: the path to the program that the RGM invokes to start a resource of this type.	N	Required unless the RTR file declares a `Prenet_start` method
`Stop` (string)	A callback method: the path to the program that the RGM invokes to stop a resource of this type.	N	Required unless the RTR file declares a `Postnet_stop` method
`Update` (string)	An optional callback method: the path to the program that the RGM invokes when properties of a running resource of this type are changed.	N	Conditional/ Explicit
`Validate` (string)	An optional callback method: the path to the program that will be invoked to check values for properties of resources of this type.	N	Conditional/ Explicit
`Vendor_ID` (string)	See the `Resource_type` property.	N	Conditional

Resource Properties

Table A–2 describes the resource properties defined by Sun Cluster. The property values are categorized as follows (in the Category column):

- **Required** — The administrator must specify a value when creating a resource with an administrative utility.
- **Optional** — If the administrator does not specify a value when creating a resource group, the system supplies a default value.
- **Conditional** — The RGM creates the property only if the property is declared in the RTR file. Otherwise, the property does not exist and is not available to system administrators. A conditional property declared in the RTR file is optional or required, depending on whether a default value is specified in the RTR file. For details, see the description of each conditional property.
- **Query-only** — Cannot be set directly by an administrative tool.

Table A–2 also lists whether and when you can update resource properties (in the Can Be Updated? column), as follows:

`None` or `False`	Never
`True` or `Anytime`	Any time
`At_creation`	When the resource is added to a cluster
`When_disabled`	When the resource is disabled

TABLE A–2 Resource Properties

Property Name	**Description**	**Can Be Updated?**	**Category**
`Affinity_timeout` (integer)	Length of time in seconds during which connections from a given client IP address for any service in the resource will be sent to the same server node. This property is relevant only when `Load_balancing_policy` is either `Lb_sticky` or `Lb_sticky_wild`. In addition, `Weak_affinity` must be set to false (the default value). This property is only used for scalable services.	Any time	Optional
`Cheap_probe_interval` (integer)	The number of seconds between invocations of a quick fault probe of the resource. This property is only created by the RGM and available to the administrator if it is declared in the RTR file. This property is optional if a default value is specified in the RTR file. If the `Tunable` attribute is not specified in the resource type file, the `Tunable` value for the property is `When_disabled`. This property is required if the `Default` attribute is not specified in the property declaration in the RTR file.	When disabled	Conditional
Extension properties	Extension properties as declared in the RTR file of the resource's type. The implementation of the resource type defines these properties. For information on the individual attributes you can set for extension properties, see Table A–4.	Depends on the specific property	Conditional

TABLE A–2 Resource Properties *(Continued)*

Property Name	Description	Can Be Updated?	Category
Failover_mode (enum)	Possible settings are None, Soft, and Hard. Controls whether the RGM relocates a resource group or aborts a node in response to a failure of a Start, Stop, or Monitor_stop method call on the resource. None indicates that the RGM should just set the resource state on method failure and wait for operator intervention. Soft indicates that failure of a Start method should cause the RGM to relocate the resource's group to a different node while failure of a Stop or Monitor_stop method should cause the RGM to set the resource to STOP_FAILED state and the resource group to ERROR_STOP_FAILED state and wait for operator intervention. For Stop or Monitor_stop failures, the None and Soft settings are equivalent. Hard indicates that failure of a Start method should cause the relocation of the group and failure of a Stop or Monitor_stop method should cause the forcible stop of the resource by aborting the cluster node. The default is None.	Any time	Optional
Load_balancing_policy (string)	A string that defines the load-balancing policy in use. This property is used only for scalable services. The RGM automatically creates this property if the Scalable property is declared in the RTR file. Load_balancing_policy can take the following values: Lb_weighted (the default). The load is distributed among various nodes according to the weights set in the Load_balancing_weights property. Lb_sticky. A given client (identified by the client IP address) of the scalable service is always sent to the same node of the cluster. Lb_sticky_wild. A given client (identified by the client's IP address), that connects to an IP address of a wildcard sticky service, is always sent to the same cluster node regardless of the port number it is coming to. The default value is Lb_weighted.	At creation	Conditional/ Optional

TABLE A–2 Resource Properties *(Continued)*

Property Name	**Description**	**Can Be Updated?**	**Category**
`Load_balancing_weights` (string array)	For scalable resources only. The RGM automatically creates this property if the `Scalable` property is declared in the RTR file. The format is *weight@node,weight@node*, where *weight* is an integer that reflects the relative portion of load distributed to the specified *node*. The fraction of load distributed to a node is the weight for this node divided by the sum of all weights. For example, `1@1,3@2` specifies that node 1 receives 1/4 of the load and node 2 receives 3/4. The empty string (""), the default, sets a uniform distribution. Any node that is not assigned an explicit weight, receives a default weight of 1. If the `Tunable` attribute is not specified in the resource type file, the `Tunable` value for the property is `Anytime`. Changing this property revises the distribution for new connections only. The default value is the empty string ("").	Any time	Conditional/ Optional
method`_timeout` for each callback method in the Type (integer)	A time lapse, in seconds, after which the RGM concludes that an invocation of the method has failed. The default is 3,600 (one hour) if the method itself is declared in the RTR file.	Any time	Conditional/ Optional
`Monitored_switch` (enum)	Set to `Enabled` or `Disabled` by the RGM if the cluster administrator enables or disables the monitor with an administrative utility. If `Disabled`, the monitor does not have its `Start` method called until it is enabled again. If the resource does not have a monitor callback method, this property does not exist. The default is `Enabled`.	Never	Query-only

TABLE A–2 Resource Properties *(Continued)*

Property Name	Description	Can Be Updated?	Category
`Network_resources_used` (string array)	A list of logical host name or shared address network resources used by the resource. For scalable services, this property must refer to shared address resources that exist in a separate resource group. For failover services, this property refers to logical host name or shared address resources that exist in the same resource group. The RGM automatically creates this property if the `Scalable` property is declared in the RTR file. If `Scalable` is not declared in the RTR file, `Network_resources_used` is unavailable unless it is explicitly declared in the RTR file. If the `Tunable` attribute is not specified in the resource type file, the `Tunable` value for the property is `At_creation`.	At creation	Conditional/ Required
`On_off_switch` (enum)	Set to `Enabled` or `Disabled` by the RGM if the cluster administrator enables or disables the resource with an administrative utility. If disabled, a resource has no callbacks invoked until it is enabled again. The default is `Disabled`.	Never	Query-only
`Port_list` (string array)	A list of port numbers on which the server is listening. Appended to each port number is the protocol being used by that port, for example, `Port_list=80/tcp`. If the `Scalable` property is declared in the RTR file, the RGM automatically creates `Port_list`. Otherwise, this property is unavailable unless it is explicitly declared in the RTR file. Setting up this property for Apache is described in the *Sun Cluster 3.1 Data Service for Apache Guide*.	At creation	Conditional/ Required
`R_description` (string)	A brief description of the resource. The default is the empty string.	Any time	Optional
`Resource_name` (string)	The name of the resource instance. This name must be unique within the cluster configuration and cannot be changed after a resource has been created.	Never	Required

TABLE A–2 Resource Properties *(Continued)*

Property Name	Description	Can Be Updated?	Category
`Resource_project_name` (string)	The Solaris project name associated with the resource. Use this property to apply Solaris resource management features such as CPU shares and resource pools to cluster data services. When the RGM brings resources online, it launches the related processes under this project name. If this property is not specified, the project name will be taken from the `RG_project_name` property of the resource group that contains the resource (see `rg_properties` (5)). If neither property is specified, the RGM will use the predefined project name `default`. The specified project name must exist in the projects database and the user `root` must be configured as a member of the named project. This property is only supported starting in Solaris 9. **Note –** Changes to this property take effect after the resource has been restarted. The default is null.	Any time	Optional
`Resource_state` on each cluster node (enum)	The RGM-determined state of the resource on each cluster node. Possible states are `Online`, `Offline`, `Stop_failed`, `Start_failed`, `Monitor_failed`, and `Online_not_monitored`. This property is not user configurable.	Never	Query-only
`Retry_count` (integer)	The number of times a monitor attempts to restart a resource if it fails. This property is created by the RGM only and available to the administrator if it is declared in the RTR file. It is optional if a default value is specified in the RTR file. If the `Tunable` attribute is not specified in the resource type file, the `Tunable` value for the property is `When_disabled`. This property is required if the `Default` attribute is not specified in the property declaration in the RTR file.	When disabled	Conditional

TABLE A–2 Resource Properties *(Continued)*

Property Name	Description	Can Be Updated?	Category
`Retry_interval` (integer)	The number of seconds over which to count attempts to restart a failed resource. The resource monitor uses this property in conjunction with `Retry_count`. This property is created by the RGM only and available to the administrator if it is declared in the RTR file. It is optional if a default value is specified in the RTR file. If the `Tunable` attribute is not specified in the resource type file, the `Tunable` value for the property is `When_disabled`. This property is required if the `Default` attribute is not specified in the property declaration in the RTR file.	When disabled	Conditional
`Scalable` (Boolean)	Indicates whether the resource is scalable. If this property is declared in the RTR file, the RGM automatically creates the following scalable service properties for resources of that type: `Network_resources_used`, `Port_list`, `Load_balancing_policy`, and `Load_balancing_weights`. These properties have their default values unless they are explicitly declared in the RTR file. The default for `Scalable`—when it is declared in the RTR file—is `True`. When this property is declared in RTR file, the `Tunable` attribute must be set to `At_creation` or resource creation fails. If this property is not declared in the RTR file, the resource is not scalable, the cluster administrator cannot tune this property and no scalable service properties are set by the RGM. However, you can explicitly declare the `Network_resources_used` and `Port_list` properties in the RTR file, if desired, because they can be useful in a non-scalable service as well as in a scalable service.	At creation	Optional
`Status` on each cluster node (enum)	Set by the resource monitor. Possible values are: `OK`, `degraded`, `faulted`, `unknown`, and `offline`. The RGM sets the value to `unknown` when the resource is brought online and to `Offline` when it is brought offline.	Never	Query-only

TABLE A–2 Resource Properties *(Continued)*

Property Name	Description	Can Be Updated?	Category
`Status_msg` on each cluster node (string)	Set by the resource monitor at the same time as the `Status` property. This property can be set per resource, per node. The RGM sets it to the empty string when the resource is brought offline.	Never	Query-only
`Thorough_probe_interval` (integer)	The number of seconds between invocations of a high-overhead fault probe of the resource. This property is created by the RGM only and available to the administrator if it is declared in the RTR file. It is optional if a default value is specified in the RTR file. If the `Tunable` attribute is not specified in the resource type file, the `Tunable` value for the property is `When_disabled`. This property is required if the `Default` attribute is not specified in the property declaration in the RTR file.	When disabled	Conditional
`Type` (string)	The resource type of which this resource is an instance.	Never	Required
`Type_version` (string)	Specifies which version of the resource type is currently associated with this resource. The RGM automatically creates this property, which cannot be declared in the RTR file. The value of this property is equal to the `RT_version` property of the resource's type. When a resource is created, the `Type_version` property is not specified explicitly, though it may appear as a suffix of the resource type name. When a resource is edited, the `Type_version` may be changed to a new value. Its tunability is derived from: ■ The current version of the resource type ■ The `#$upgrade_from` directive in the RTR file	See description	See description

TABLE A–2 Resource Properties *(Continued)*

Property Name	Description	Can Be Updated?	Category
`UDP_affinity` (Boolean)	If true, all UDP traffic from a given client is sent to the same server node that currently handles all TCP traffic for the client. This property is relevant only when `Load_balancing_policy` is either `Lb_sticky` or `Lb_sticky_wild`. In addition, `Weak_affinity` must be set to False (the default value). This property is only used for scalable services.	When disabled	Optional
`Weak_affinity` (Boolean)	If true, enable the weak form of the client affinity. This allows connections from a given client to be sent to the same server node except: ■ When a server listener starts up, for example, due to a fault monitor restarts, a resource failover or switchover, or a node rejoining a cluster after failing. ■ When `Load_balancing_weights` for the scalable resource changes due to an administration action. Weak affinity provides a low overhead alternative to the default form, both in terms of memory consumption and processor cycles. This property is relevant only when `Load_balancing_policy` is either `Lb_sticky` or `Lb_sticky_wild`. This property is only used for scalable services.	When disabled	Optional

Resource Group Properties

The following table describes the resource group properties defined by Sun Cluster. The property values are categorized as follows (in the Category column):

- **Required** — The administrator must specify a value when creating a resource group with an administrative utility.
- **Optional** — If the administrator does not specify a value when creating a resource group, the system supplies a default value.

- **Query-only** — Cannot be set directly by an administrative tool.

The Can Be Updated? column shows whether the property can be updated (Y) or not (N) after it is initially set.

TABLE A–3 Resource Group Properties

Property Name	Description	Can Be Updated?	Category
`Auto_start_on_new_cluster` (Boolean)	This property disallows automatic startup of the Resource Group when a new cluster is forming. The default is `TRUE`. If set to `TRUE`, the Resource Group Manager attempts to start the resource group automatically to achieve `Desired_primaries` when the cluster is rebooted. If set to `FALSE`, the Resource Group does not start automatically when the cluster reboots.	Y	Optional
`Desired_primaries` (integer)	The number of nodes where the group is desired to be online at once. The default is 1. If the `RG_mode` property is `Failover`, the value of this property must be no greater than 1. If the `RG_mode` property is `Scalable`, a value greater than 1 is allowed.	Y	Optional
`Failback` (Boolean)	A Boolean value that indicates whether to recalculate the set of nodes where the group is online when the cluster membership changes. A recalculation can cause the RGM to bring the group offline on less preferred nodes and online on more preferred nodes. The default is `False`.	Y	Optional
`Global_resources_used` (string array)	Indicates whether cluster file systems are used by any resource in this resource group. Legal values that the administrator can specify are an asterisk (*) to indicate all global resources, and the empty string (“”) to indicate no global resources. The default is all global resources.	Y	Optional

TABLE A–3 Resource Group Properties *(Continued)*

Property Name	**Description**	**Can Be Updated?**	**Category**
`Implicit_network_dependencies` (Boolean)	A Boolean value that indicates, when `True`, that the RGM should enforce implicit strong dependencies of non-network-address resources on network-address resources within the group. Network-address resources include the logical host name and shared address resource types. In a scalable resource group, this property has no effect because a scalable resource group does not contain any network-address resources. The default is `True`.	Y	Optional
`Maximum_primaries` (integer)	The maximum number of nodes where the group might be online at once. The default is 1. If the `RG_mode` property is `Failover`, the value of this property must be no greater than 1. If the `RG_mode` property is `Scalable`, a value greater than 1 is allowed.	Y	Optional
`Nodelist` (string array)	A list of cluster nodes where the group can be brought online in order of preference. These nodes are known as the potential primaries or masters of the resource group. The default is the list of all cluster nodes.	Y	Optional
`Pathprefix` (string)	A directory in the cluster file system in which resources in the group can write can write essential administrative files. Some resources might require this property. Make `Pathprefix` unique for each resource group. The default is the empty string.	Y	Optional

TABLE A–3 Resource Group Properties *(Continued)*

Property Name	Description	Can Be Updated?	Category
`Pingpong_interval` (integer)	A non-negative integer value (in seconds) used by the RGM to determine where to bring the resource group online in the event of a reconfiguration or as the result of a `scha_control -O GIVEOVER` command or `scha_control()` function with the `SCHA_GIVEOVER` argument being executed. In the event of a reconfiguration, if the resource group fails to come online more than once within the past `Pingpong_interval` seconds on a particular node (because the resource's `Start` or `Prenet_start` method exited non-zero or timed out), that node is considered ineligible to host the resource group and the RGM looks for another master. If a call to a resource's `scha_control` command or `scha_control()` function causes the resource group to be brought offline on a particular node within the past `Pingpong_interval` seconds, that node is ineligible to host the resource group as the result of a subsequent call to `scha_control()` originating from another node. The default value is 3,600 (one hour).	Y	Optional
`Resource_list` (string array)	The list of resources that are contained in the group. The administrator does not set this property directly. Rather, the RGM updates this property as the administrator adds or removes resources from the resource group. The default is the empty list.	N	Query-only
`RG_description` (string)	A brief description of the resource group. The default is the empty string.	Y	Optional

TABLE A–3 Resource Group Properties *(Continued)*

Property Name	Description	Can Be Updated?	Category
`RG_mode` (enum)	Indicates whether the resource group is a failover or scalable group. If the value is `Failover`, the RGM sets the `Maximum_primaries` property of the group to 1 and restricts the resource group to being mastered by a single node. If the value of this property is `Scalable`, the RGM allows the `Maximum_primaries` property to have a value greater than 1, meaning the group can be mastered by multiple nodes simultaneously. The RGM does not allow a resource whose `Failover` property is `True` to be added to a resource group whose `RG_mode` is `Scalable`. The default is `Failover` if `Maximum_primaries` is 1 and `Scalable` if `Maximum_primaries` is greater than 1.	N	Optional
`RG_name` (string)	The name of the resource group. This name must be unique within the cluster.	N	Required
`RG_project_name` (string)	The Solaris project name associated with the resource group. Use this property to apply Solaris resource management features such as CPU shares and resource pools to cluster data services. When the RGM brings resource groups online, it launches the related processes under this project name for resources that do not have the `Resource_project_name` property set. The specified project name must exist in the projects database and the user `root` must be configured as a member of the named project. This property is only supported starting in Solaris 9. **Note –** Changes to this property take effect after the resource has been restarted.	Any time	Required
`RG_state` on each cluster node (enum)	Set by the RGM to `Online`, `Offline`, `Pending_online`, `Pending_offline`, `Pending_online_blocked`, `Error_stop_failed`, or `Online_faulted` to describe the state of the group on each cluster node. This property is not user configurable. However, you can indirectly set this property by invoking `scswitch`(1M) (or by using the equivalent `scsetup`(1M) or SunPlex Manager commands).	N	Query-only

Resource Property Attributes

The following table describes the resource property attributes that can be used to change system-defined properties or create extension properties.

Caution – You cannot specify NULL or the empty string (“”) as the default value for boolean, enum, or int types.

TABLE A–4 Resource Property Attributes

Property	Description
Property	The name of the resource property.
Extension	If used, indicates that the RTR file entry declares an extension property defined by the resource type implementation. Otherwise, the entry is a system-defined property.
Description	A string annotation intended to be a brief description of the property. The description attribute cannot be set in the RTR file for system-defined properties.
Type of the property	Allowable types are: string, boolean, int, enum, and stringarray. You cannot set the type attribute in an RTR file entry for system-defined properties. The type determines acceptable property values and the type-specific attributes that are allowed in the RTR file entry. an enum type is a set of string values.
Default	Indicates a default value for the property.
Tunable	Indicates when the cluster administrator can set the value of this property in a resource. Can be set to None or False to prevent the administrator from setting the property. Values that allow administrator tuning are: True or Anytime (at any time), At_creation (only when the resource is created), or When_disabled (when the resource is offline). The default is True (Anytime).
Enumlist	For an enum type, a set of string values permitted for the property.
Min	For an int type, the minimal value permitted for the property.
Max	For an int type, the maximum value permitted for the property.
Minlength	For string and stringarray types, the minimum string length permitted.
Maxlength	For string and stringarray types, the maximum string length permitted.
Array_minsize	For stringarray type, the minimum number of array elements permitted.
Array_maxsize	For stringarray type, the maximum number of array elements permitted.

APPENDIX **B**

Sample Data Service Code Listings

This appendix provides the complete code for each method in the sample data service. It also lists the contents of the resource type registration file.

This appendix includes the following code listings.

Resource Type Registration File Listing

The RTR (resource type registration) file contains resource and resource type property declarations that define the initial configuration of the data service at the time the cluster administrator registers the data service.

EXAMPLE B–1 `SUNW.Sample` RTR File

```
#
# Copyright (c) 1998-2003 by Sun Microsystems, Inc.
# All rights reserved.
#
# Registration information for Domain Name Service (DNS)
#
```

EXAMPLE B–1 `SUNW.Sample` RTR File *(Continued)*

```
#pragma ident   "@(#)SUNW.sample   1.1   00/05/24 SMI"

RESOURCE_TYPE = "sample";
VENDOR_ID = SUNW;
RT_DESCRIPTION = "Domain Name Service on Sun Cluster";

RT_VERSION ="1.0";
API_VERSION = 2;
FAILOVER = TRUE;

RT_BASEDIR=/opt/SUNWsample/bin;
PKGLIST = SUNWsample;

START              = dns_svc_start;
STOP               = dns_svc_stop;

VALIDATE           = dns_validate;
UPDATE             = dns_update;

MONITOR_START      = dns_monitor_start;
MONITOR_STOP       = dns_monitor_stop;
MONITOR_CHECK      = dns_monitor_check;

# A list of bracketed resource property declarations follows the
# resource-type declarations. The property-name declaration must
be
# the first attribute after the open curly bracket of each entry.
#

# The <method>_timeout properties set the value in seconds
after which
# the RGM concludes invocation of the method has failed.

# The MIN value for all method timeouts is set to 60 seconds. This
# prevents administrators from setting shorter timeouts, which do
not
# improve switchover/failover performance, and can lead to undesired
# RGM actions (false failovers, node reboot, or moving the resource
group
# to ERROR_STOP_FAILED state, requiring operator intervention).
Setting
# too-short method timeouts leads to a *decrease* in overall availability
# of the data service.
{
   PROPERTY = Start_timeout;
   MIN=60;
   DEFAULT=300;
}

{
             PROPERTY = Stop_timeout;
            MIN=60;
```

EXAMPLE B–1 `SUNW.Sample` RTR File *(Continued)*

```
           DEFAULT=300;
}
{
        PROPERTY = Validate_timeout;
        MIN=60;
        DEFAULT=300;
}
{
        PROPERTY = Update_timeout;
        MIN=60;
        DEFAULT=300;
}
{
        PROPERTY = Monitor_Start_timeout;
        MIN=60;
        DEFAULT=300;
}
{
        PROPERTY = Monitor_Stop_timeout;
        MIN=60;
        DEFAULT=300;
}
{
        PROPERTY = Thorough_Probe_Interval;
        MIN=1;
        MAX=3600;
        DEFAULT=60;
        TUNABLE = ANYTIME;
}

# The number of retries to be done within a certain period before
concluding
# that the application cannot be successfully started on this node.
{
        PROPERTY = Retry_Count;
        MIN=0;
        MAX=10;
        DEFAULT=2;
        TUNABLE = ANYTIME;
}

# Set Retry_Interval as a multiple of 60 since it is converted from
seconds
# to minutes, rounding up. For example, a value of 50 (seconds)
# is converted to 1 minute. Use this property to time the number
of
# retries (Retry_Count).
{
        PROPERTY = Retry_Interval;
        MIN=60;
        MAX=3600;
        DEFAULT=300;
        TUNABLE = ANYTIME;
```

EXAMPLE B–1 `SUNW.Sample` RTR File *(Continued)*

```
}

{
        PROPERTY = Network_resources_used;
        TUNABLE = AT_CREATION;
        DEFAULT = "";
}

#
# Extension Properties
#

# The cluster administrator must set the value of this property
to point to the
# directory that contains the configuration files used by the application.
# For this application, DNS, specify the path of the DNS configuration
file on
# PXFS (typically named.conf).
{
   PROPERTY = Confdir;
   EXTENSION;
   STRING;
   TUNABLE = AT_CREATION;
   DESCRIPTION = "The Configuration Directory Path";
}

# Time out value in seconds before declaring the probe as failed.
{
        PROPERTY = Probe_timeout;
        EXTENSION;
        INT;
        DEFAULT = 30;
        TUNABLE = ANYTIME;
        DESCRIPTION = "Time out value for the probe (seconds)";
}
```

`Start` Method

The RGM invokes the `Start` method on a cluster node when the resource group containing the data service resource is brought online on that node or when the resource is enabled. In the sample application, the `Start` method activates the `in.named` (DNS) daemon on that node.

EXAMPLE B–2 `dns_svc_start` Method

```
#!/bin/ksh
#
# Start Method for HA-DNS.
```

EXAMPLE B–2 dns_svc_start Method *(Continued)*

```
#
# This method starts the data service under the control of PMF.
Before starting
# the in.named process for DNS, it performs some sanity checks.
The PMF tag for
# the data service is $RESOURCE_NAME.named. PMF tries to start the
service a
# specified number of times (Retry_count) and if the number of attempts
exceeds
# this value within a specified interval (Retry_interval) PMF reports
a failure
# to start the service. Retry_count and Retry_interval are both
properties of the
# resource set in the RTR file.


#pragma ident   "@(#)dns_svc_start   1.1   00/05/24 SMI"

###############################################################################
# Parse program arguments.
#
function parse_args # [args ...]
{
        typeset opt

        while getopts 'R:G:T:' opt
        do
                case "$opt" in
                R)
                        # Name of the DNS resource.
                        RESOURCE_NAME=$OPTARG
                        ;;
                G)
                        # Name of the resource group in which the
resource is
                        # configured.
                        RESOURCEGROUP_NAME=$OPTARG
                        ;;
                T)
                        # Name of the resource type.
                        RESOURCETYPE_NAME=$OPTARG
                        ;;

                *)
                    logger -p ${SYSLOG_FACILITY}.err \
                    -t [$RESOURCETYPE_NAME,$RESOURCEGROUP_NAME,$RESOURCE_NAME]
\
                    "ERROR: Option $OPTARG unknown"
                     exit 1
                     ;;

                esac
        done
```

EXAMPLE B–2 `dns_svc_start` Method *(Continued)*

```
}



###############################################################################
# MAIN
#
##############################################################################

export PATH=/bin:/usr/bin:/usr/cluster/bin:/usr/sbin:/usr/proc/bin:$PATH

# Obtain the syslog facility to use to log messages.
SYSLOG_FACILITY=`scha_cluster_get -O SYSLOG_FACILITY`

# Parse the arguments that have been passed to this method
parse_args "$@"

PMF_TAG=$RESOURCE_NAME.named
SYSLOG_TAG=$RESOURCETYPE_NAME,$RESOURCEGROUP_NAME,$RESOURCE_NAME

# Get the value of the Confdir property of the resource in order
to start
# DNS. Using the resource name and the resource group entered, find
the value of
# Confdir value set by the cluster administrator when adding the
resource.
config_info=`scha_resource_get -O Extension -R $RESOURCE_NAME
-G $RESOURCEGROUP_NAME Confdir`
# scha_resource_get returns the "type" as well
as the "value" for the extension
# properties. Get only the value of the extension property.
CONFIG_DIR=`echo $config_info | awk '{print $2}'`

# Check if $CONFIG_DIR is accessible.
if [ ! -d $CONFIG_DIR ]; then
   logger -p ${SYSLOG_FACILITY}.err -t [$SYSLOG_TAG] \
       "${ARGV0} Directory $CONFIG_DIR missing or not mounted"
   exit 1
fi

# Change to the $CONFIG_DIR directory in case there are relative
# path names in the data files.
cd $CONFIG_DIR

# Check that the named.conf file is present in the $CONFIG_DIR directory.
if [ ! -s named.conf ]; then
   logger -p ${SYSLOG_FACILITY}.err -t [$SYSLOG_TAG] \
       "${ARGV0} File $CONFIG_DIR/named.conf is missing or
empty"
   exit 1
fi
```

EXAMPLE B–2 dns_svc_start Method *(Continued)*

```
# Get the value for Retry_count from the RTR file.
RETRY_CNT=`scha_resource_get -O Retry_Count -R $RESOURCE_NAME
-G \ $RESOURCEGROUP_NAMÈ

# Get the value for Retry_interval from the RTR file. Convert this
value, which is in
# seconds, to minutes for passing to pmfadm. Note that this is a
# conversion with round-up, for example, 50 seconds rounds up to
one minute.
((RETRY_INTRVAL = `scha_resource_get -O Retry_Interval
-R $RESOURCE_NAME -G $RESOURCEGROUP_NAMÈ / 60))

# Start the in.named daemon under the control of PMF. Let it crash
and restart
# up to $RETRY_COUNT times in a period of $RETRY_INTERVAL; if it
crashes
# more often than that, PMF will cease trying to restart it. If
there is a
# process already registered under the tag <$PMF_TAG>,
then,
# PMF sends out an alert message that the process is already running.
echo "Retry interval is "$RETRY_INTRVAL
pmfadm -c $PMF_TAG.named -n $RETRY_CNT -t $RETRY_INTRVAL \
    /usr/sbin/in.named -c named.conf

# Log a message indicating that HA-DNS has been started.
if [ $? -eq 0 ]; then
   logger -p ${SYSLOG_FACILITY}.info -t [$SYSLOG_TAG]\
           "${ARGV0} HA-DNS successfully started"
fi
exit 0
```

Stop Method

The Stop method is invoked on a cluster node when the resource group containing the HA-DNS resource is brought offline on that node or the resource is disabled. This method stops the in.named (DNS) daemon on that node.

EXAMPLE B–3 dns_svc_stop Method

```
#!/bin/ksh
#
# Stop method for HA-DNS
#
# Stop the data service using PMF. If the service is not running
```

EXAMPLE B–3 `dns_svc_stop` Method *(Continued)*

```
the
# method exits with status 0 as returning any other value puts the
resource
# in STOP_FAILED state.


#pragma ident   "@(#)dns_svc_stop   1.1   00/05/24 SMI"

###############################################################################
# Parse program arguments.
#
function parse_args # [args ...]
{
        typeset opt

        while getopts 'R:G:T:' opt
        do
                case "$opt" in
                R)
                        # Name of the DNS resource.
                        RESOURCE_NAME=$OPTARG
                        ;;
                G)
                        # Name of the resource group in which the
resource is
                        # configured.
                        RESOURCEGROUP_NAME=$OPTARG
                        ;;
                T)
                        # Name of the resource type.
                        RESOURCETYPE_NAME=$OPTARG
                        ;;

                *)
                    logger -p ${SYSLOG_FACILITY}.err \
                    -t [$RESOURCETYPE_NAME,$RESOURCEGROUP_NAME,$RESOURCE_NAME]
\
                    "ERROR: Option $OPTARG unknown"
                     exit 1
                     ;;

                esac
        done

}


###############################################################################
# MAIN
#
##############################################################################

export PATH=/bin:/usr/bin:/usr/cluster/bin:/usr/sbin:/usr/proc/bin:$PATH
```

EXAMPLE B–3 `dns_svc_stop` Method *(Continued)*

```
# Obtain the syslog facility to use to log messages.
SYSLOG_FACILITY=`scha_cluster_get -O SYSLOG_FACILITY`

# Parse the arguments that have been passed to this method
parse_args "$@"

PMF_TAG=$RESOURCE_NAME.named
SYSLOG_TAG=$RESOURCETYPE_NAME,$RESOURCEGROUP_NAME,$RESOURCE_NAME

# Obtain the Stop_timeout value from the RTR file.
STOP_TIMEOUT=`scha_resource_get -O STOP_TIMEOUT -R $RESOURCE_NAME
-G \ $RESOURCEGROUP_NAMÈ

# Attempt to stop the data service in an orderly manner using a
SIGTERM
# signal through PMF. Wait for up to 80% of the Stop_timeout value
to
# see if SIGTERM is successful in stopping the data service. If
not, send SIGKILL
# to stop the data service. Use up to 15% of the Stop_timeout value
to see
# if SIGKILL is successful. If not, there is a failure and the method
exits with
# non-zero status. The remaining 5% of the Stop_timeout is for other
uses.
((SMOOTH_TIMEOUT=$STOP_TIMEOUT * 80/100))

((HARD_TIMEOUT=$STOP_TIMEOUT * 15/100))

# See if in.named is running, and if so, kill it.
if pmfadm -q $PMF_TAG.named; then
   # Send a SIGTERM signal to the data service and wait for 80% of
the
   # total timeout value.
   pmfadm -s $PMF_TAG.named -w $SMOOTH_TIMEOUT TERM
   if [ $? -ne 0 ]; then
      logger -p ${SYSLOG_FACILITY}.info -t [SYSLOG_TAG] \
          "${ARGV0} Failed to stop HA-DNS with SIGTERM; Retry
with \
           SIGKILL"

      # Since the data service did not stop with a SIGTERM signal, use
      # SIGKILL now and wait for another 15% of the total timeout value.
      pmfadm -s $PMF_TAG.named -w $HARD_TIMEOUT KILL
      if [ $? -ne 0 ]; then
          logger -p ${SYSLOG_FACILITY}.err -t [SYSLOG_TAG]
\
          "${ARGV0} Failed to stop HA-DNS; Exiting UNSUCCESFUL"

          exit 1
      fi
fi
```

```
else
   # The data service is not running as of now. Log a message and
   # exit success.
   logger -p ${SYSLOG_FACILITY}.info -t [SYSLOG_TAG] \
           "HA-DNS is not started"

   # Even if HA-DNS is not running, exit success to avoid putting
   # the data service in STOP_FAILED State.

   exit 0

fi

# Successfully stopped DNS. Log a message and exit success.
logger -p ${SYSLOG_FACILITY}.info -t [$SYSLOG_TAG] \
    "HA-DNS successfully stopped"
exit 0
```

`gettime` Utility

The `gettime` utility is a C program used by the `PROBE` program to track the elapsed time between restarts of the probe. You must compile this program and place it in the same directory as the callback methods, that is, the directory pointed to by the `RT_basedir` property.

EXAMPLE B–4 `gettime.c` Utility Program

```
#
# This utility program, used by the probe method of the data service,
tracks
# the elapsed time in seconds from a known reference point (epoch
point). It
# must be compiled and placed in the same directory as the data
service callback
# methods (RT_basedir).


#pragma ident   "@(#)gettime.c   1.1   00/05/24 SMI"


#include <stdio.h>
#include <sys/types.h>
#include <time.h>

main()
{
    printf("%d\n", time(0));
```

EXAMPLE B–4 `gettime.c` Utility Program *(Continued)*

```
    exit(0);
}
```

PROBE Program

The PROBE program checks the availability of the data service using nslookup(1M) commands. The Monitor_start callback method launches this program and the Monitor_start callback method stops it.

EXAMPLE B–5 dns_probe Program

```
#!/bin/ksh
#pragma ident   "@(#)dns_probe   1.1   00/04/19 SMI"
#
# Probe method for HA-DNS.
#
# This program checks the availability of the data service using
nslookup, which
# queries the DNS server to look for the DNS server itself. If the
server
# does not respond or if the query is replied to by some other server,
# then the probe concludes that there is some problem with the data
service
# and fails the service over to another node in the cluster. Probing
is done
# at a specific interval set by THOROUGH_PROBE_INTERVAL in the RTR
file.

#pragma ident   "@(#)dns_probe   1.1   00/05/24 SMI"


###############################################################################
# Parse program arguments.
#
function parse_args # [args ...]
{
        typeset opt

        while getopts 'R:G:T:' opt
        do
                case "$opt" in
                R)
                        # Name of the DNS resource.
                        RESOURCE_NAME=$OPTARG
                        ;;
                G)
                        # Name of the resource group in which the
```

EXAMPLE B–5 dns_probe Program *(Continued)*

```
resource is
                        # configured.
                        RESOURCEGROUP_NAME=$OPTARG
                        ;;
                T)
                        # Name of the resource type.
                        RESOURCETYPE_NAME=$OPTARG
                        ;;

                *)
                    logger -p ${SYSLOG_FACILITY}.err \
                    -t [$RESOURCETYPE_NAME,$RESOURCEGROUP_NAME,$RESOURCE_NAME]
\
                    "ERROR: Option $OPTARG unknown"
                     exit 1
                     ;;

                esac
        done

}


###############################################################################
# restart_service ()
#
# This function tries to restart the data service by calling the
Stop method
# followed by the Start method of the dataservice. If the dataservice
has
# already died and no tag is registered for the dataservice under
PMF,
# then this function fails the service over to another node in the
cluster.
#
function restart_service
{

        # To restart the dataservice, first, verify that the
        # dataservice itself is still registered under PMF.
        pmfadm -q $PMF_TAG
        if [[ $? -eq 0 ]]; then
                # Since the TAG for the dataservice is still registered
under
                # PMF, first stop the dataservice and start it back
up again.

                # Obtain the Stop method name and the STOP_TIMEOUT
value for
                # this resource.
                STOP_TIMEOUT=`scha_resource_get -O STOP_TIMEOUT
\
                        -R $RESOURCE_NAME -G $RESOURCEGROUP_NAMÈ
```

EXAMPLE B–5 dns_probe Program *(Continued)*

```
                STOP_METHOD=`scha_resource_get -O STOP
\
                        -R $RESOURCE_NAME -G $RESOURCEGROUP_NAMÈ
                hatimerun -t $STOP_TIMEOUT $RT_BASEDIR/$STOP_METHOD
\
                        -R $RESOURCE_NAME -G $RESOURCEGROUP_NAME
\
                        -T $RESOURCETYPE_NAME

                if [[ $? -ne 0 ]]; then
                        logger-p ${SYSLOG_FACILITY}.err -t [$SYSLOG_TAG]
\
                                "${ARGV0} Stop method failed."
                        return 1
                fi

                # Obtain the Start method name and the START_TIMEOUT
value for
                # this resource.
                START_TIMEOUT=`scha_resource_get -O START_TIMEOUT
\
                        -R $RESOURCE_NAME -G $RESOURCEGROUP_NAMÈ
                START_METHOD=`scha_resource_get -O START
\
                        -R $RESOURCE_NAME -G $RESOURCEGROUP_NAMÈ
                hatimerun -t $START_TIMEOUT $RT_BASEDIR/$START_METHOD
\
                        -R $RESOURCE_NAME -G $RESOURCEGROUP_NAME
\
                        -T $RESOURCETYPE_NAME

                if [[ $? -ne 0 ]]; then
                        logger-p ${SYSLOG_FACILITY}.err -t [$SYSLOG_TAG]
\
                                "${ARGV0} Start method
failed."
                        return 1
                fi


        else
                # The absence of the TAG for the dataservice
                # implies that the dataservice has already
                # exceeded the maximum retries allowed under PMF.
                # Therefore, do not attempt to restart the
                # dataservice again, but try to failover
                # to another node in the cluster.
                scha_control -O GIVEOVER -G $RESOURCEGROUP_NAME
\
                        -R $RESOURCE_NAME
        fi

        return 0
```

EXAMPLE B–5 dns_probe Program *(Continued)*

```
}



###############################################################################
# decide_restart_or_failover ()
#
# This function decides the action to be taken upon the failure
of a probe:
# restart the data service locally or fail over to another node
in the cluster.
#
function decide_restart_or_failover
{

   # Check if this is the first restart attempt.
   if [ $retries -eq 0 ]; then
         # This is the first failure. Note the time of
         # this first attempt.
         start_time=`$RT_BASEDIR/gettimè
         retries=`expr $retries + 1`
         # Because this is the first failure, attempt to restart
         # the data service.
         restart_service
         if [ $? -ne 0 ]; then
            logger -p ${SYSLOG_FACILITY}.err -t [$SYSLOG_TAG] \
                “${ARGV0} Failed to restart data service.”
            exit 1
         fi
   else
      # This is not the first failure
      current_time=`$RT_BASEDIR/gettimè
      time_diff=`expr $current_time - $start_timè
      if [ $time_diff -ge $RETRY_INTERVAL ]; then
         # This failure happened after the time window
         # elapsed, so reset the retries counter,
         # slide the window, and do a retry.
         retries=1
         start_time=$current_time
         # Because the previous failure occurred more than
         # Retry_interval ago, attempt to restart the data service.
         restart_service
         if [ $? -ne 0 ]; then
            logger -p ${SYSLOG_FACILITY}.err \
                -t [$SYSLOG_TAG
                “${ARGV0} Failed to restart HA-DNS.”
            exit 1
         fi
      elif [ $retries -ge $RETRY_COUNT ]; then
         # Still within the time window,
         # and the retry counter expired, so fail over.
         retries=0
```

EXAMPLE B–5 dns_probe Program *(Continued)*

```
         scha_control -O GIVEOVER -G $RESOURCEGROUP_NAME \
             -R $RESOURCE_NAME
         if [ $? -ne 0 ]; then
            logger -p ${SYSLOG_FACILITY}.err -t [$SYSLOG_TAG] \
                "${ARGV0} Failover attempt failed."
            exit 1
         fi
      else
         # Still within the time window,
         # and the retry counter has not expired,
         # so do another retry.
         retries=`expr $retries + 1`
         restart_service
         if [ $? -ne 0 ]; then
            logger -p ${SYSLOG_FACILITY}.err -t [$SYSLOG_TAG] \
                "${ARGV0} Failed to restart HA-DNS."
            exit 1
         fi
      fi
fi
}


###############################################################################
# MAIN
###############################################################################

export PATH=/bin:/usr/bin:/usr/cluster/bin:/usr/sbin:/usr/proc/bin:$PATH

# Obtain the syslog facility to use to log messages.
SYSLOG_FACILITY=`scha_cluster_get -O SYSLOG_FACILITY`

# Parse the arguments that have been passed to this method
parse_args "$@"

PMF_TAG=$RESOURCE_NAME.named
SYSLOG_TAG=$RESOURCETYPE_NAME,$RESOURCEGROUP_NAME,$RESOURCE_NAME

# The interval at which probing is to be done is set in the system
defined
# property THOROUGH_PROBE_INTERVAL. Obtain the value of this property
with
# scha_resource_get
PROBE_INTERVAL=`scha_resource_get -O THOROUGH_PROBE_INTERVAL
-R $RESOURCE_NAME -G $RESOURCEGROUP_NAMÈ

# Obtain the timeout value allowed for the probe, which is set in
the
# PROBE_TIMEOUT extension property in the RTR file. The default
timeout for
# nslookup is 1.5 minutes.
probe_timeout_info=`scha_resource_get -O Extension -R $RESOURCE_NAME
-G \$RESOURCEGROUP_NAME Probe_timeout`
```

EXAMPLE B–5 dns_probe Program *(Continued)*

```
PROBE_TIMEOUT=`echo $probe_timeout_info | awk '{print $2}'`

# Identify the server on which DNS is serving by obtaining the value
# of the NETWORK_RESOURCES_USED property of the resource.
DNS_HOST=`scha_resource_get -O NETWORK_RESOURCES_USED -R
$RESOURCE_NAME -G \$RESOURCEGROUP_NAMÈ

# Get the retry count value from the system defined property Retry_count
RETRY_COUNT=`scha_resource_get -O RETRY_COUNT -R $RESOURCE_NAME
-G \$RESOURCEGROUP_NAMÈ

# Get the retry interval value from the system defined property
Retry_interval
RETRY_INTERVAL=`scha_resource_get -O RETRY_INTERVAL -R
$RESOURCE_NAME -G \$RESOURCEGROUP_NAMÈ

# Obtain the full path for the gettime utility from the
# RT_basedir property of the resource type.
RT_BASEDIR=`scha_resource_get -O RT_BASEDIR -R $RESOURCE_NAME
-G \$RESOURCEGROUP_NAMÈ

# The probe runs in an infinite loop, trying nslookup commands.
# Set up a temporary file for the nslookup replies.
DNSPROBEFILE=/tmp/.$RESOURCE_NAME.probe
probefail=0
retries=0

while :
do
   # The interval at which the probe needs to run is specified in
the
   # property THOROUGH_PROBE_INTERVAL. Therefore, set the probe to
sleep for a
   # duration of <THOROUGH_PROBE_INTERVAL>
   sleep $PROBE_INTERVAL

   # Run the probe, which queries the IP address on
   # which DNS is serving.
   hatimerun -t $PROBE_TIMEOUT /usr/sbin/nslookup $DNS_HOST $DNS_HOST
\
           > $DNSPROBEFILE 2>&1

   retcode=$?
        if [ retcode -ne 0 ]; then
                probefail=1
        fi

   # Make sure that the reply to nslookup command comes from the HA-DNS
   # server and not from another name server listed in the
   # /etc/resolv.conf file.
   if [ $probefail -eq 0 ]; then
      # Get the name of the server that replied to the nslookup query.
                 SERVER=` awk ' $1=="Server:" {
```

EXAMPLE B–5 dns_probe Program *(Continued)*

```
print $2 }' \
                   $DNSPROBEFILE | awk -F. ' { print $1 } ' `
                if [ -z "$SERVER" ];
then
                        probefail=1
                else
                        if [ $SERVER != $DNS_HOST ]; then
                                probefail=1
                        fi
                fi
        fi

   # If the probefail variable is not set to 0, either the nslookup command
   # timed out or the reply to the query was came from another server
   # (specified in the /etc/resolv.conf file). In either case, the DNS server is
   # not responding and the method calls decide_restart_or_failover,
   # which evaluates whether to restart the data service or to fail it over
   # to another node.

   if [ $probefail -ne 0 ]; then
         decide_restart_or_failover
   else
         logger -p ${SYSLOG_FACILITY}.info -t [$SYSLOG_TAG]\
         "${ARGV0} Probe for resource HA-DNS successful"
   fi
done
```

Monitor_start Method

This method starts the PROBE program for the data service.

EXAMPLE B–6 dns_monitor_start Method

```
#!/bin/ksh
#
# Monitor start Method for HA-DNS.
#
# This method starts the monitor (probe) for the data service under
the
# control of PMF. The monitor is a process that probes the data
service
# at periodic intervals and if there is a problem restarts it on
the same node
# or fails it over to another node in the cluster. The PMF tag for
the
# monitor is $RESOURCE_NAME.monitor.
```

```
#pragma ident   "@(#)dns_monitor_start   1.1   00/05/24 SMI"

###############################################################################
# Parse program arguments.
#
function parse_args # [args ...]
{
        typeset opt

        while getopts 'R:G:T:' opt
        do
                case "$opt" in
                R)
                        # Name of the DNS resource.
                        RESOURCE_NAME=$OPTARG
                        ;;
                G)
                        # Name of the resource group in which the
resource is
                        # configured.
                        RESOURCEGROUP_NAME=$OPTARG
                        ;;
                T)
                        # Name of the resource type.
                        RESOURCETYPE_NAME=$OPTARG
                        ;;

                *)
          logger -p ${SYSLOG_FACILITY}.err \
                   -t [$RESOURCETYPE_NAME,$RESOURCEGROUP_NAME,$RESOURCE_NAME]
\
                    "ERROR: Option $OPTARG unknown"
                     exit 1
                     ;;
                esac
        done

}



###############################################################################
# MAIN
#
##############################################################################

export PATH=/bin:/usr/bin:/usr/cluster/bin:/usr/sbin:/usr/proc/bin:$PATH

# Obtain the syslog facility to use to log messages.
SYSLOG_FACILITY=`scha_cluster_get -O SYSLOG_FACILITY`

# Parse the arguments that have been passed to this method
```

EXAMPLE B–6 dns_monitor_start Method *(Continued)*

```
parse_args "$@"

PMF_TAG=$RESOURCE_NAME.monitor
SYSLOG_TAG=$RESOURCETYPE_NAME,$RESOURCEGROUP_NAME,$RESOURCE_NAME

# Find where the probe method resides by obtaining the value of
the
# RT_BASEDIR property of the data service.
RT_BASEDIR=`scha_resource_get -O RT_BASEDIR -R $RESOURCE_NAME
-G \$RESOURCEGROUP_NAMÈ

# Start the probe for the data service under PMF. Use the infinite
retries
# option to start the probe. Pass the resource name, group, and
type to the
# probe method.
pmfadm -c $PMF_TAG.monitor -n -1 -t -1 \
    $RT_BASEDIR/dns_probe -R $RESOURCE_NAME -G $RESOURCEGROUP_NAME
\
    -T $RESOURCETYPE_NAME

# Log a message indicating that the monitor for HA-DNS has been
started.
if [ $? -eq 0 ]; then
   logger -p ${SYSLOG_FACILITY}.info -t [$SYSLOG_TAG] \
           "${ARGV0} Monitor for HA-DNS successfully started"
fi
exit 0
```

Monitor_stop Method

This method stops the PROBE program for the data service.

EXAMPLE B–7 dns_monitor_stop Method

```
#!/bin/ksh
#
# Monitor stop method for HA-DNS
#
# Stops the monitor that is running using PMF.


#pragma ident   "@(#)dns_monitor_stop   1.1   00/05/24 SMI"


###############################################################################
```

EXAMPLE B–7 `dns_monitor_stop` Method *(Continued)*

```
# Parse program arguments.
#
function parse_args # [args ...]
{
        typeset opt

        while getopts 'R:G:T:' opt
        do
                case "$opt" in
                R)
                        # Name of the DNS resource.
                        RESOURCE_NAME=$OPTARG
                        ;;
                G)
                        # Name of the resource group in which the
resource is
                        # configured.
                        RESOURCEGROUP_NAME=$OPTARG
                        ;;
                T)
                        # Name of the resource type.
                        RESOURCETYPE_NAME=$OPTARG
                        ;;

                *)
                    logger -p ${SYSLOG_FACILITY}.err \
                    -t [$RESOURCETYPE_NAME,$RESOURCEGROUP_NAME,$RESOURCE_NAME]
\
                    "ERROR: Option $OPTARG unknown"
                     exit 1
                     ;;

                esac
        done

}


###############################################################################
# MAIN
#
##############################################################################

export PATH=/bin:/usr/bin:/usr/cluster/bin:/usr/sbin:/usr/proc/bin:$PATH

# Obtain the syslog facility to use to log messages.
SYSLOG_FACILITY=`scha_cluster_get -O SYSLOG_FACILITY`

# Parse the arguments that have been passed to this method
parse_args "$@"

PMF_TAG=$RESOURCE_NAME.monitor
SYSLOG_TAG=$RESOURCETYPE_NAME,$RESOURCEGROUP_NAME,$RESOURCE_NAME
```

EXAMPLE B–7 `dns_monitor_stop` Method *(Continued)*

```
# See if the monitor is running, and if so, kill it.
if pmfadm -q $PMF_TAG.monitor; then
   pmfadm -s $PMF_TAG.monitor KILL
   if [ $? -ne 0 ]; then
      logger -p ${SYSLOG_FACILITY}.err -t [$SYSLOG_TAG] \
          "${ARGV0} Could not stop monitor for resource " \
          $RESOURCE_NAME
           exit 1
   else
      # Could successfully stop the monitor. Log a message.
      logger -p ${SYSLOG_FACILITY}.info -t [$SYSLOG_TAG]\
          "${ARGV0} Monitor for resource " $RESOURCE_NAME
\
          " successfully stopped"
   fi
fi

exit 0
```

`Monitor_check` Method

This method verifies the existence of the directory pointed to by the `Confdir` property. The RGM calls `Monitor_check` whenever the `PROBE` method fails the data service over to a new node and also to check nodes that are potential masters.

EXAMPLE B–8 `dns_monitor_check` Method

```
#!/bin/ksh
#
# Monitor check  Method for DNS.
#
# The RGM calls this method whenever the fault monitor fails the
data service
# over to a new node. Monitor_check calls the Validate method to
verify
# that the configuration directory and files are available on the
new node.


#pragma ident   "@(#)dns_monitor_check 1.1   00/05/24 SMI"

###############################################################################
# Parse program arguments.
#
function parse_args # [args ...]
{
```

EXAMPLE B–8 `dns_monitor_check` Method *(Continued)*

```
   typeset opt

   while getopts 'R:G:T:' opt
   do
      case "$opt" in

      R)
      # Name of the DNS resource.
      RESOURCE_NAME=$OPTARG
      ;;

      G)
      # Name of the resource group in which the resource is
      # configured.
      RESOURCEGROUP_NAME=$OPTARG
      ;;

      T)
      # Name of the resource type.
      RESOURCETYPE_NAME=$OPTARG
      ;;

      *)
      logger -p ${SYSLOG_FACILITY}.err \
      -t [$RESOURCETYPE_NAME,$RESOURCEGROUP_NAME,$RESOURCE_NAME]
\
      "ERROR: Option $OPTARG unknown"
      exit 1
      ;;

      esac
   done

}

###############################################################################
# MAIN
##############################################################################

export PATH=/bin:/usr/bin:/usr/cluster/bin:/usr/sbin:/usr/proc/bin:$PATH

# Obtain the syslog facility to use to log messages.
SYSLOG_FACILITY=`scha_cluster_get -O SYSLOG_FACILITY`

# Parse the arguments that have been passed to this method.
parse_args "$@"

PMF_TAG=$RESOURCE_NAME.named
SYSLOG_TAG=$RESOURCETYPE_NAME,$RESOURCEGROUP_NAME,$RESOURCE_NAME

# Obtain the full path for the Validate method from
# the RT_BASEDIR property of the resource type.
RT_BASEDIR=`scha_resource_get -O RT_BASEDIR -R $RESOURCE_NAME
```

```
\
   -G $RESOURCEGROUP_NAMÈ

# Obtain the name of the Validate method for this resource.
VALIDATE_METHOD=`scha_resource_get -O VALIDATE \
   -R $RESOURCE_NAME -G $RESOURCEGROUP_NAMÈ

# Obtain the value of the Confdir property in order to start the
# data service. Use the resource name and the resource group entered
to
# obtain the Confdir value set at the time of adding the resource.
config_info=`scha_resource_get -O Extension -R $RESOURCE_NAME
-G $RESOURCEGROUP_NAME Confdir`

# scha_resource_get returns the type as well as the value for extension
# properties. Use awk to get only the value of the extension property.
CONFIG_DIR=`echo $config_info | awk '{print $2}'`

# Call the validate method so that the dataservice can be failed
over
# successfully to the new node.
$RT_BASEDIR/$VALIDATE_METHOD -R $RESOURCE_NAME -G $RESOURCEGROUP_NAME
\
   -T $RESOURCETYPE_NAME -x Confdir=$CONFIG_DIR

# Log a message indicating that monitor check was successful.
if [ $? -eq 0 ]; then
   logger -p ${SYSLOG_FACILITY}.info -t [$SYSLOG_TAG] \
      "${ARGV0} Monitor check for DNS successful."
   exit 0
else
   logger -p ${SYSLOG_FACILITY}.err -t [$SYSLOG_TAG] \
      "${ARGV0} Monitor check for DNS not successful."
   exit 1
fi
```

`Validate` Method

This method verifies the existence of the directory pointed to by the `Confdir` property. The RGM calls this method when the data service is created and when data service properties are updated by the cluster administrator. The `Monitor_check` method calls this method whenever the fault monitor fails the data service over to a new node.

EXAMPLE B–9 `dns_validate` Method

```
#!/bin/ksh
#
```

EXAMPLE B–9 `dns_validate` Method *(Continued)*

```
# Validate method for HA-DNS.
# This method validates the Confdir property of the resource. The
Validate
# method gets called in two scenarios. When the resource is being
created and
# when a resource property is getting updated. When the resource
is being
# created, this method gets called with the -c flag and all the
system-defined
# and extension properties are passed as command-line arguments.
When a resource
# property is being updated, the Validate method gets called with
the -u flag,
# and only the property/value pair of the property being updated
is passed as a
# command-line argument.
#
# ex: When the resource is being created command args will be
#
# dns_validate -c -R <..> -G <...> -T <..>
-r <sysdef-prop=value>...
#       -x <extension-prop=value>.... -g <resourcegroup-prop=value>....
#
# when the resource property is being updated
#
# dns_validate -u -R <..> -G <...> -T <..>
-r <sys-prop_being_updated=value>
#   OR
# dns_validate -u -R <..> -G <...> -T <..>
-x <extn-prop_being_updated=value>
#


#pragma ident   "@(#)dns_validate   1.1   00/05/24 SMI"

###############################################################################
# Parse program arguments.
#
function parse_args # [args ...]
{
   typeset opt

   while getopts 'cur:x:g:R:T:G:' opt
   do
                case "$opt" in
                R)
                        # Name of the DNS resource.
                        RESOURCE_NAME=$OPTARG
                        ;;
                G)
                        # Name of the resource group in which the resource is
                        # configured.
                        RESOURCEGROUP_NAME=$OPTARG
```

EXAMPLE B–9 `dns_validate` Method *(Continued)*

```
                        ;;
                T)
                        # Name of the resource type.
                        RESOURCETYPE_NAME=$OPTARG
                        ;;

                r)
                        #The method is not accessing any system defined
                        #properties, so this is a no-op.
                        ;;

                g)
                        # The method is not accessing any resource group
                        # properties, so this is a no-op.
                        ;;

                c)
                        # Indicates the Validate method is being called while
                        # creating the resource, so this flag is a no-op.
                        ;;

                u)
                        # Indicates the updating of a property when the
                        # resource already exists. If the update is to the
                        # Confdir property then Confdir should appear in the
                        # command-line arguments. If it does not, the method must
                        # look for it specifically using scha_resource_get.
                        UPDATE_PROPERTY=1
                        ;;

                x)
                        # Extension property list. Separate the property and
                        # value pairs using "=" as the separator.
                        PROPERTY=`echo $OPTARG | awk -F= '{print $1}'`
                        VAL=`echo $OPTARG | awk -F= '{print $2}'`

                        # If the Confdir extension property is found on the
                        # command line, note its value.
                        if [ $PROPERTY == "Confdir" ];
                        then
                        CONFDIR=$VAL
                        CONFDIR_FOUND=1
                        fi
                        ;;

                *)
                        logger -p ${SYSLOG_FACILITY}.err \
                        -t [$SYSLOG_TAG] \
                        "ERROR: Option $OPTARG unknown"
                        exit 1
                        ;;
                esac
done
```

EXAMPLE B–9 `dns_validate` Method *(Continued)*

```
}

###############################################################################
# MAIN
#
##############################################################################

export PATH=/bin:/usr/bin:/usr/cluster/bin:/usr/sbin:/usr/proc/bin:$PATH

# Obtain the syslog facility to use to log messages.
SYSLOG_FACILITY=`scha_cluster_get -O SYSLOG_FACILITY`

# Set the Value of CONFDIR to null. Later, this method retrieves
the value
# of the Confdir property from the command line or using scha_resource_get.
CONFDIR=""
UPDATE_PROPERTY=0
CONFDIR_FOUND=0

# Parse the arguments that have been passed to this method.
parse_args "$@"

# If the validate method is being called due to the updating of
properties
# try to retrieve the value of the Confdir extension property from
the command
# line. Otherwise, obtain the value of Confdir using scha_resource_get.
if ( (( $UPDATE_PROPERTY == 1 )) &&  (( CONFDIR_FOUND
== 0 )) ); then
   config_info=`scha_resource_get -O Extension -R $RESOURCE_NAME
\
       -G $RESOURCEGROUP_NAME Confdir`
   CONFDIR=`echo $config_info | awk '{print $2}'`
fi

# Verify that the Confdir property has a value. If not there is
a failure
# and exit with status 1.
if [[ -z $CONFDIR ]]; then
   logger -p ${SYSLOG_FACILITY}.err \
       "${ARGV0} Validate method for resource "$RESOURCE_NAME " failed"
   exit 1
fi

# Now validate the actual Confdir property value.

# Check if $CONFDIR is accessible.
if [ ! -d $CONFDIR ]; then
        logger -p ${SYSLOG_FACILITY}.err -t [$SYSLOG_TAG]\
            "${ARGV0} Directory $CONFDIR missing or not
mounted"
        exit 1
fi
```

EXAMPLE B–9 `dns_validate` Method *(Continued)*

```
# Check that the named.conf file is present in the Confdir directory.
if [ ! -s $CONFDIR/named.conf ]; then
        logger -p ${SYSLOG_FACILITY}.err -t [$SYSLOG_TAG]
\
            "${ARGV0} File $CONFDIR/named.conf is missing
or empty"
        exit 1
fi

# Log a message indicating that the Validate method was successful.
logger -p ${SYSLOG_FACILITY}.info -t [$SYSLOG_TAG] \
   "${ARGV0} Validate method for resource "$RESOURCE_NAME
\
   " completed successfully"

exit 0
```

`Update` Method

The RGM calls the `Update` method to notify a running resource that its properties have been changed.

EXAMPLE B–10 `dns_update` Method

```
#!/bin/ksh
#
# Update method for HA-DNS.
#
# The actual updates to properties are done by the RGM. Updates
affect only
# the fault monitor so this method must restart the fault monitor.


#pragma ident   "@(#)dns_update   1.1   00/05/24 SMI"

###############################################################################
# Parse program arguments.
#
function parse_args # [args ...]
{
        typeset opt

        while getopts 'R:G:T:' opt
        do
                case "$opt" in
                R)
```

```
                        # Name of the DNS resource.
                        RESOURCE_NAME=$OPTARG
                        ;;
                G)
                        # Name of the resource group in which the
resource is
                        # configured.
                        RESOURCEGROUP_NAME=$OPTARG
                        ;;
                T)
                        # Name of the resource type.
                        RESOURCETYPE_NAME=$OPTARG
                        ;;

                *)
                    logger -p ${SYSLOG_FACILITY}.err \
                    -t [$RESOURCETYPE_NAME,$RESOURCEGROUP_NAME,$RESOURCE_NAME]
\
                    "ERROR: Option $OPTARG unknown"
                     exit 1
                     ;;

                esac
        done

}



###############################################################################
# MAIN
#
##############################################################################

export PATH=/bin:/usr/bin:/usr/cluster/bin:/usr/sbin:/usr/proc/bin:$PATH

# Obtain the syslog facility to use to log messages.
SYSLOG_FACILITY=`scha_cluster_get -O SYSLOG_FACILITY`

# Parse the arguments that have been passed to this method
parse_args "$@"

PMF_TAG=$RESOURCE_NAME.monitor
SYSLOG_TAG=$RESOURCETYPE_NAME,$RESOURCEGROUP_NAME,$RESOURCE_NAME

# Find where the probe method resides by obtaining the value of
the
# RT_BASEDIR property of the resource.
RT_BASEDIR=`scha_resource_get -O RT_BASEDIR -R $RESOURCE_NAME
-G $RESOURCEGROUP_NAMÈ

# When the Update method is called, the RGM updates the value of
```

EXAMPLE B–10 `dns_update` Method *(Continued)*

```
the property
# being updated. This method must check if the fault monitor (probe)
# is running, and if so, kill it and then restart it.
if pmfadm -q $PMF_TAG.monitor; then

   # Kill the monitor that is running already
        pmfadm -s $PMF_TAG.monitor TERM
        if [ $? -ne 0 ]; then
                logger -p ${SYSLOG_FACILITY}.err -t [$SYSLOG_TAG]
\
                    "${ARGV0} Could not stop the monitor"
                exit 1
        else
                # Could successfully stop DNS. Log a message.
                logger -p ${SYSLOG_FACILITY}.info -t [$SYSLOG_TAG]
\
                    "Monitor for HA-DNS successfully stopped"
        fi

   # Restart the monitor.
   pmfadm -c $PMF_TAG.monitor -n -1 -t -1 $RT_BASEDIR/dns_probe \
      -R $RESOURCE_NAME -G $RESOURCEGROUP_NAME -T $RESOURCETYPE_NAME
   if [ $? -ne 0 ]; then
          logger -p ${SYSLOG_FACILITY}.err -t [$SYSLOG_TAG]\
                  "${ARGV0} Could not restart monitor for HA-DNS "
      exit 1
   else
      logger -p ${SYSLOG_FACILITY}.info -t [$SYSLOG_TAG]\
                    "Monitor for HA-DNS successfully restarted"

   fi
fi
exit 0
```

APPENDIX **C**

Data Service Development Library Sample Resource Type Code Listing

This appendix lists the complete code for each method in the `SUNW.xfnts` resource type. It includes the listing for `xfnts.c`, which contains code for the subroutines called by the callback methods. The code listings in this appendix are as follows.

xfnts.c

This file implements the subroutines called by the `SUNW.xfnts` methods.

EXAMPLE C–1 `xfnts.c`

```
/*
 * Copyright (c) 1998-2003 by Sun Microsystems, Inc.
 * All rights reserved.
 *
 * xfnts.c - Common utilities for HA-XFS
 *
 * This utility has the methods for performing the validation, starting
and
 * stopping the data service and the fault monitor. It also contains
the method
 * to probe the health of the data service. The probe just returns
```

```
either
 * success or failure. Action is taken based on this returned value
in the
 * method found in the file xfnts_probe.c
 *
 */

#pragma ident "@(#)xfnts.c 1.47 01/01/18 SMI"

#include <stdio.h>
#include <stdlib.h>
#include <strings.h>
#include <unistd.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <sys/socket.h>
#include <sys/wait.h>
#include <netinet/in.h>
#include <scha.h>
#include <rgm/libdsdev.h>
#include <errno.h>
#include "xfnts.h"

/*
 * The initial timeout allowed for the HAXFS data service to
 * be fully up and running. We will wait for 3 % (SVC_WAIT_PCT)
 * of the start_timeout time before probing the service.
 */
#define   SVC_WAIT_PCT      3

/*
 * We need to use 95% of probe_timeout to connect to the port and
the
 * remaining time is used to disconnect from port in the svc_probe
function.
 */
#define   SVC_CONNECT_TIMEOUT_PCT      95

/*
 * SVC_WAIT_TIME is used only during starting in svc_wait().
 * In svc_wait() we need to be sure that the service is up
 * before returning, thus we need to call svc_probe() to
 * monitor the service. SVC_WAIT_TIME is the time between
 * such probes.
 */

#define   SVC_WAIT_TIME      5

/*
 * This value will be used as disconnect timeout, if there is no
 * time left from the probe_timeout.
 */
```

EXAMPLE C–1 `xfnts.c` *(Continued)*

```
#define   SVC_DISCONNECT_TIMEOUT_SECONDS      2


/*
 * svc_validate():
 *
 * Do HA-XFS specific validation of the resource configuration.
 *
 * svc_validate will check for the following
 * 1. Confdir_list extension property
 * 2. fontserver.cfg file
 * 3. xfs binary
 * 4. port_list property
 * 5. network resources
 * 6. other extension properties
 *
 * If any of the above validation fails then, Return > 0 otherwise
return 0 for
 * success
 */

int
svc_validate(scds_handle_t scds_handle)
{
   char   xfnts_conf[SCDS_ARRAY_SIZE];
   scha_str_array_t *confdirs;
   scds_net_resource_list_t *snrlp;
   int rc;
   struct stat statbuf;
   scds_port_list_t   *portlist;
   scha_err_t   err;

   /*
    * Get the configuration directory for the XFS dataservice from the
    * confdir_list extension property.
    */
   confdirs = scds_get_ext_confdir_list(scds_handle);

   /* Return an error if there is no confdir_list extension property
*/
   if (confdirs == NULL || confdirs->array_cnt != 1) {
      scds_syslog(LOG_ERR,
          "Property Confdir_list is not set properly.");
      return (1); /* Validation failure */
   }

   /*
    * Construct the path to the configuration file from the extension
    * property confdir_list. Since HA-XFS has only one configuration
    * we will need to use the first entry of the confdir_list property.
    */
   (void) sprintf(xfnts_conf, "%s/fontserver.cfg",
confdirs->str_array[0]);
```

EXAMPLE C–1 `xfnts.c` *(Continued)*

```
   /*
    * Check to see if the HA-XFS configuration file is in the right place.
    * Try to access the HA-XFS configuration file and make sure the
    * permissions are set properly
    */
   if (stat(xfnts_conf, &statbuf) != 0) {
      /*
       * suppress lint error because errno.h prototype
       * is missing void arg
       */
      scds_syslog(LOG_ERR,
          "Failed to access file <%s> : <%s>",
          xfnts_conf, strerror(errno));   /*lint !e746 */
      return (1);
   }

   /*
    * Make sure that xfs binary exists and that the permissions
    * are correct. The XFS binary are assumed to be on the local
    * File system and not on the Global File System
    */
   if (stat("/usr/openwin/bin/xfs", &statbuf)
!= 0) {
      scds_syslog(LOG_ERR,
          "Cannot access XFS binary : <%s> ",
strerror(errno));
      return (1);
   }

   /* HA-XFS will have only port */
   err = scds_get_port_list(scds_handle, &portlist);
   if (err != SCHA_ERR_NOERR) {
      scds_syslog(LOG_ERR,
          "Could not access property Port_list: %s.",
         scds_error_string(err));
      return (1); /* Validation Failure */
   }

#ifdef TEST
   if (portlist->num_ports != 1) {
      scds_syslog(LOG_ERR,
          "Property Port_list must have only one value.");
      scds_free_port_list(portlist);
      return (1); /* Validation Failure */
   }
#endif

   /*
    * Return an error if there is an error when trying to get the
    * available network address resources for this resource
    */
   if ((err = scds_get_rs_hostnames(scds_handle, &snrlp))
```

EXAMPLE C–1 `xfnts.c` *(Continued)*

```
      != SCHA_ERR_NOERR) {
      scds_syslog(LOG_ERR,
          "No network address resource in resource group: %s.",
         scds_error_string(err));
      return (1); /* Validation Failure */
   }

   /* Return an error if there are no network address resources */
   if (snrlp == NULL || snrlp->num_netresources == 0) {
      scds_syslog(LOG_ERR,
          "No network address resource in resource group.");
      rc = 1;
      goto finished;
   }

   /* Check to make sure other important extension props are set */
   if (scds_get_ext_monitor_retry_count(scds_handle) <= 0)
{
      scds_syslog(LOG_ERR,
          "Property Monitor_retry_count is not set.");
      rc = 1; /* Validation Failure */
      goto finished;
   }
   if (scds_get_ext_monitor_retry_interval(scds_handle) <=
0) {
      scds_syslog(LOG_ERR,
          "Property Monitor_retry_interval is not set.");
      rc = 1; /* Validation Failure */
      goto finished;
   }

   /* All validation checks were successful */
   scds_syslog(LOG_INFO, "Successful validation.");
   rc = 0;

finished:
   scds_free_net_list(snrlp);
   scds_free_port_list(portlist);

   return (rc); /* return result of validation */
}


/*
 * svc_start():
 *
 * Start up the X font server
 * Return 0 on success, > 0 on failures.
 *
 * The XFS service will be started by running the command
 * /usr/openwin/bin/xfs -config <fontserver.cfg file> -port <port
to listen>
 * XFS will be started under PMF. XFS will be started as a single
```

EXAMPLE C–1 `xfnts.c` *(Continued)*

```
instance
 * service. The PMF tag for the data service will be of the form
 * <resourcegroupname,resourcename,instance_number.svc>.
In case of XFS, since
 * there will be only one instance the instance_number in the tag
will be 0.
 */

int
svc_start(scds_handle_t scds_handle)
{
   char    xfnts_conf[SCDS_ARRAY_SIZE];
   char   cmd[SCDS_ARRAY_SIZE];
   scha_str_array_t *confdirs;
   scds_port_list_t    *portlist;
   scha_err_t   err;

   /* get the configuration directory from the confdir_list property */
   confdirs = scds_get_ext_confdir_list(scds_handle);

   (void) sprintf(xfnts_conf, "%s/fontserver.cfg",
confdirs->str_array[0]);

   /* obtain the port to be used by XFS from the Port_list property */
   err = scds_get_port_list(scds_handle, &portlist);
   if (err != SCHA_ERR_NOERR) {
      scds_syslog(LOG_ERR,
          "Could not access property Port_list.");
      return (1);
   }

   /*
    * Construct the command to start HA-XFS.
    * NOTE: XFS daemon prints the following message while stopping the XFS
    * "/usr/openwin/bin/xfs notice: terminating"
    * In order to suppress the daemon message,
    * the output is redirected to /dev/null.
    */
   (void) sprintf(cmd,
       "/usr/openwin/bin/xfs -config %s -port %d 2>/dev/null",
       xfnts_conf, portlist->ports[0].port);

   /*
    * Start HA-XFS under PMF. Note that HA-XFS is started as a single
    * instance service. The last argument to the scds_pmf_start function
    * denotes the level of children to be monitored. A value of -1 for
    * this parameter means that all the children along with the original
    * process are to be monitored.
    */
   scds_syslog(LOG_INFO, "Issuing a start request.");
   err = scds_pmf_start(scds_handle, SCDS_PMF_TYPE_SVC,
      SCDS_PMF_SINGLE_INSTANCE, cmd, -1);
```

EXAMPLE C–1 `xfnts.c` *(Continued)*

```
   if (err == SCHA_ERR_NOERR) {
      scds_syslog(LOG_INFO,
          "Start command completed successfully.");
   } else {
      scds_syslog(LOG_ERR,
          "Failed to start HA-XFS ");
   }

   scds_free_port_list(portlist);
   return (err); /* return Success/failure status */
}


/*
 * svc_stop():
 *
 * Stop the XFS server
 * Return 0 on success, > 0 on failures.
 *
 * svc_stop will stop the server by calling the toolkit function:
 * scds_pmf_stop.
 */
int
svc_stop(scds_handle_t scds_handle)
{
   scha_err_t   err;

   /*
    * The timeout value for the stop method to succeed is set in the
    * Stop_Timeout (system defined) property
    */
   scds_syslog(LOG_ERR, "Issuing a stop request.");
   err = scds_pmf_stop(scds_handle,
       SCDS_PMF_TYPE_SVC, SCDS_PMF_SINGLE_INSTANCE, SIGTERM,
       scds_get_rs_stop_timeout(scds_handle));

   if (err != SCHA_ERR_NOERR) {
      scds_syslog(LOG_ERR,
          "Failed to stop HA-XFS.");
      return (1);
   }

   scds_syslog(LOG_INFO,
       "Successfully stopped HA-XFS.");
   return (SCHA_ERR_NOERR); /* Successfully stopped */
}

/*
 * svc_wait():
 *
 * wait for the data service to start up fully and make sure it
is running
 * healthy
```

EXAMPLE C–1 `xfnts.c` *(Continued)*

```
 */

int
svc_wait(scds_handle_t scds_handle)
{
   int rc, svc_start_timeout, probe_timeout;
   scds_netaddr_list_t   *netaddr;

   /* obtain the network resource to use for probing */
   if (scds_get_netaddr_list(scds_handle, &netaddr)) {
      scds_syslog(LOG_ERR,
          "No network address resources found in resource group.");
      return (1);
   }

   /* Return an error if there are no network resources */
   if (netaddr == NULL || netaddr->num_netaddrs == 0) {
      scds_syslog(LOG_ERR,
          "No network address resource in resource group.");
      return (1);
   }

   /*
    * Get the Start method timeout, port number on which to probe,
    * the Probe timeout value
    */
   svc_start_timeout = scds_get_rs_start_timeout(scds_handle);
   probe_timeout = scds_get_ext_probe_timeout(scds_handle);

   /*
    * sleep for SVC_WAIT_PCT percentage of start_timeout time
    * before actually probing the dataservice. This is to allow
    * the dataservice to be fully up in order to reply to the
    * probe. NOTE: the value for SVC_WAIT_PCT could be different
    * for different data services.
    * Instead of calling sleep(),
    * call scds_svc_wait() so that if service fails too
    * many times, we give up and return early.
    */
   if (scds_svc_wait(scds_handle, (svc_start_timeout * SVC_WAIT_PCT)/100)
      != SCHA_ERR_NOERR) {

      scds_syslog(LOG_ERR, "Service failed to start.");
      return (1);
   }

   do {
      /*
       * probe the data service on the IP address of the
       * network resource and the portname
       */
      rc = svc_probe(scds_handle,
          netaddr->netaddrs[0].hostname,
```

EXAMPLE C–1 `xfnts.c` *(Continued)*

```
          netaddr->netaddrs[0].port_proto.port, probe_timeout);
      if (rc == SCHA_ERR_NOERR) {
         /* Success. Free up resources and return */
         scds_free_netaddr_list(netaddr);
         return (0);
      }

      /*
       * Dataservice is still trying to come up. Sleep for a while
       * before probing again. Instead of calling sleep(),
       * call scds_svc_wait() so that if service fails too
       * many times, we give up and return early.
       */
      if (scds_svc_wait(scds_handle, SVC_WAIT_TIME)
         != SCHA_ERR_NOERR) {
         scds_syslog(LOG_ERR, "Service failed to start.");
         return (1);
      }

   /* We rely on RGM to timeout and terminate the program */
   } while (1);

}

/*
 * This function starts the fault monitor for a HA-XFS resource.
 * This is done by starting the probe under PMF. The PMF tag
 * is derived as <RG-name,RS-name,instance_number.mon>.
The restart option
 * of PMF is used but not the "infinite restart".
Instead
 * interval/retry_time is obtained from the RTR file.
 */

int
mon_start(scds_handle_t scds_handle)
{
   scha_err_t   err;

   scds_syslog_debug(DBG_LEVEL_HIGH,
      "Calling MONITOR_START method for resource <%s>.",
      scds_get_resource_name(scds_handle));

   /*
    * The probe xfnts_probe is assumed to be available in the same
    * subdirectory where the other callback methods for the RT are
    * installed. The last parameter to scds_pmf_start denotes the
    * child monitor level. Since we are starting the probe under PMF
    * we need to monitor the probe process only and hence we are using
    * a value of 0.
    */
   err = scds_pmf_start(scds_handle, SCDS_PMF_TYPE_MON,
       SCDS_PMF_SINGLE_INSTANCE, "xfnts_probe",
0);

   if (err != SCHA_ERR_NOERR) {
      scds_syslog(LOG_ERR,
          "Failed to start fault monitor.");
      return (1);
   }

   scds_syslog(LOG_INFO,
       "Started the fault monitor.");

   return (SCHA_ERR_NOERR); /* Successfully started Monitor */
}


/*
 * This function stops the fault monitor for a HA-XFS resource.
 * This is done via PMF. The PMF tag for the fault monitor is
 * constructed based on <RG-name_RS-name,instance_number.mon>.
 */

int
mon_stop(scds_handle_t scds_handle)
{

   scha_err_t   err;

   scds_syslog_debug(DBG_LEVEL_HIGH,
      "Calling scds_pmf_stop method");

   err = scds_pmf_stop(scds_handle, SCDS_PMF_TYPE_MON,
       SCDS_PMF_SINGLE_INSTANCE, SIGKILL,
       scds_get_rs_monitor_stop_timeout(scds_handle));

   if (err != SCHA_ERR_NOERR) {
      scds_syslog(LOG_ERR,
          "Failed to stop fault monitor.");
      return (1);
   }

   scds_syslog(LOG_INFO,
       "Stopped the fault monitor.");

   return (SCHA_ERR_NOERR); /* Successfully stopped monitor */
}

/*
 * svc_probe(): Do data service specific probing. Return a float value
 * between 0 (success) and 100(complete failure).
 *
 * The probe does a simple socket connection to the XFS server on the specified
 * port which is configured as the resource extension property (Port_list) and
 * pings the dataservice. If the probe fails to connect to the port, we return
 * a value of 100 indicating that there is a total failure. If the connection
 * goes through and the disconnect to the port fails, then a value of 50 is
 * returned indicating a partial failure.
 *
 */
int
svc_probe(scds_handle_t scds_handle, char *hostname, int port, int
timeout)
{
   int  rc;
   hrtime_t   t1, t2;
   int    sock;
   char   testcmd[2048];
   int    time_used, time_remaining;
   time_t      connect_timeout;


   /*
    * probe the dataservice by doing a socket connection to the port
    * specified in the port_list property to the host that is
    * serving the XFS dataservice. If the XFS service which is configured
    * to listen on the specified port, replies to the connection, then
    * the probe is successful. Else we will wait for a time period set
    * in probe_timeout property before concluding that the probe failed.
    */

   /*
    * Use the SVC_CONNECT_TIMEOUT_PCT percentage of timeout
    * to connect to the port
    */
   connect_timeout = (SVC_CONNECT_TIMEOUT_PCT * timeout)/100;
   t1 = (hrtime_t)(gethrtime()/1E9);

   /*
    * the probe makes a connection to the specified hostname and port.
    * The connection is timed for 95% of the actual probe_timeout.
    */
   rc = scds_fm_tcp_connect(scds_handle, &sock, hostname, port,
       connect_timeout);
   if (rc) {
      scds_syslog(LOG_ERR,
          "Failed to connect to port <%d> of resource <%s>.",
          port, scds_get_resource_name(scds_handle));
      /* this is a complete failure */
      return (SCDS_PROBE_COMPLETE_FAILURE);
   }

   t2 = (hrtime_t)(gethrtime()/1E9);

   /*
    * Compute the actual time it took to connect. This should be less than
    * or equal to connect_timeout, the time allocated to connect.
    * If the connect uses all the time that is allocated for it,
```

EXAMPLE C–1 `xfnts.c` *(Continued)*

```
     * then the remaining value from the probe_timeout that is passed to
     * this function will be used as disconnect timeout. Otherwise, the
     * the remaining time from the connect call will also be added to
     * the disconnect timeout.
     *
     */

    time_used = (int)(t2 - t1);

    /*
     * Use the remaining time(timeout - time_took_to_connect) to disconnect
     */

    time_remaining = timeout - (int)time_used;

    /*
     * If all the time is used up, use a small hardcoded timeout
     * to still try to disconnect. This will avoid the fd leak.
     */
    if (time_remaining <= 0) {
       scds_syslog_debug(DBG_LEVEL_LOW,
           "svc_probe used entire timeout of "
           "%d seconds during connect operation and exceeded the "
           "timeout by %d seconds. Attempting disconnect with timeout"
           " %d ",
           connect_timeout,
           abs(time_used),
           SVC_DISCONNECT_TIMEOUT_SECONDS);

       time_remaining = SVC_DISCONNECT_TIMEOUT_SECONDS;
    }

    /*
     * Return partial failure in case of disconnection failure.
     * Reason: The connect call is successful, which means
     * the application is alive. A disconnection failure
     * could happen due to a hung application or heavy load.
     * If it is the later case, don't declare the application
     * as dead by returning complete failure. Instead, declare
     * it as partial failure. If this situation persists, the
     * disconnect call will fail again and the application will be
     * restarted.
     */
    rc = scds_fm_tcp_disconnect(scds_handle, sock, time_remaining);
    if (rc != SCHA_ERR_NOERR) {
       scds_syslog(LOG_ERR,
           "Failed to disconnect to port %d of resource %s.",
           port, scds_get_resource_name(scds_handle));
       /* this is a partial failure */
       return (SCDS_PROBE_COMPLETE_FAILURE/2);
    }

    t2 = (hrtime_t)(gethrtime()/1E9);
```

EXAMPLE C–1 `xfnts.c` *(Continued)*

```
   time_used = (int)(t2 - t1);
   time_remaining = timeout - time_used;

   /*
    * If there is no time left, don't do the full test with
    * fsinfo. Return SCDS_PROBE_COMPLETE_FAILURE/2
    * instead. This will make sure that if this timeout
    * persists, server will be restarted.
    */
   if (time_remaining <= 0) {
      scds_syslog(LOG_ERR, "Probe timed out.");
      return (SCDS_PROBE_COMPLETE_FAILURE/2);
   }

   /*
    * The connection and disconnection to port is successful,
    * Run the fsinfo command to perform a full check of
    * server health.
    * Redirect stdout, otherwise the output from fsinfo
    * ends up on the console.
    */
   (void) sprintf(testcmd,
       "/usr/openwin/bin/fsinfo -server %s:%d > /dev/null",
       hostname, port);
   scds_syslog_debug(DBG_LEVEL_HIGH,
       "Checking the server status with %s.", testcmd);
   if (scds_timerun(scds_handle, testcmd, time_remaining,
      SIGKILL, &rc) != SCHA_ERR_NOERR || rc != 0) {

      scds_syslog(LOG_ERR,
         "Failed to check server status with command <%s>",
         testcmd);
      return (SCDS_PROBE_COMPLETE_FAILURE/2);
   }
   return (0);
}
```

`xfnts_monitor_check` Method

This method verifies that the basic resource type configuration is valid.

EXAMPLE C–2 `xfnts_monitor_check.c`

```
/*
 * Copyright (c) 1998-2003 by Sun Microsystems, Inc.
 * All rights reserved.
 *
```

EXAMPLE C–2 `xfnts_monitor_check.c` *(Continued)*

```
 * xfnts_monitor_check.c - Monitor Check method for HA-XFS
 */

#pragma ident “@(#)xfnts_monitor_check.c 1.11 01/01/18
SMI”

#include <rgm/libdsdev.h>
#include “xfnts.h”

/*
 * just make a simple validate check on the service
 */

int
main(int argc, char *argv[])
{
   scds_handle_t   scds_handle;
   int   rc;

   /* Process the arguments passed by RGM and initialize syslog */
   if (scds_initialize(&scds_handle, argc, argv) != SCHA_ERR_NOERR)
{
      scds_syslog(LOG_ERR, “Failed to initialize the handle.”);
      return (1);
   }

   rc =  svc_validate(scds_handle);
   scds_syslog_debug(DBG_LEVEL_HIGH,
       “monitor_check method “
       “was called and returned <%d>.”, rc);

   /* Free up all the memory allocated by scds_initialize */
   scds_close(&scds_handle);

   /* Return the result of validate method run as part of monitor check */
   return (rc);
}
```

`xfnts_monitor_start` Method

This method starts the xfnts_probe method.

EXAMPLE C–3 `xfnts_monitor_start.c`

```
/*
 * Copyright (c) 1998-2003 by Sun Microsystems, Inc.
 * All rights reserved.
```

EXAMPLE C–3 `xfnts_monitor_start.c` *(Continued)*

```
 *
 * xfnts_monitor_start.c - Monitor Start method for HA-XFS
 */

#pragma ident "@(#)xfnts_monitor_start.c 1.10 01/01/18
SMI"

#include <rgm/libdsdev.h>
#include "xfnts.h"

/*
 * This method starts the fault monitor for a HA-XFS resource.
 * This is done by starting the probe under PMF. The PMF tag
 * is derived as RG-name,RS-name.mon. The restart option of PMF
 * is used but not the "infinite restart". Instead
 * interval/retry_time is obtained from the RTR file.
 */

int
main(int argc, char *argv[])
{
   scds_handle_t   scds_handle;
   int   rc;

   /* Process arguments passed by RGM and initialize syslog */
   if (scds_initialize(&scds_handle, argc, argv) != SCHA_ERR_NOERR)
{
      scds_syslog(LOG_ERR, "Failed to initialize the handle.");
      return (1);
   }

   rc = mon_start(scds_handle);

   /* Free up all the memory allocated by scds_initialize */
   scds_close(&scds_handle);

   /* Return the result of monitor_start method */
   return (rc);
}
```

`xfnts_monitor_stop` Method

This method stops the `xfnts_probe` method.

EXAMPLE C–4 `xfnts_monitor_stop.c`

```
/*
 * Copyright (c) 1998-2003 by Sun Microsystems, Inc.
 * All rights reserved.
```

EXAMPLE C–4 `xfnts_monitor_stop.c` *(Continued)*

```
 *
 * xfnts_monitor_stop.c - Monitor Stop method for HA-XFS
 */

#pragma ident "@(#)xfnts_monitor_stop.c 1.9 01/01/18 SMI"

#include <rgm/libdsdev.h>
#include "xfnts.h"

/*
 * This method stops the fault monitor for a HA-XFS resource.
 * This is done via PMF. The PMF tag for the fault monitor is
 * constructed based on RG-name_RS-name.mon.
 */

int
main(int argc, char *argv[])
{

   scds_handle_t   scds_handle;
   int    rc;

   /* Process arguments passed by RGM and initialize syslog */
   if (scds_initialize(&scds_handle, argc, argv) != SCHA_ERR_NOERR)
{
      scds_syslog(LOG_ERR, "Failed to initialize the handle.");
      return (1);
   }
   rc = mon_stop(scds_handle);

   /* Free up all the memory allocated by scds_initialize */
   scds_close(&scds_handle);

   /* Return the result of monitor stop method */
   return (rc);
}
```

`xfnts_probe` Method

The `xfnts_probe` method checks the availability of the application and decides whether to failover or restart the data service. The `xfnts_monitor_start` callback method launches this program and the `xfnts_monitor_stop` callback method stops it.

EXAMPLE C–5 `xfnts_probe.c+`

```
/*
 * Copyright (c) 1998-2003 by Sun Microsystems, Inc.
```

EXAMPLE C–5 `xfnts_probe.c+` *(Continued)*

```
 * All rights reserved.
 *
 * xfnts_probe.c - Probe for HA-XFS
 */

#pragma ident “@(#)xfnts_probe.c 1.26 01/01/18 SMI”

#include <stdio.h>
#include <stdlib.h>
#include <strings.h>
#include <unistd.h>
#include <signal.h>
#include <sys/time.h>
#include <sys/socket.h>
#include <strings.h>
#include <rgm/libdsdev.h>
#include “xfnts.h”


/*
 * main():
 * Just an infinite loop which sleep()s for sometime, waiting for
 * the PMF action script to interrupt the sleep(). When interrupted
 * It calls the start method for HA-XFS to restart it.
 *
 */

int
main(int argc, char *argv[])
{
   int         timeout;
   int         port, ip, probe_result;
   scds_handle_t      scds_handle;

   hrtime_t      ht1, ht2;
   unsigned long      dt;

   scds_netaddr_list_t *netaddr;
   char   *hostname;

   if (scds_initialize(&scds_handle, argc, argv) != SCHA_ERR_NOERR)
{
      scds_syslog(LOG_ERR, “Failed to initialize the handle.”);
      return (1);
   }


   /* Get the ip addresses available for this resource */
   if (scds_get_netaddr_list(scds_handle, &netaddr)) {
      scds_syslog(LOG_ERR,
          “No network address resource in resource group.”);
      scds_close(&scds_handle);
      return (1);
```

```
}

/* Return an error if there are no network resources */
if (netaddr == NULL || netaddr->num_netaddrs == 0) {
   scds_syslog(LOG_ERR,
       "No network address resource in resource group.");
   return (1);
}


/*
 * Set the timeout from the X props. This means that each probe
 * iteration will get a full timeout on each network resource
 * without chopping up the timeout between all of the network
 * resources configured for this resource.
 */
timeout = scds_get_ext_probe_timeout(scds_handle);

for (;;) {

   /*
    * sleep for a duration of thorough_probe_interval between
    *  successive probes.
    */
   (void) scds_fm_sleep(scds_handle,
       scds_get_rs_thorough_probe_interval(scds_handle));

   /*
    * Now probe all ipaddress we use. Loop over
    * 1. All net resources we use.
    * 2. All ipaddresses in a given resource.
    * For each of the ipaddress that is probed,
    * compute the failure history.
    */
   probe_result = 0;
   /*
    * Iterate through the all resources to get each
    * IP address to use for calling svc_probe()
    */
   for (ip = 0; ip < netaddr->num_netaddrs; ip++) {
      /*
       * Grab the hostname and port on which the
       * health has to be monitored.
       */
      hostname = netaddr->netaddrs[ip].hostname;
      port = netaddr->netaddrs[ip].port_proto.port;
      /*
       * HA-XFS supports only one port and
       * hence obtain the port value from the
       * first entry in the array of ports.
       */
      ht1 = gethrtime(); /* Latch probe start time */
      scds_syslog(LOG_INFO, "Probing the service on "
            "port: %d.", port);

         probe_result =
         svc_probe(scds_handle, hostname, port, timeout);

         /*
          * Update service probe history,
          * take action if necessary.
          * Latch probe end time.
          */
         ht2 = gethrtime();

         /* Convert to milliseconds */
         dt = (ulong_t)((ht2 - ht1) / 1e6);

         /*
          * Compute failure history and take
          * action if needed
          */
         (void) scds_fm_action(scds_handle,
             probe_result, (long)dt);
      }   /* Each net resource */
   }    /* Keep probing forever */
}
```

`xfnts_start` Method

The RGM invokes the `Start` method on a cluster node when the resource group containing the data service resource is brought online on that node or when the resource is enabled. The `xfnts_start` method activates the `xfs` daemon on that node.

EXAMPLE C–6 `xfnts_start.c`

```
/*
 * Copyright (c) 1998-2003 by Sun Microsystems, Inc.
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 *
 * xfnts_svc_start.c - Start method for HA-XFS
 */

#pragma ident "@(#)xfnts_svc_start.c 1.13 01/01/18 SMI"

#include <rgm/libdsdev.h>
#include "xfnts.h"

/*
```

```
 * The start method for HA-XFS. Does some sanity checks on
 * the resource settings then starts the HA-XFS under PMF with
 * an action script.
 */

int
main(int argc, char *argv[])
{
   scds_handle_t   scds_handle;
   int rc;

   /*
    * Process all the arguments that have been passed to us from RGM
    * and do some initialization for syslog
    */

   if (scds_initialize(&scds_handle, argc, argv) != SCHA_ERR_NOERR)
{
      scds_syslog(LOG_ERR, "Failed to initialize the handle.");
      return (1);
   }

   /* Validate the configuration and if there is an error return back */
   rc = svc_validate(scds_handle);
   if (rc != 0) {
      scds_syslog(LOG_ERR,
          "Failed to validate configuration.");
      return (rc);
   }

   /* Start the data service, if it fails return with an error */
   rc = svc_start(scds_handle);
   if (rc != 0) {
      goto finished;
   }

   /* Wait for the service to start up fully */
   scds_syslog_debug(DBG_LEVEL_HIGH,
       "Calling svc_wait to verify that service has started.");

   rc = svc_wait(scds_handle);

   scds_syslog_debug(DBG_LEVEL_HIGH,
       "Returned from svc_wait");

   if (rc == 0) {
      scds_syslog(LOG_INFO, "Successfully started the service.");
   } else {
      scds_syslog(LOG_ERR, "Failed to start the service.");
   }


finished:
```

EXAMPLE C–6 `xfnts_start.c` *(Continued)*

```
   /* Free up the Environment resources that were allocated */
   scds_close(&scds_handle);

   return (rc);
}
```

The `xfnts_stop` Method

The RGM invokes the `Stop` method on a cluster node when the resource group containing the HA-XFS resource is brought offline on that node or the resource is disabled. This method stops the `xfs` daemon on that node.

EXAMPLE C–7 `xfnts_stop.c`

```
/*
 * Copyright (c) 1998-2003 by Sun Microsystems, Inc.
 * All rights reserved.
 *
 * xfnts_svc_stop.c - Stop method for HA-XFS
 */

#pragma ident "@(#)xfnts_svc_stop.c 1.10 01/01/18 SMI"

#include <rgm/libdsdev.h>
#include "xfnts.h"

/*
 * Stops the HA-XFS process using PMF
 */

int
main(int argc, char *argv[])
{

   scds_handle_t   scds_handle;
   int      rc;

   /* Process the arguments passed by RGM and initialize syslog */
   if (scds_initialize(&scds_handle, argc, argv) != SCHA_ERR_NOERR)
{
      scds_syslog(LOG_ERR, "Failed to initialize the handle.");
      return (1);
   }

   rc = svc_stop(scds_handle);

   /* Free up all the memory allocated by scds_initialize */
```

EXAMPLE C–7 `xfnts_stop.c` *(Continued)*

```
   scds_close(&scds_handle);

   /* Return the result of svc_stop method */
   return (rc);
}
```

The `xfnts_update` Method

The RGM calls the `Update` method to notify a running resource that its properties have been changed. The RGM invokes `Update` after an administrative action succeeds in setting properties of a resource or its group.

EXAMPLE C–8 `xfnts_update.c`

```
#pragma ident "@(#)xfnts_update.c  1.10     01/01/18 SMI"

/*
 * Copyright (c) 1998-2003 by Sun Microsystems, Inc.
 * All rights reserved.
 *
 * xfnts_update.c - Update method for HA-XFS
 */

#include <stdio.h>
#include <stdlib.h>
#include <signal.h>
#include <rgm/libdsdev.h>

/*
 * Some of the resource properties might have been updated. All
such
 * updatable properties are related to the fault monitor. Hence,
just
 * restarting the monitor should be enough.
 */

int
main(int argc, char *argv[])
{
   scds_handle_t   scds_handle;
   scha_err_t   result;

   /* Process the arguments passed by RGM and initialize syslog */
   if (scds_initialize(&scds_handle, argc, argv) != SCHA_ERR_NOERR)
{
      scds_syslog(LOG_ERR, "Failed to initialize the handle.");
      return (1);
```

EXAMPLE C–8 `xfnts_update.c` *(Continued)*

```
   }

   /*
    * check if the Fault monitor is already running and if so stop and
    * restart it. The second parameter to scds_pmf_restart_fm() uniquely
    * identifies the instance of the fault monitor that needs to be
    * restarted.
    */

   scds_syslog(LOG_INFO, "Restarting the fault monitor.");
   result = scds_pmf_restart_fm(scds_handle, 0);
   if (result != SCHA_ERR_NOERR) {
      scds_syslog(LOG_ERR,
          "Failed to restart fault monitor.");
      /* Free up all the memory allocated by scds_initialize */
      scds_close(&scds_handle);
      return (1);
   }

   scds_syslog(LOG_INFO,
       "Completed successfully.");

   /* Free up all the memory allocated by scds_initialize */
   scds_close(&scds_handle);

   return (0);
}
```

The `xfnts_validate` Method Code Listing

This method verifies the existence of the directory pointed to by the `Confdir_list` property. The RGM calls this method when the data service is created and when data service properties are updated by the cluster administrator. The `Monitor_check` method calls this method whenever the fault monitor fails the data service over to a new node.

EXAMPLE C–9 `xfnts_validate.c`

```
/*
 * Copyright (c) 1998-2003 by Sun Microsystems, Inc.
 * All rights reserved.
 *
 * xfnts_validate.c - validate method for HA-XFS
 */
```

EXAMPLE C–9 `xfnts_validate.c` *(Continued)*

```
#pragma ident “@(#)xfnts_validate.c 1.9 01/01/18 SMI”

#include <rgm/libdsdev.h>
#include “xfnts.h”

/*
 * Check to make sure that the properties have been set properly.
 */

int
main(int argc, char *argv[])
{
   scds_handle_t   scds_handle;
   int   rc;

   /* Process arguments passed by RGM and initialize syslog */
   if (scds_initialize(&scds_handle, argc, argv) != SCHA_ERR_NOERR)
{
      scds_syslog(LOG_ERR, “Failed to initialize the handle.”);
      return (1);
   }
   rc = svc_validate(scds_handle);

   /* Free up all the memory allocated by scds_initialize */
   scds_close(&scds_handle);

   /* Return the result of validate method */
   return (rc);

}
```

APPENDIX **D**

Legal RGM Names and Values

This appendix lists the requirements for legal characters for RGM names and values.

RGM Legal Names

RGM names fall into five categories:

- Resource group names
- Resource type names
- Resource names
- Property names
- Enumeration literal names

Except for resource type names, all names must comply with the following rules:

- Must be in ASCII.
- Must start with a letter.
- Can contain upper and lowercase letters, digits, dashes (-), and underscores (_).
- Must not exceed 255 characters.

A resource type name can be a simple name (specified by the `Resource_type` property in the RTR file) or a complete name (specified by the `Vendor_id` and `Resource_type` properties in the RTR file). When you specify both these properties, the RGM inserts a period between the `Vendor_id` and `Resource_type` to form the complete name. For example, if `Vendor_id=SUNW` and `Resource_type=sample`, the complete name is `SUNW.sample`. This is the only case where a period is a legal character in an RGM name.

RGM Values

RGM values fall into two categories: property values and description values, both of which share the same rules, as follows:

- Values must be in ASCII.
- The maximum length of a value is 4 megabytes minus 1, that is, 4,194,303 bytes.
- Values cannot contain any of the following characters: null, newline, comma, or semicolon.

APPENDIX **E**

Requirements for Non-Cluster Aware Applications

An ordinary, non-cluster-aware application must meet certain requirements to be a candidate for high availability (HA). The section "Analyzing the Application for Suitability" on page 25 lists these requirements. This appendix provides additional details about particular items in that list.

An application is made highly available by configuring its resources into resource groups. The application's data is placed on a highly available global file system, making the data accessible by a surviving server in the event that one server fails. See information regarding cluster file systems in *Sun Cluster 3.1 10/03 Concepts Guide*.

For network access by clients on the network, a logical network IP address is configured in logical host name resources that are contained in the same resource group as the data service resource. The data service resource and the network address resources fail over together, causing network clients of the data service to access the data service resource on its new host.

Multihosted Data

The highly available global file systems' disk sets are multihosted so that when a physical host crashes, one of the surviving hosts can access the disk. For an application to be highly available, its data must be highly available, and thus its data must reside in the global HA file systems.

The global file system is mounted on disk groups that are created as independent entities. The user can choose to use some disk groups as mounted global file systems and others as raw devices for use with a data service, such as HA Oracle.

An application might have command-line switches or configuration files pointing to the location of the data files. If the application uses hard-wired pathnames, you could change the pathnames to symbolic links that point to a files in a global file system, without changing the application code. See "Using Symbolic Links for Multihosted Data Placement" on page 306 for a more detailed discussion about using symbolic links.

In the worst case, the application's source code must be modified to provide some mechanism for pointing to the actual data location. You could do this by implementing additional command-line switches.

Sun Cluster supports the use of UNIX UFS file systems and HA raw devices configured in a volume manager. When installing and configuring , the system administrator must specify which disk resources to use for UFS file systems and which for raw devices. Typically, raw devices are used only by database servers and multimedia servers.

Using Symbolic Links for Multihosted Data Placement

Occasionally an application has the path names of its data files hard-wired, with no mechanism for overriding the hard-wired path names. To avoid modifying the application code, you can sometimes use symbolic links.

For example, suppose the application names its data file with the hard-wired path name `/etc/mydatafile`. You can change that path from a file to a symbolic link that has its value pointing to a file in one of the logical host's file systems. For example, you can make it a symbolic link to `/global/phys-schost-2/mydatafile`.

A problem can occur with this use of symbolic links if the application, or one of its administrative procedures, modifies the data file name as well as its contents. For example, suppose that the application performs an update by first creating a new temporary file, `/etc/mydatafile.new`. Then it renames the temporary file to have the real file name by using the `rename(2)` system call (or the `mv(1)` program). By creating the temporary file and then renaming it to the real file, the data service is attempting to ensure that its data file contents are always well formed.

Unfortunately, the `rename(2)` action destroys the symbolic link. The name `/etc/mydatafile` is now a regular file, and is in the same file system as the `/etc` directory, not in the cluster's global file system. Because the `/etc` file system is private to each host, the data is not available after a takeover or switchover.

The underlying problem in this situation is that the existing application is not aware of the symbolic link and was not written with symbolic links considered. To use symbolic links to redirect data access into the logical host's file systems, the application implementation must behave in a way that does not obliterate the symbolic links. So, symbolic links are not a complete remedy for the problem of placing data on the cluster's global file systems.

Host Names

You must determine whether the data service ever needs to know the host name of the server on which it is running. If so, the data service might need to be modified to use a logical host name (that is, a host name configured into a logical host name resource that resides in the same resource group as the application resource), rather than that of the physical host.

Occasionally, in the client-server protocol for a data service, the server returns its own host name to the client as part of the contents of a message to the client. For such protocols, the client could be depending on this returned host name as the host name to use when contacting the server. For the returned host name to be usable after a takeover or switchover, the host name should be a logical host name of the resource group, not the name of the physical host. In this case, you must modify the data service code to return the logical host name to the client.

Multihomed Hosts

The term *multihomed host* describes a host that is on more than one public network. Such a host has multiple host names and IP addresses. It has one host name-IP address pair for each network. Sun Cluster is designed to permit a host to appear on any number of networks, including just one (the non-multihomed case). Just as the physical host name has multiple host name-IP address pairs, each resource group can have multiple host name-IP address pairs, one for each public network. When Sun Cluster moves a resource group from one physical host to another, the complete set of host name-IP address pairs for that resource group is moved.

The set of host name-IP address pairs for a resource group is configured as logical host name resources contained in the resource group. These network address resources are specified by the system administrator when the resource group is created and configured. The Sun Cluster Data Service API contains facilities for querying these host name-IP address pairs.

Most off-the-shelf data service daemons that have been written for the Solaris environment already handle multihomed hosts properly. Many data services do all their network communication by binding to the Solaris wildcard address `INADDR_ANY`. This binding automatically causes the data services to handle all the IP addresses for all the network interfaces. `INADDR_ANY` effectively binds to all IP addresses currently configured on the machine. A data service daemon that uses `INADDR_ANY` generally does not have to be changed to handle the Sun Cluster logical network addresses.

Binding to `INADDR_ANY` Versus Binding to Specific IP Addresses

Even when non-multihomed hosts are used, the Sun Cluster logical network address concept enables the machine to have more than one IP address. The machine has one IP address for its own physical host and additional IP addresses for each network address (logical host name) resource that it currently masters. When a machine becomes the master of a network address resource, it dynamically acquires additional IP addresses. When it gives up mastery of a network address resource, it dynamically relinquishes IP addresses.

Some data services cannot work properly in a Sun Cluster environment if they bind to `INADDR_ANY`. These data services must dynamically change the set of IP addresses to which they are bound as the resource group is mastered or unmastered. One strategy for accomplishing the rebinding is to have the starting and stopping methods for these data services kill and restart the data service's daemons.

The `Network_resources_used` resource property permits the end user to configure a specific set of network address resources to which the application resource should bind. For resource types that require this feature, the `Network_resources_used` property must be declared in the RTR file for the resource type.

When the RGM brings the resource group online or offline, it follows a specific order for plumbing, unplumbing and configuring network address up or down in relation to when it calls call data service resource methods. See "Deciding Which `Start` and `Stop` Methods to Use" on page 41.

By the time the data service's `Stop` method returns, the data service must have stopped using the resource group's network addresses. Similarly, by the time the `Start` method returns, the data service must have started to use the network addresses.

If the data service binds to `INADDR_ANY` rather than to individual IP addresses, the order in which data service resource methods are called and network address methods are called is not relevant.

If the data service's stopping and starting methods accomplish their work by killing and restarting data service's daemons, then the data service stops and starts using the network addresses at the appropriate times.

Client Retry

To a network client, a takeover or switchover appears to be a crash of the logical host followed by a fast reboot. Ideally, the client application and the client-server protocol are structured to do some amount of retrying. If the application and protocol already handle the case of a single server crashing and rebooting, then they also will handle the case of the resource group being taken over or switched over. Some applications might elect to retry endlessly. More sophisticated applications notify the user that a long retry is in progress and enable the user to choose whether to continue.

APPENDIX **F**

Document Type Definitions for CRNP

This appendix lists the DTDs (document type definitions) for Cluster Reconfiguration Notification Protocol (CRNP).

`SC_CALLBACK_REG` XML DTD

Note – The `NVPAIR` data structure that is used by both `SC_CALLBACK_REG` and `SC_EVENT` is defined only once.

```
<!— SC_CALLBACK_REG XML format specification
        Copyright 2001-2003 Sun Microsystems, Inc. All rights reserved.
        Use is subject to license terms.

        Intended Use:

A client of the Cluster Reconfiguration Notification Protocol should use this xml format
to register initially with the service, to subsequently register for more events, to
subsequently remove registration of some events, or to remove itself from the service
entirely.

A client is uniquely identified by its callback IP and port.  The port is defined in the
SC_CALLBACK_REG element, and the IP is taken as the source IP of the registration
connection.  The final attribute of the root SC_CALLBACK_REG element is either an
ADD_CLIENT, ADD_EVENTS, REMOVE_CLIENT, or REMOVE_EVENTS, depending on which form of the
message the client is using.

The SC_CALLBACK_REG contains 0 or more SC_EVENT_REG sub-elements.

One SC_EVENT_REG is the specification for one event type.  A client may specify only the
CLASS (an attribute of the SC_EVENT_REG element), or may specify a SUBCLASS (an optional
attribute) for further granularity.  Also, the SC_EVENT_REG has as subelements 0 or more
```

```
NVPAIRs, which can be used to further specify the event.

Thus, the client can specify events to whatever granularity it wants.  Note that a client
cannot both register for and unregister for events in the same message.  However a client
can subscribe to the service and sign up for events in the same message.

Note on versioning: the VERSION attribute of each root element is marked "fixed", which
means that all message adhering to these DTDs must have the version value specified.  If a
new version of the protocol is created, the revised DTDs will have a new value for this
fixed" VERSION attribute, such that all message adhering to the new version must have the
new version number.
—>

<!— SC_CALLBACK_REG definition

The root element of the XML document is a registration message.  A registration message
consists of the callback port and the protocol version as attributes, and either an
ADD_CLIENT, ADD_EVENTS, REMOVE_CLIENT, or REMOVE_EVENTS attribute, specifying the
registration type.  The ADD_CLIENT, ADD_EVENTS, and REMOVE_EVENTS types should have one or
more SC_EVENT_REG subelements.  The REMOVE_CLIENT should not specify an SC_EVENT_REG
subelement.
        ATTRIBUTES:
               VERSION        The CRNP protocol version of the message.
               PORT           The callback port.
               REG_TYPE       The type of registration.  One of:
                       ADD_CLIENT, ADD_EVENTS, REMOVE_CLIENT, REMOVE_EVENTS

        CONTENTS:
SUBELEMENTS: SC_EVENT_REG (0 or more)
—>
<!ELEMENT SC_CALLBACK_REG (SC_EVENT_REG*)>
<!ATTLIST SC_CALLBACK_REG
       VERSION        NMTOKEN                                                #FIXED
       PORT           NMTOKEN                                                #REQUIRED
       REG_TYPE       (ADD_CLIENT|ADD_EVENTS|REMOVE_CLIENT|REMOVE_EVENTS)    #REQUIRED

>
<!— SC_EVENT_REG definition

The SC_EVENT_REG defines an event for which the client is either registering or
unregistering interest in receiving event notifications.  The registration can be for any
level of granularity, from only event class down to specific name/value pairs that must be
present.  Thus, the only required attribute is the CLASS.  The SUBCLASS attribute, and the
NVPAIRS sub-elements are optional, for higher granularity.

Registrations that specify name/value pairs are registering interest in notification of
messages from the class/subclass specified with ALL name/value pairs present.
Unregistrations that specify name/value pairs are unregistering interest in notifications
that have EXACTLY those name/value pairs in granularity previously specified.
Unregistrations that do not specify name/value pairs unregister interest in ALL event
notifications of the specified class/subclass.

        ATTRIBUTES:
               CLASS:        The event class for which this element is registering
                             or unregistering interest.
               SUBCLASS:     The subclass of the event (optional).

        CONTENTS:
               SUBELEMENTS: 0 or more NVPAIRs.
—>

<!ELEMENT SC_EVENT_REG (NVPAIR*)>
<!ATTLIST SC_EVENT_REG
       CLASS          CDATA                #REQUIRED
       SUBCLASS       CDATA                #IMPLIED
>
```

NVPAIR XML DTD

```
<!— NVPAIR XML format specification

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        Use is subject to license terms.

        Intended Use:
              An nvpair element is meant to be used in an SC_EVENT or SC_CALLBACK_REG
              element.
—>

<!— NVPAIR definition

       The NVPAIR is a name/value pair to represent arbitrary name/value combinations.
       It is intended to be a direct, generic, translation of the Solaris nvpair_t
       structure used by the sysevent framework.  However, there is no type information
       associated with the name or the value (they are both arbitrary text) in this xml
       element.

       The NVPAIR consists simply of one NAME element and one or more VALUE elements.
       One VALUE element represents a scalar value, while multiple represent an array
       VALUE.

       ATTRIBUTES:

       CONTENTS:
               SUBELEMENTS: NAME(1), VALUE(1 or more)
—>

<!ELEMENT NVPAIR (NAME,VALUE+)>
<!— NAME definition

        The NAME is simply an arbitrary length string.

        ATTRIBUTES:
```

```
        CONTENTS:
                Arbitrary text data.  Should be wrapped with <![CDATA[...]]> to prevent XML
                parsing inside.
—>
<!ELEMENT NAME (#PCDATA)>

<!— VALUE definition
        The VALUE is simply an arbitrary length string.

        ATTRIBUTES:

        CONTENTS:
                Arbitrary text data.  Should be wrapped with <![CDATA[...]]> to prevent XML
                parsing inside.
—>

<!ELEMENT VALUE (#PCDATA)>
```

SC_REPLY XML DTD

```
<!— SC_REPLY XML format specification

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        Use is subject to license terms.
—>

<!— SC_REPLY definition

        The root element of the XML document represents a reply to a message.  The reply
        contains a status code and a status message.

        ATTRIBUTES:
                VERSION:        The CRNP protocol version of the message.
                STATUS_CODE:    The return code for the message.  One of the
                                following: OK, RETRY, LOW_RESOURCES, SYSTEM_ERROR, FAIL,
                                MALFORMED, INVALID_XML, VERSION_TOO_HIGH, or
                                VERSION_TOO_LOW.

                CONTENTS:
                        SUBELEMENTS: SC_STATUS_MSG(1)
—>

<!ELEMENT SC_REPLY (SC_STATUS_MSG)>
<!ATTLIST SC_REPLY
        VERSION         NMTOKEN                                         #FIXED   "1.0"
        STATUS_CODE     OK|RETRY|LOW_RESOURCE|SYSTEM_ERROR|FAIL|MALFORMED|INVALID,\
                        VERSION_TOO_HIGH, VERSION_TOO_LOW) #REQUIRED
>
```

```
<!— SC_STATUS_MSG definition
        The SC_STATUS_MSG is simply an arbitrary text string elaborating on the status
        code.  Should be wrapped with <![CDATA[...]]> to prevent XML parsing inside.

        ATTRIBUTES:

        CONTENTS:
                Arbitrary string.
—>

<!ELEMENT SC_STATUS_MSG (#PCDATA)>
```

SC_EVENT XML DTD

Note – The NVPAIR data structure that is used by both SC_CALLBACK_REG and SC_EVENT is defined only once.

```
<!— SC_EVENT XML format specification

        Copyright 2001-2003 Sun Microsystems, Inc. All rights reserved.
        Use is subject to license terms.

        The root element of the XML document is intended to be a direct, generic,
        translation of the Solaris syseventd message format.  It has attributes to
        represent the class, subclass, vendor, and publisher, and contains any number of
        NVPAIR elements.

        ATTRIBUTES:
                VERSION:        The CRNP protocol version of the message.
                CLASS:          The sysevent class of the event
                SUBCLASS:       The subclass of the event
                VENDOR:         The vendor associated with the event
                PUBLISHER:      The publisher of the event
        CONTENTS:
                SUBELEMENTS: NVPAIR (0 or more)
—>

<!ELEMENT SC_EVENT (NVPAIR*)>
<!ATTLIST SC_EVENT
        VERSION         NMTOKEN         #FIXED "1.0"
        CLASS           CDATA           #REQUIRED
        SUBCLASS        CDATA           #REQUIRED
        VENDOR          CDATA           #REQUIRED
        PUBLISHER       CDATA           #REQUIRED
>
```

APPENDIX G

CrnpClient.java Application

This appendix shows the complete `CrnpClient.java` application that is discussed in more detail in Chapter 12.

Contents of CrnpClient.java

```
/*
 * CrnpClient.java
 * ================
 *
 * Note regarding XML parsing:
 *
 * This program uses the Sun Java Architecture for XML Processing (JAXP) API.
 * See http://java.sun.com/xml/jaxp/index.html for API documentation and
 * availability information.
 *
 * This program was written for Java 1.3.1 or higher.
 *
 * Program overview:
 *
 * The main thread of the program creates a CrnpClient object, waits for the
 * user to terminate the demo, then calls shutdown on the CrnpClient object
 * and exits the program.
 *
 * The CrnpClient constructor creates an EventReceptionThread object,
 * opens a connection to the CRNP server (using the host and port specified
 * on the command line), constructs a registration message (based on the
 * command-line specifications), sends the registartion message, and reads
 * and parses the reply.
 *
 * The EventReceptionThread creates a listening socket bound to
 * the hostname of the machine on which this program runs, and the port
 * specified on the command line. It waits for an incoming event callback,
 * at which point it constructs an XML Document from the incoming socket
 * stream, which is then passed back to the CrnpClient object to process.
 *
 * The shutdown method in the CrnpClient just sends an unregistration
 * (REMOVE_CLIENT) SC_CALLBACK_REG message to the crnp server.
 *
 * Note regarding error handling: for the sake of brevity, this program just
 * exits on most errors.  Obviously, a real application would attempt to handle
 * some errors in various ways, such as retrying when appropriate.
 */

// JAXP packages
import javax.xml.parsers.*;
import javax.xml.transform.*;
import javax.xml.transform.dom.*;
import javax.xml.transform.stream.*;
import org.xml.sax.*;
import org.xml.sax.helpers.*;
import org.w3c.dom.*;

// standard packages
import java.net.*;
import java.io.*;
import java.util.*;

/*
 * class CrnpClient
 * -----------------
 * See file header comments above.
 */
class CrnpClient
{
    /*
     * main
     * ----
     * The entry point of the execution, main simply verifies the
     * number of command-line arguments, and constructs an instance
     * of a CrnpClient to do all the work.
     */
    public static void main(String []args)
    {
        InetAddress regIp = null;
        int regPort = 0, localPort = 0;

        /* Verify the number of command-line arguments */
        if (args.length < 4) {
            System.out.println(
                "Usage: java CrnpClient crnpHost crnpPort "
                + "localPort (-ac | -ae | -re) "
                + "[(M | A | RG=name | R=name) [...]]");
            System.exit(1);
        }


        /*
```

```
         * We expect the command line to contain the ip/port of the
         * crnp server, the local port on which we should listen, and
         * arguments specifying the type of registration.
         */
        try {
            regIp = InetAddress.getByName(args[0]);
            regPort = (new Integer(args[1])).intValue();
            localPort = (new Integer(args[2])).intValue();
        } catch (UnknownHostException e) {
            System.out.println(e);
            System.exit(1);
        }

        // Create the CrnpClient
        CrnpClient client = new CrnpClient(regIp, regPort, localPort,
            args);

        // Now wait until the user wants to end the program
        System.out.println("Hit return to terminate demo...");

        // read will block until the user enters something
        try {
            System.in.read();
        } catch (IOException e) {
            System.out.println(e.toString());
        }

        // shutdown the client
        client.shutdown();
        System.exit(0);
    }

    /*
     * ======================
     * public methods
     * ======================
     */

    /*
     * CrnpClient constructor
     * -----------------------
     * Parses the command line arguments so we know how to contact
     * the crnp server, creates the event reception thread, and starts it
     * running, creates the XML DocumentBuilderFactory obect, and, finally,
     * registers for callbacks with the crnp server.
     */
    public CrnpClient(InetAddress regIpIn, int regPortIn, int localPortIn,
        String []clArgs)
    {
        try {

            regIp = regIpIn;
            regPort = regPortIn;
            localPort = localPortIn;
            regs = clArgs;
            /*
             * Setup the document builder factory for
             * xml processing.
             */
            setupXmlProcessing();

            /*
             * Create the EventReceptionThread, which creates a
             * ServerSocket and binds it to a local ip and port.
             */
            createEvtRecepThr();

            /*
             * Register with the crnp server.
             */
            registerCallbacks();

        } catch (Exception e) {
            System.out.println(e.toString());
            System.exit(1);
        }
    }

    /*
     * processEvent
     * ---------------
     * Callback into the CrnpClient, used by the EventReceptionThread
     * when it receives event callbacks.
     */
    public void processEvent(Event event)
    {
        /*
         * For demonstration purposes, simply print the event
         * to System.out.  A real application would obviously make
         * use of the event in some way.
         */
        event.print(System.out);
    }

    /*
     * shutdown
     * -------------
     * Unregister from the CRNP server.
     */
    public void shutdown()
    {
        try {
            /* send an unregistration message to the server */
            unregister();
        } catch (Exception e) {
            System.out.println(e);
            System.exit(1);
        }
    }
```

```
/*
 * ======================
 * private helper methods
 * ======================
 */

/*
 * setupXmlProcessing
 * --------------------
 * Create the document builder factory for
 * parsing the xml replies and events.
 */
private void setupXmlProcessing() throws Exception
{
    dbf = DocumentBuilderFactory.newInstance();

    // We don't need to bother validating
    dbf.setValidating(false);
    dbf.setExpandEntityReferences(false);

    // We want to ignore comments and whitespace
    dbf.setIgnoringComments(true);
    dbf.setIgnoringElementContentWhitespace(true);

    // Coalesce CDATA sections into TEXT nodes.
    dbf.setCoalescing(true);
}

/*
 * createEvtRecepThr
 * -------------------
 * Creates a new EventReceptionThread object, saves the ip
 * and port to which its listening socket is bound, and
 * starts the thread running.
 */
private void createEvtRecepThr() throws Exception
{
    /* create the thread object */
    evtThr = new EventReceptionThread(this);

    /*
     * Now start the thread running to begin listening
     * for event delivery callbacks.
     */
    evtThr.start();
}


/*
 * registerCallbacks
 * ------------------
 * Creates a socket connection to the crnp server and sends
 * an event registration message.
```

```
     */
    private void registerCallbacks() throws Exception
    {
        System.out.println("About to register");

        /*
         * Create a socket connected to the registration ip/port
         * of the crnp server and send the registration information.
         */
        Socket sock = new Socket(regIp, regPort);
        String xmlStr = createRegistrationString();
        PrintStream ps = new PrintStream(sock.getOutputStream());
        ps.print(xmlStr);

        /*
         * Read the reply
         */
        readRegistrationReply(sock.getInputStream());

        /*
         * Close the socket connection.
         */
        sock.close();
    }

    /*
     * unregister
     * ----------
     * As in registerCallbacks, we create a socket connection to
     * the crnp server, send the unregistration message, wait for
     * the reply from the server, then close the socket.
     */
    private void unregister() throws Exception
    {
        System.out.println("About to unregister");

        /*
         * Create a socket connected to the registration ip/port
         * of the crnp server and send the unregistration information.
         */
        Socket sock = new Socket(regIp, regPort);
        String xmlStr = createUnregistrationString();
        PrintStream ps = new PrintStream(sock.getOutputStream());
        ps.print(xmlStr);

        /*
         * Read the reply
         */
        readRegistrationReply(sock.getInputStream());

        /*
         * Close the socket connection.
         */
        sock.close();
    }
```

```
/*
 * createRegistrationString
 * ------------------
 * Constructs a CallbackReg object based on the command line arguments
 * to this program, then retrieves the XML string from the CallbackReg
 * object.
 */
private String createRegistrationString() throws Exception
{
    /*
     * create the actual CallbackReg class and set the port.
     */
    CallbackReg cbReg = new CallbackReg();
    cbReg.setPort("" + localPort);

    // set the registration type
    if (regs[3].equals("-ac")) {
        cbReg.setRegType(CallbackReg.ADD_CLIENT);
    } else if (regs[3].equals("-ae")) {
        cbReg.setRegType(CallbackReg.ADD_EVENTS);
    } else if (regs[3].equals("-re")) {
        cbReg.setRegType(CallbackReg.REMOVE_EVENTS);
    } else {
        System.out.println("Invalid reg type: " + regs[3]);
        System.exit(1);
    }

    // add the events
    for (int i = 4; i < regs.length; i++) {
        if (regs[i].equals("M")) {
            cbReg.addRegEvent(
                createMembershipEvent());
        } else if (regs[i].equals("A")) {
            cbReg.addRegEvent(
                createAllEvent());
        } else if (regs[i].substring(0,2).equals("RG")) {
            cbReg.addRegEvent(createRgEvent(
                regs[i].substring(3)));
        } else if (regs[i].substring(0,1).equals("R")) {
            cbReg.addRegEvent(createREvent(
                regs[i].substring(2)));
        }
    }

    String xmlStr = cbReg.convertToXml();
    System.out.println(xmlStr);
    return (xmlStr);
}

/*
 * createAllEvent
 * ----------------
 * Creates an XML registartion event with class EC_Cluster, and no
 * subclass.
```

```
     */
    private Event createAllEvent()
    {
        Event allEvent = new Event();
        allEvent.setClass("EC_Cluster");
        return (allEvent);
    }

    /*
     * createMembershipEvent
     * ---------------------
     * Creates an XML registration event with class EC_Cluster, subclass
     * ESC_cluster_memberhip.
     */
    private Event createMembershipEvent()
    {
        Event membershipEvent = new Event();
        membershipEvent.setClass("EC_Cluster");
        membershipEvent.setSubclass("ESC_cluster_membership");
        return (membershipEvent);
    }

    /*
     * createRgEvent
     * ----------------
     * Creates an XML registration event with class EC_Cluster,
     * subclass ESC_cluster_rg_state, and one "rg_name" nvpair (based
     * on input parameter).
     */
    private Event createRgEvent(String rgname)
    {
        /*
         * Create a Resource Group state change event for the
         * rgname Resource Group.  Note that we supply
         * a name/value pair (nvpair) for this event type, to
         * specify in which Resource Group we are interested.
         */
        /*
         * Construct the event object and set the class and subclass.
         */
        Event rgStateEvent = new Event();
        rgStateEvent.setClass("EC_Cluster");
        rgStateEvent.setSubclass("ESC_cluster_rg_state");

        /*
         * Create the nvpair object and add it to the Event.
         */
        NVPair rgNvpair = new NVPair();
        rgNvpair.setName("rg_name");
        rgNvpair.setValue(rgname);
        rgStateEvent.addNvpair(rgNvpair);

        return (rgStateEvent);
    }
```

```
/*
 * createREvent
 * ----------------
 * Creates an XML registration event with class EC_Cluster,
 * subclass ESC_cluster_r_state, and one "r_name" nvpair (based
 * on input parameter).
 */
private Event createREvent(String rname)
{
    /*
     * Create a Resource state change event for the
     * rgname Resource.  Note that we supply
     * a name/value pair (nvpair) for this event type, to
     * specify in which Resource Group we are interested.
     */
    Event rStateEvent = new Event();
    rStateEvent.setClass("EC_Cluster");
    rStateEvent.setSubclass("ESC_cluster_r_state");

    NVPair rNvpair = new NVPair();
    rNvpair.setName("r_name");
    rNvpair.setValue(rname);
    rStateEvent.addNvpair(rNvpair);

    return (rStateEvent);
}

/*
 * createUnregistrationString
 * ------------------
 * Constructs a REMOVE_CLIENT CallbackReg object, then retrieves
 * the XML string from the CallbackReg object.
 */
private String createUnregistrationString() throws Exception
{
    /*
     * Crate the CallbackReg object.
     */
    CallbackReg cbReg = new CallbackReg();
    cbReg.setPort("" + localPort);
    cbReg.setRegType(CallbackReg.REMOVE_CLIENT);

    /*
     * we marshall the registration to the OutputStream
     */
    String xmlStr = cbReg.convertToXml();

    // Print the string for debugging purposes
    System.out.println(xmlStr);
    return (xmlStr);
}


/*
 * readRegistrationReply
```

```
     * ------------------------
     * Parse the xml into a Document, construct a RegReply object
     * from the document, and print the RegReply object.  Note that
     * a real application would take action based on the status_code
     * of the RegReply object.
     */
    private void readRegistrationReply(InputStream stream)
        throws Exception
    {
        // Create the document builder
        DocumentBuilder db = dbf.newDocumentBuilder();

        //
        // Set an ErrorHandler before parsing
        // Use the default handler.
        //
        db.setErrorHandler(new DefaultHandler());

        //parse the input file
        Document doc = db.parse(stream);

        RegReply reply = new RegReply(doc);
        reply.print(System.out);
    }

    /* private member variables */
    private InetAddress regIp;
    private int regPort;
    private EventReceptionThread evtThr;
    private String regs[];

    /* public member variables */
    public int localPort;
    public DocumentBuilderFactory dbf;
}

/*
 * class EventReceptionThread
 * ----------------------------
 * See file header comments above.
 */
class EventReceptionThread extends Thread
{
    /*
     * EventReceptionThread constructor
     * ----------------------------------
     * Creates a new ServerSocket, bound to the local hostname and
     * a wildcard port.
     */
    public EventReceptionThread(CrnpClient clientIn) throws IOException
    {
        /*
         * keep a reference to the client so we can call it back
         * when we get an event.
         */
        client = clientIn;

        /*
         * Specify the IP to which we should bind.  It's
         * simply the local host ip.  If there is more
         * than one public interface configured on this
         * machine, we'll go with whichever one
         * InetAddress.getLocalHost comes up with.
         *
         */
        listeningSock = new ServerSocket(client.localPort, 50,
            InetAddress.getLocalHost());
            System.out.println(listeningSock);
    }

    /*
     * run
     * ---
     * Called by the Thread.Start method.
     *
     * Loops forever, waiting for incoming connections on the ServerSocket.
     *
     * As each incoming connection is accepted, an Event object
     * is created from the xml stream, which is then passed back to
     * the CrnpClient object for processing.
     */
    public void run()
    {
        /*
         * Loop forever.
         */
        try {
            //
            // Create the document builder using the document
            // builder factory in the CrnpClient.
            //
            DocumentBuilder db = client.dbf.newDocumentBuilder();

            //
            // Set an ErrorHandler before parsing
            // Use the default handler.
            //
            db.setErrorHandler(new DefaultHandler());

            while(true) {
                /* wait for a callback from the server */
                Socket sock = listeningSock.accept();

                // parse the input file
                Document doc = db.parse(sock.getInputStream());

                Event event = new Event(doc);
                client.processEvent(event);

                /* close the socket */
```

```
                sock.close();
            }
            // UNREACHABLE

        } catch (Exception e) {
            System.out.println(e);
            System.exit(1);
        }
    }

    /* private member variables */
    private ServerSocket listeningSock;
    private CrnpClient client;
}

/*
 * class NVPair
 * -----------
 * This class stores a name/value pair (both Strings).  It knows how to
 * construct an NVPAIR XML message from its members, and how to parse
 * an NVPAIR XML Element into its members.
 *
 * Note that the formal specification of an NVPAIR allows for multiple values.
 * We make the simplifying assumption of only one value.
 */
class NVPair
{
    /*
     * Two constructors: the first creates an empty NVPair, the second
     * creates an NVPair from an NVPAIR XML Element.
     */
    public NVPair()
    {
        name = value = null;
    }

    public NVPair(Element elem)
    {
        retrieveValues(elem);
    }

    /*
     * Public setters.
     */
    public void setName(String nameIn)
    {
        name = nameIn;
    }

    public void setValue(String valueIn)
    {
        value = valueIn;
    }

    /*
```

```
     * Prints the name and value on a single line.
     */
    public void print(PrintStream out)
    {
        out.println("NAME=" + name + " VALUE=" + value);
    }

    /*
     * createXmlElement
     * ------------------
     * Constructs an NVPAIR XML Element from the member variables.
     * Takes the Document as a parameter so that it can create the
     * Element.
     */
    public Element createXmlElement(Document doc)
    {
        // Create the element.
        Element nvpair = (Element)
            doc.createElement("NVPAIR");
        //
        // Add the name.  Note that the actual name is
        // a separate CDATA section.
        //
        Element eName = doc.createElement("NAME");
        Node nameData = doc.createCDATASection(name);
        eName.appendChild(nameData);
        nvpair.appendChild(eName);
        //
        // Add the value.  Note that the actual value is
        // a separate CDATA section.
        //
        Element eValue = doc.createElement("VALUE");
        Node valueData = doc.createCDATASection(value);
        eValue.appendChild(valueData);
        nvpair.appendChild(eValue);

        return (nvpair);
    }

    /*
     * retrieveValues
     * ----------------
     * Parse the XML Element to retrieve the name and value.
     */
    private void retrieveValues(Element elem)
    {
        Node n;
        NodeList nl;

        //
        // Find the NAME element
        //
        nl = elem.getElementsByTagName("NAME");
        if (nl.getLength() != 1) {
            System.out.println("Error in parsing: can't find "
                + "NAME node.");
            return;
        }

        //
        // Get the TEXT section
        //
        n = nl.item(0).getFirstChild();
        if (n == null || n.getNodeType() != Node.TEXT_NODE) {
            System.out.println("Error in parsing: can't find "
                + "TEXT section.");
            return;
        }

        // Retrieve the value
        name = n.getNodeValue();

        //
        // Now get the value element
        //
        nl = elem.getElementsByTagName("VALUE");
        if (nl.getLength() != 1) {
            System.out.println("Error in parsing: can't find "
                + "VALUE node.");
            return;
        }

        //
        // Get the TEXT section
        //
        n = nl.item(0).getFirstChild();
        if (n == null || n.getNodeType() != Node.TEXT_NODE) {
            System.out.println("Error in parsing: can't find "
                + "TEXT section.");
            return;
        }

        // Retrieve the value
        value = n.getNodeValue();
    }


    /*
     * Public accessors
     */
    public String getName()
    {
        return (name);
    }

    public String getValue()
    {
        return (value);
    }
    // Private member vars
    private String name, value;
}


/*
 * class Event
 * -----------
 * This class stores an event, which consists of a class, subclass, vendor,
 * publisher, and list of name/value pairs.  It knows how to
 * construct an SC_EVENT_REG XML Element from its members, and how to parse
 * an SC_EVENT XML Element into its members.  Note that there is an assymetry
 * here: we parse SC_EVENT elements, but construct SC_EVENT_REG elements.
 * That is because SC_EVENT_REG elements are used in registration messages
 * (which we must construct), while SC_EVENT elements are used in event
 * deliveries (which we must parse).  The only difference is that SC_EVENT_REG
 * elements don't have a vendor or publisher.
 */
class Event
{

    /*
     * Two constructors: the first creates an empty Event; the second
     * creates an Event from an SC_EVENT XML Document.
     */
    public Event()
    {
        regClass = regSubclass = null;
        nvpairs = new Vector();
    }

    public Event(Document doc)
    {

        nvpairs = new Vector();

        //
        // Convert the document to a string to print for debugging
        // purposes.
        //
        DOMSource domSource = new DOMSource(doc);
        StringWriter strWrite = new StringWriter();
        StreamResult streamResult = new StreamResult(strWrite);
        TransformerFactory tf = TransformerFactory.newInstance();
        try {
            Transformer transformer = tf.newTransformer();
            transformer.transform(domSource, streamResult);
        } catch (TransformerException e) {
            System.out.println(e.toString());
            return;
        }
        System.out.println(strWrite.toString());

        // Do the actual parsing.
        retrieveValues(doc);
    }

    /*
     * Public setters.
     */
    public void setClass(String classIn)
    {
        regClass = classIn;
    }

    public void setSubclass(String subclassIn)
    {
        regSubclass = subclassIn;
    }

    public void addNvpair(NVPair nvpair)
    {
        nvpairs.add(nvpair);
    }

    /*
     * createXmlElement
     * ------------------
     * Constructs an SC_EVENT_REG XML Element from the member variables.
     * Takes the Document as a parameter so that it can create the
     * Element.  Relies on the NVPair createXmlElement ability.
     */
    public Element createXmlElement(Document doc)
    {
        Element event = (Element)
            doc.createElement("SC_EVENT_REG");
        event.setAttribute("CLASS", regClass);
        if (regSubclass != null) {
            event.setAttribute("SUBCLASS", regSubclass);
        }
        for (int i = 0; i < nvpairs.size(); i++) {
            NVPair tempNv = (NVPair)
                (nvpairs.elementAt(i));
            event.appendChild(tempNv.createXmlElement(
                doc));
        }
        return (event);
    }

    /*
     * Prints the member vars on multiple lines.
     */
    public void print(PrintStream out)
    {
        out.println("\tCLASS=" + regClass);
        out.println("\tSUBCLASS=" + regSubclass);
        out.println("\tVENDOR=" + vendor);
        out.println("\tPUBLISHER=" + publisher);
        for (int i = 0; i < nvpairs.size(); i++) {
            NVPair tempNv = (NVPair)
                (nvpairs.elementAt(i));
            out.print("\t\t");
            tempNv.print(out);
        }
    }

     /*
     * retrieveValues
     * ----------------
     * Parse the XML Document to retrieve the class, subclass, vendor,
     * publisher, and nvpairs.
     */
    private void retrieveValues(Document doc)
    {
        Node n;
        NodeList nl;

        //
        // Find the SC_EVENT element.
        //
        nl = doc.getElementsByTagName("SC_EVENT");
        if (nl.getLength() != 1) {
            System.out.println("Error in parsing: can't find "
                + "SC_EVENT node.");
            return;
        }

        n = nl.item(0);

        //
        // Retrieve the values of the CLASS, SUBCLASS,
        // VENDOR and PUBLISHER attributes.
        //
        regClass = ((Element)n).getAttribute("CLASS");
        regSubclass = ((Element)n).getAttribute("SUBCLASS");
        publisher = ((Element)n).getAttribute("PUBLISHER");
        vendor = ((Element)n).getAttribute("VENDOR");

        //
        // Retrieve all the nv pairs
        //
        for (Node child = n.getFirstChild(); child != null;
             child = child.getNextSibling())
        {
            nvpairs.add(new NVPair((Element)child));
        }
    }

    /*
     * Public accessor methods.
     */
    public String getRegClass()
    {
        return (regClass);
    }
```

```
    public String getSubclass()
    {
        return (regSubclass);
    }

    public String getVendor()
    {
        return (vendor);
    }

    public String getPublisher()
    {
        return (publisher);
    }

    public Vector getNvpairs()
    {
        return (nvpairs);
    }

    // Private member vars.
    private String regClass, regSubclass;
    private Vector nvpairs;
    private String vendor, publisher;
}


/*
 * class CallbackReg
 * -----------
 * This class stores a port and regType (both Strings), and a list of Events.
 * It knows how to construct an SC_CALLBACK_REG XML message from its members.
 *
 * Note that this class does not need to be able to parse SC_CALLBACK_REG
 * messages, because only the CRNP server must parse SC_CALLBACK_REG
 * messages.
 */
class CallbackReg
{
    // Useful defines for the setRegType method
    public static final int ADD_CLIENT = 0;
    public static final int ADD_EVENTS = 1;
    public static final int REMOVE_EVENTS = 2;
    public static final int REMOVE_CLIENT = 3;

    public CallbackReg()
    {
        port = null;
        regType = null;
        regEvents = new Vector();
    }

    /*
     * Public setters.
     */
    public void setPort(String portIn)
    {
        port = portIn;
    }

    public void setRegType(int regTypeIn)
    {
        switch (regTypeIn) {
        case ADD_CLIENT:
            regType = "ADD_CLIENT";
            break;
        case ADD_EVENTS:
            regType = "ADD_EVENTS";
            break;
        case REMOVE_CLIENT:
            regType = "REMOVE_CLIENT";
            break;
        case REMOVE_EVENTS:
            regType = "REMOVE_EVENTS";
            break;
        default:
            System.out.println("Error, invalid regType " +
                regTypeIn);
            regType = "ADD_CLIENT";
            break;
        }
    }

    public void addRegEvent(Event regEvent)
    {
        regEvents.add(regEvent);
    }


    /*
     * convertToXml
     * ------------------
     * Constructs an SC_CALLBACK_REG XML Document from the member
     * variables.  Relies on the Event createXmlElement ability.
     */
    public String convertToXml()
    {
        Document document = null;
        DocumentBuilderFactory factory =
            DocumentBuilderFactory.newInstance();
        try {
            DocumentBuilder builder = factory.newDocumentBuilder();
            document = builder.newDocument();
        } catch (ParserConfigurationException pce) {
            // Parser with specified options can't be built
            pce.printStackTrace();
            System.exit(1);
        }
        Element root = (Element) document.createElement(
            "SC_CALLBACK_REG");
        root.setAttribute("VERSION", "1.0");
        root.setAttribute("PORT", port);
        root.setAttribute("REG_TYPE", regType);
        for (int i = 0; i < regEvents.size(); i++) {
            Event tempEvent = (Event)
                (regEvents.elementAt(i));
            root.appendChild(tempEvent.createXmlElement(
                document));
        }
        document.appendChild(root);

        //
        // Now convert the document to a string.
        //
        DOMSource domSource = new DOMSource(document);
        StringWriter strWrite = new StringWriter();
        StreamResult streamResult = new StreamResult(strWrite);
        TransformerFactory tf = TransformerFactory.newInstance();
        try {
            Transformer transformer = tf.newTransformer();
            transformer.transform(domSource, streamResult);
        } catch (TransformerException e) {
            System.out.println(e.toString());
            return ("");
        }
        return (strWrite.toString());
    }

    // private member vars
    private String port;
    private String regType;
    private Vector regEvents;
}

/*
 * class RegReply
 * -----------
 * This class stores a status_code and status_msg (both Strings).
 * It knows how to parse an SC_REPLY XML Element into its members.
 */
class RegReply
{

    /*
     * The only constructor takes an XML Document and parses it.
     */
    public RegReply(Document doc)
    {
        //
        // Now convert the document to a string.
        //
        DOMSource domSource = new DOMSource(doc);
        StringWriter strWrite = new StringWriter();
        StreamResult streamResult = new StreamResult(strWrite);
        TransformerFactory tf = TransformerFactory.newInstance();
        try {
            Transformer transformer = tf.newTransformer();
            transformer.transform(domSource, streamResult);
        } catch (TransformerException e) {
            System.out.println(e.toString());
            return;
        }
        System.out.println(strWrite.toString());

        retrieveValues(doc);
    }

    /*
     * Public accessors
     */
    public String getStatusCode()
    {
        return (statusCode);
    }

    public String getStatusMsg()
    {
        return (statusMsg);
    }

    /*
     * Prints the info on a single line.
     */
    public void print(PrintStream out)
    {
        out.println(statusCode + ": " +
            (statusMsg != null ? statusMsg : ""));
    }

     /*
     * retrieveValues
     * ----------------
     * Parse the XML Document to retrieve the statusCode and statusMsg.
     */
    private void retrieveValues(Document doc)
    {
        Node n;
        NodeList nl;

        //
        // Find the SC_REPLY element.
        //
        nl = doc.getElementsByTagName("SC_REPLY");
        if (nl.getLength() != 1) {
            System.out.println("Error in parsing: can't find "
                + "SC_REPLY node.");
            return;
        }
```

```
        n = nl.item(0);

        // Retrieve the value of the STATUS_CODE attribute
        statusCode = ((Element)n).getAttribute("STATUS_CODE");

        //
        // Find the SC_STATUS_MSG element
        //
        nl = ((Element)n).getElementsByTagName("SC_STATUS_MSG");
        if (nl.getLength() != 1) {
            System.out.println("Error in parsing: can't find "
                + "SC_STATUS_MSG node.");
            return;
        }

        //
        // Get the TEXT section, if there is one.
        //
        n = nl.item(0).getFirstChild();
        if (n == null || n.getNodeType() != Node.TEXT_NODE) {
            // Not an error if there isn't one, so we
            // just silently return.
            return;
        }

        // Retrieve the value
        statusMsg = n.getNodeValue();
    }

    // private member vars
    private String statusCode;
    private String statusMsg;
}
```

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