Sun Java™ System

Directory Server 5.2 Administration Guide

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Contents

Preface

The *Directory Server Administration Guide* describes the procedures you need to configure and maintain a directory service based on Directory Server. It includes the procedures for configuring all Directory Server features from the console and from the command line when appropriate.

This preface contains the following sections:

- Who Should Read This Guide
- How This Guide Is Organized
- Using the Documentation
- Conventions
- Resources and Tools on the Web
- How to Report Problems
- Sun Welcomes Your Comments

Before performing any of the tasks described in this guide, read the *Directory Server Release Notes*.

Who Should Read This Guide

This guide is intended for directory administrators.

The author of this guide assumes you are familiar with the following:

- Specifications for LDAP and related protocols
- Clustering model (if you are using Directory Server with Sun Cluster software)
- Internet and World Wide Web technologies

How This Guide Is Organized

This guide is divided into the following chapters:

- Directory Server Administration Overview

  Provides overview information about Directory Server, and the most basic tasks you need to start administering a directory service using the console.

- Managing Directory Entries

  Discusses how to use Directory Server Console and the LDAP command-line utilities to manage the contents of your directory. It also describes how attributes are stored with the optional attribute encryption feature, and how to access your directory using DSML.

- Creating Your Directory Tree

  Describes the directory tree, and its administration in terms of suffixes, subsuffixes, and chained suffixes. This chapter also outlines creating and administering directory tree elements using Directory Server Console and the command-line tools.

- Backing Up and Restoring Data

  Outlines the tools provided for importing directory data in bulk, importing and exporting entire suffixes, making backups of all suffixes at once and restoring data from a backup.

- Managing Identity and Roles

  Explains the advanced entry management functionality provided by groups, roles and class of service (CoS.)

- Managing Access Control

  Describes access control instructions (ACIs) that determine what permissions are granted to users who access the directory.

- Managing User Accounts and Passwords

  Outlines the tasks for user account management, including configuring password and account lockout policies, inactivating accounts or groups of users, and limiting system resources available to users.

- Managing Replication

  Describes the tasks to be performed to set up various replication scenarios, including steps for configuring replication, replication over WAN and SSL, monitoring replication status, and solving replication conflicts.

- Extending the Directory Schema

  Discusses how to extend the schema when the default directory schema is insufficient for your requirements.

- Indexing Directory Data

  Provides an overview of indexing functionality and describes how the various kinds of indexes are managed.

- Managing Authentication and Encryption

  Provides an overview of the security mechanims available with Directory Server, and describes how each of these methods can be implemented and configured.

- Implementing Pass-Through Authentication

  Describes how you can use pass-through authentication to administer user and configuration directories on separate instances of Directory Server.

- Monitoring Directory Server Using Log Files

  Describes how to monitor Directory Server by configuring a logging policy and analyzing the status information maintained by the server.

- Monitoring Directory Server Using SNMP

  Describes the Directory Server subagent that enables the server to be monitored by an SNMP manager application.

- Enforcing Attribute Value Uniqueness

  Describes the use of the UID uniqueness plug-in to ensure that the value of a given attribute is unique among all entries of the directory or of a subtree.

- Troubleshooting Directory Server

  Provides basic troubleshooting information on installing Directory Server.

- Using the Sun Crypto Accelerator Board

  Provides instructions on using a Sun Crypto Accelerator board with Directory Server to enhance performance for connections using the Secure Sockets Layer (SSL) protocol with certificate-based authentication.

- Third Party Licence Acknowledgements

  Provides the copyright notices of all third party elements of the software.

Using the Documentation

The Directory Server manuals are available as online files in Portable Document Format (PDF) and Hypertext Markup Language (HTML) formats. Both formats are readable by assistive technologies for users with disabilities. The Sun™ documentation web site can be accessed here:

`http://docs.sun.com`

The Directory Server documentation set can be accessed here:

`http://docs.sun.com/coll/DirectoryServer_04q2`

Table 1 briefly describes each document in the set. The left column provides the name and Web location of each document. The right column describes the general contents of the document.

Table 1 Directory Server Documentation

Document	Contents
Directory Server Release Notes `http://docs.sun.com/doc/817-5216`	Contains the latest information about Directory Server, including known problems.
Directory Server Technical Overview `http://docs.sun.com/doc/817-5217`	Provides a quick look at many key features of Directory Server.
Directory Server Deployment Planning Guide `http://docs.sun.com/doc/817-5218`	Explains how to plan directory topology, data structure, security, and monitoring, and discusses example deployments.

Table 1 Directory Server Documentation *(Continued)*

Document	Contents
Directory Server Installation and Migration Guide `http://docs.sun.com/doc/817-5219`	Covers update, upgrade, and data migration procedures for moving to the latest version of Directory Server.
Directory Server Performance Tuning Guide `http://docs.sun.com/doc/817-5220`	Provides tips and explanations you can use to optimize Directory Server performance.
Directory Server Administration Guide `http://docs.sun.com/doc/817-5221`	Gives the procedures for using the console and command-line to manage your directory contents and configure every feature of Directory Server.
Directory Server Administration Reference `http://docs.sun.com/doc/817-5235`	Details the Directory Server configuration parameters, commands, files, error messages, and schema.
Directory Server Plug-In Developer's Guide `http://docs.sun.com/doc/817-5222`	Demonstrates how to develop Directory Server plug-ins.
Directory Server Plug-In Developer's Reference `http://docs.sun.com/doc/817-5223`	Details the data structures and functions of the Directory Server plug-in API.

Conventions

Table 2 describes the typeface conventions used in this guide.

Table 2 Typeface Conventions

Typeface	Meaning	Examples
`AaBbCc123` (Monospace)	API and language elements, HTML tags, web site URLs, command names, file names, directory path names, on-screen computer output, sample code.	Edit your `.login` file. Use `ls -a` to list all files. `% You have mail.`
`AaBbCc123` (Monospace bold)	What you type, as contrasted with on-screen computer output.	`%` **`su`** `Password:`
AaBbCc123 (Italic)	Book titles.	Read Chapter 6 in the *Developer's Guide*.
	New words or terms.	These are called *class* options.
	Words to be emphasized.	You *must* be superuser to do this.
	Command-line variables to be replaced by real names or values.	The file is located in the *ServerRoot* directory.

Table 3 describes placeholder conventions used in this guide.

Table 3 Placeholder Conventions

Item	Meaning	Examples
install-dir	Placeholder for the directory prefix under which software binaries reside after installation.	The default *install-dir* prefix on Solaris systems is `/`. The default *install-dir* prefix on Red Hat systems is `/opt/sun`.
ServerRoot	Placeholder for the directory where server instances and data reside. You can manage each server under a *ServerRoot* remotely through your client-side Server Console. The Server Console uses the server-side Administration Server to perform tasks that must execute directly on the server-side system.	The default *ServerRoot* directory is `/var/opt/mps/serverroot`.
`slapd-`*serverID*	Placeholder for the directory where a specific server instance resides under the *ServerRoot* and its associated data resides by default.	The default *serverID* is the host name.

Table 4 describes the symbol conventions used in this book.

Table 4 Symbol Conventions

Symbol	Meaning	Notation	Example
`[ ]`	Contain optional command options.	`O[`*n*`]`	`-O4, -O`
`{ }`	Contain a set of choices for a required command option.	`d{y|n}`	`-dy`
|	Separates command option choices.		
+	Joins simultaneous keystrokes in keyboard shortcuts that are used in a graphical user interface.		Ctrl+A
-	Joins consecutive keystrokes in keyboard shortcuts that are used in a graphical user interface.		Esc-S
>	Indicates menu selection in a graphical user interface.		File > New File > New > Templates

Table 5 describes the shell prompt conventions used in this book.

Table 5 Shell Prompts

Shell	Prompt
C shell	*machine-name*%
C shell superuser	*machine-name*#
Bourne shell and Korn shell	$
Bourne shell and Korn shell superuser	#

Input and output of Directory Server commands are usually expressed using the LDAP Data Interchange Format (LDIF) [RFC 2849] . Lines are wrapped for readability.

Resources and Tools on the Web

The following location contains information about Java Enterprise System and its component products such as Directory Server:

`http://wwws.sun.com/software/learnabout/enterprisesystem/index.html`

Some supported platforms provide native tools for accessing Directory Server. For more tools useful when testing and maintaining LDAP directory servers, download the Sun Java System Directory Server Resource Kit (DSRK). This software is available at the following location:

`http://wwws.sun.com/software/download/`

Installation instructions and reference documentation for the DSRK tools is available in the *Directory Server Resource Kit Tools Reference*.

For developing directory client applications, you may also download the Sun Java System Directory SDK for C and the Sun Java System Directory SDK for Java from the same location.

Additionally, Java Naming and Directory Interface (JNDI) technology supports accessing Directory Server using LDAP and DSML v2 from Java applications. Information about JNDI is available from:

`http://java.sun.com/products/jndi/`

The JNDI Tutorial contains detailed descriptions and examples of how to use JNDI. It is available at:

http://java.sun.com/products/jndi/tutorial/

Third-party URLs are included in this document to provide additional, related information.

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How to Report Problems

If you have problems with Directory Server, contact Sun customer support using one of the following mechanisms:

- Sun Software Support services online at

  http://www.sun.com/service/sunone/software

  This site has links to the Online Support Center and ProductTracker, as well as to maintenance programs and support contact numbers.

- The SunSolve support website at

  http://sunsolve.sun.com

  This site includes patches, support documents, security information, and the Sun System Handbook.

- The telephone dispatch number associated with your maintenance contract

So that we can best assist you in resolving problems, please have the following information available when you contact support:

- Description of the problem, including the situation where the problem occurs and its impact on your operation
- Machine type, operating system version, and product version, including any patches and other software that might be affecting the problem

- Detailed steps on the methods you have used to reproduce the problem
- Any error logs or core dumps

Sun Welcomes Your Comments

Sun is interested in improving its documentation and welcomes your comments and suggestions. Use the web-based form to provide feedback to Sun:

`http://www.sun.com/hwdocs/feedback/`

Please provide the full document title and part number in the appropriate fields. The part number is a seven-digit or nine-digit number that can be found on the title page of the book or at the top of the document. For example, the part number of this Administration Guide is 817-5221-05.

Chapter 1

Directory Server Administration Overview

The Directory Server product includes a Directory Server, an Administration Server to manage multiple directories, and a Server Console to manage both servers through a graphical interface. This chapter provides overview information about Directory Server, and the most basic tasks you need to start administering a directory service.

Two new features of Directory Server 5.2 covered in this chapter are plug-in signatures and the DSML-over-HTTP protocol. Verifying plug-in signatures is an additional security feature that allows the server to detect or prevent unauthorized plug-ins from being loaded. Directory Server Markup Language (DSML) is a new XML-based format for sending requests to a directory server.

This chapter includes the following sections:

- Overview of Directory Server Management
- Starting and Stopping Directory Server
- Starting the Server with SSL Enabled
- Using Directory Server Console
- Configuring LDAP Parameters
- Verifying Plug-In Signatures
- Configuring DSML

NOTE If you are running more than one version of Directory Server, note that all examples in this chapter assume that Directory Server 5.2 is the default version. If this is not the case, you must either run the following command once to set 5.2 as the default version:

```
# /usr/sbin/directoryserver -d 5.2
```

or include the `-useversion` option each time you run the `directoryserver` command to specify the version, for example:

```
# /usr/sbin/directoryserver -useversion 5.2 start
```

Overview of Directory Server Management

Directory Server is a robust, scalable server designed to manage an enterprise-wide directory of users and resources. It is based on an open-systems server protocol called the Lightweight Directory Access Protocol (LDAP). Directory Server runs as the `ns-slapd` process or service on your machine. The server manages the directory contents and responds to client requests.

You perform most Directory Server administrative tasks through the Administration Server, a second server that Sun Java System provides to help you manage Directory Server (and several other Sun Java System servers). Server Console is the graphical interface to the Administration Server. *Directory Server Console* is a part of Server Console designed specifically for use with Directory Server.

You can perform most Directory Server administrative tasks from Directory Server Console. You can also perform administrative tasks manually by editing the configuration files or by using command-line utilities. For more information about Server Console see the *Administration Server Administration Guide*.

NOTE If you are using the Sun Cluster HA for Directory Server data service, you must use the `directoryserver`(1M) command and its subcommands when administering Directory Server and from the command line.

Do not use the standalone scripts and binaries directly.

Starting and Stopping Directory Server

If you are not using Secure Sockets Layer (SSL), you can start and stop Directory Server using the methods listed here. If you are using SSL, see "Starting the Server with SSL Enabled" on page 26.

Starting and Stopping the Server From the Command Line

To start or stop the server from the command line. Run the following commands:

```
# /usr/sbin/directoryserver -useversion 5.2 start
```

or

```
# /usr/sbin/directoryserver -useversion 5.2 stop
```

The `useversion` option is required only if Directory Server 5.2 is not the default version. For the complete syntax of the `directoryserver` command, refer to Chapter 1, "Command-Line Tools Reference," in the *Directory Server Administration Reference*.

These commands must be run as root if:

- you specified root as the UID for Directory Server
- you are using a port < 1024 (which requires privileged access)

Otherwise, both commands must run with the same UID and GID as Directory Server. For example, if Directory Server runs as `nobody`, you must run the `start` and `stop` utilities as `nobody`.

For users of previous versions of Directory Server, note that starting the server in referral mode is no longer available.You can set global referrals using Directory Server Console. This procedure is explained in "Setting the Default Referrals" on page 80.

Starting and Stopping the Server From the Console

When Directory Server Console is running, you can start, stop, and restart Directory Server through its graphical interface. For instructions on running the console, see "Starting Directory Server Console" on page 27.

1. On the top-level Tasks tab of Directory Server Console, click the button beside "Start Directory Server", "Stop Directory Server", or "Restart Directory Server," as appropriate.

When you successfully start or stop Directory Server from Directory Server Console, the console displays a message dialog stating that the server has been either started or shut down. In case of an error, the console will show all messages pertaining to the error.

Starting the Server with SSL Enabled

Before enabling SSL, you must install and configure certificates on your server. For instructions on managing certificates and enabling SSL, see Chapter 11, "Managing Authentication and Encryption." For information on certificates, certificate databases, and obtaining a server certificate, see Chapter 9, "Using SSL and TLS with Sun Java System Servers," in the *Administration Server Administration Guide*.

To start the server with SSL enabled, you must start the server from the command line and provide the password which protects the server's certificates.

Alternatively, you can create a password file to store your certificate password. By placing your certificate database password in a file, you can start your server from the server console, and also allow the server to restart automatically when running unattended.

CAUTION This password is stored in clear text within the password file, so its usage represents a significant security risk. Do not use a password file if your server is running in an unsecured environment.

The password file must be placed in the following location:

ServerRoot`/alias/slapd-`*serverID*`-pin.txt`

where *serverID* is the identifier you specified for the server when you installed it.

Include the name of the security token and its password in the file as follows:

deviceName `Token:`*password*

The device name for the internal certificate database is shown in this example (capitalization and spacing must be exactly as shown):

`Internal (Software) Token:` *password*

If you store certificates in an alternate device, use the name of the device that appears in the drop-down menu at the top of the Manage Certificates Dialog. To create certificate databases, you must use the administration server and the Certificate Setup Wizard. For information on using SSL with Directory Server, see Chapter 11, "Managing Authentication and Encryption."

Using Directory Server Console

Directory Server Console is an interface that you access as a separate window of Server Console. You start Directory Server Console from Server Console, as described in the following procedure.

Starting Directory Server Console

1. Check that the Directory Server daemon, `slapd-`*serverID* is running. If it is not, as root or administrative user, enter the following command to start it:

   ```
   # /usr/sbin/directoryserver -useversion 5.2 start
   ```

2. Check that the administration server daemon, `ns-httpd`, is running. If it is not, as root or administrative user, enter the following command to start it:

   ```
   # /usr/sbin/directoryserver -useversion 5.2 start-admin
   ```

3. Start Server Console by entering the following command:

   ```
   # /usr/sbin/directoryserver -useversion 5.2 startconsole
   ```

   If you are running Server Console on a machine other than the one on which Administration Server is installed, you may need to configure the connection restrictions on the Administration Server, as described in "Network Settings" in Chapter 6 of the *Administration Server Administration Guide*.

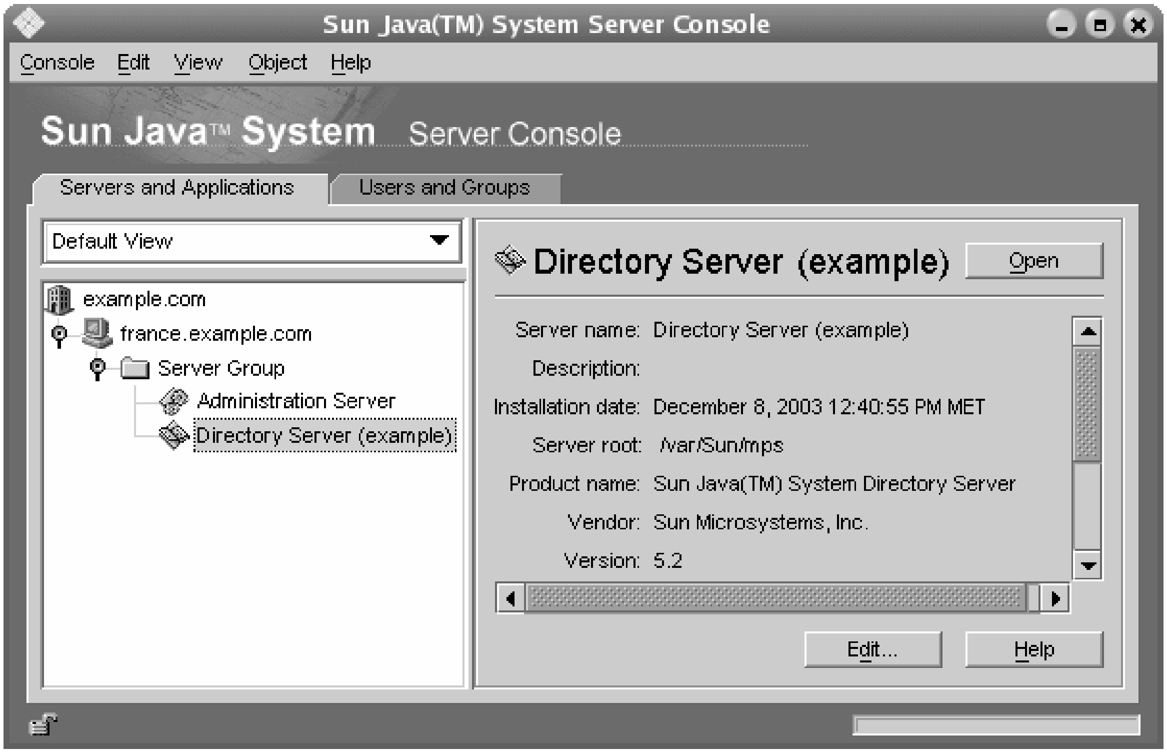
   The Console login window is displayed. Or, if your configuration directory (the directory that contains the `o=NetscapeRoot` suffix) is stored in a separate instance of Directory Server, a window is displayed requesting the administrator user DN, password, and the URL of the Administration Server for that directory server.

4. Log in using the bind DN and password of a user with sufficient access permissions for the operations you want to perform.

   Server Console is displayed.

5. Navigate through the tree in the left-hand panel to find the machine hosting your Directory Server and click on its name or icon to display its general properties.

Figure 1-1 Sun Java System Server Console


Sun Java(TM) System Server Console
Console Edit View Object Help
Sun Java™ System Server Console
Servers and Applications
Users and Groups
Default View
example.com
france.example.com
Server Group
Administration Server
Directory Server (example)
Directory Server (example)
Open
Edit...
Help

Server name: Directory Server (example)
Description:
Installation date: December 8, 2003 12:40:55 PM MET
Server root: /var/Sun/mps
Product name: Sun Java(TM) System Directory Server
Vendor: Sun Microsystems, Inc.
Version: 5.2

To edit the name and description of your Directory Server, click the Edit button. Enter the new name and description in the text boxes. Click OK to set the new name and description. The name will appear in the tree on the left, as shown in the previous figure.

6. Double-click the name of your Directory Server in the tree or click the Open button to display the Directory Server Console for managing this directory server.

Navigating Directory Server Console

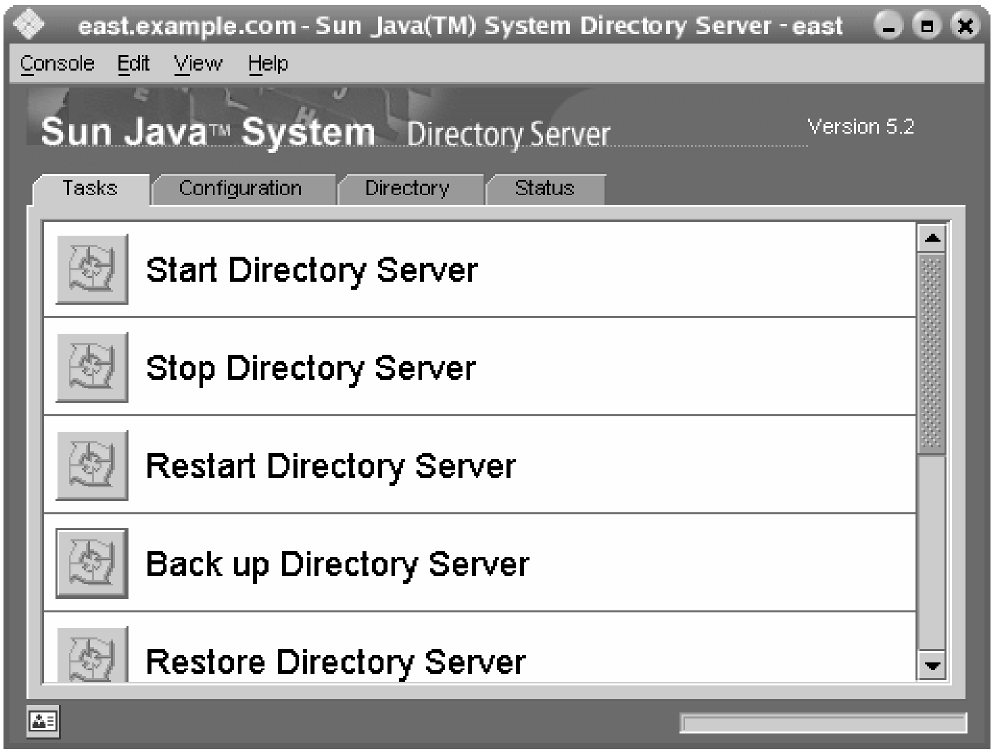
Directory Server Console provides the interface for browsing and performing administration operations on your Directory Server instance. It always displays four tabs from which you can access all Directory Server functionality:

- Tasks Tab - Contains buttons for administrative tasks such as restarting the server.
- Configuration Tab - Provides access to all parameters for managing the server.
- Directory Tab - Displays and edits the data entries contained in the directory.
- Status Tab - Displays the statistics, logs and replication status of the server.

Tasks Tab

The Tasks tab is the first interface visible when opening Directory Server Console. It contains buttons for all of the major administrative tasks such as starting or stopping Directory Server as shown in the following figure. To view all of the tasks and their buttons, you may need to scroll through the list.

Figure 1-2 Tasks Tab of Directory Server Console



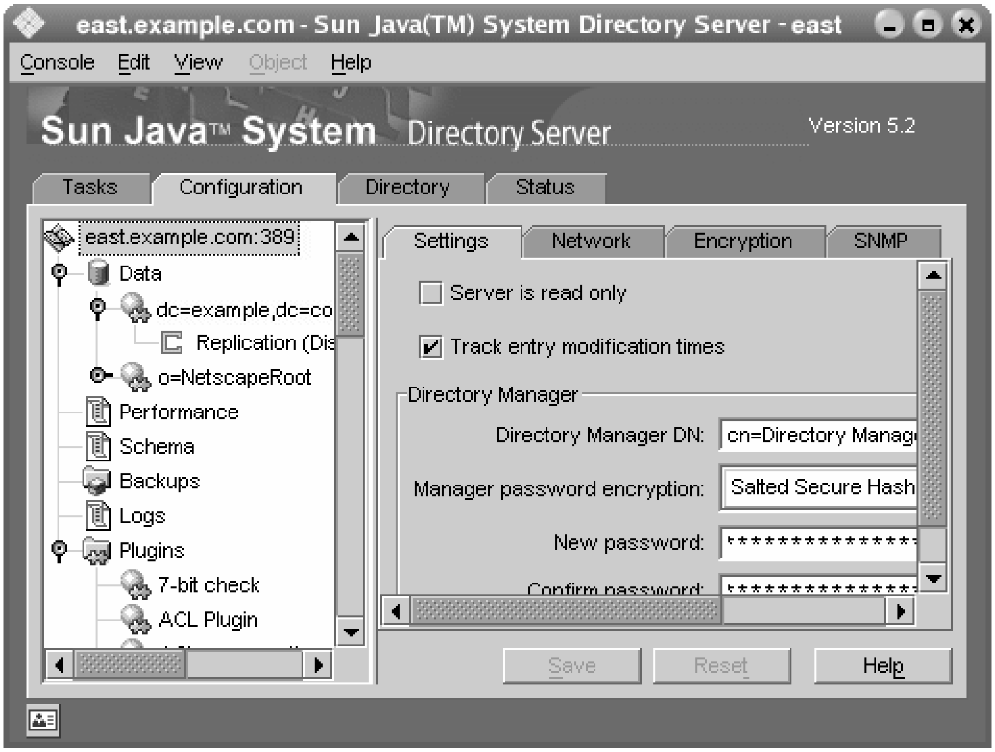
You must be logged in as a user with administrator rights in order to perform these tasks. The task buttons will not be visible to users with insufficient rights.

Configuration Tab

The Configuration tab of Directory Server Console provides interfaces and dialogs to view and modify all directory settings such as those for suffixes, replication, schema, logs, and plug-ins. These dialogs are only available or will only take effect if you are logged in as a user with administrator rights.

The left side of this tab contains a tree of all configuration functions and the right-hand side displays the interface specific to managing each function. These interfaces often contain other tabs, dialogs or pop-up windows. For example, the following figure shows the general settings for the entire directory.

Figure 1-3 Configuration Tab of Directory Server Console



☐ Server is read only

☑ Track entry modification times

Directory Manager

Directory Manager DN:	cn=Directory Manag
Manager password encryption:	Salted Secure Hash
New password:	***************
Confirm password:	***************

When you select a configurable item in the left-hand tree, the current settings for that item will appear in one or more tabs in the right-hand panel. For the explanation and behavior of these settings, please refer to the chapter in this guide that describes each functionality. Depending on the setting, some changes will take effect immediately when saved, and others not until the server is restarted. The console will display a dialog informing you when the server needs to be restarted.

Unsaved changes in a tab are signalled by a red mark next to the tab name. Unsaved changes will remain on the tab even if you configure another item or view one of the other major tabs. The Save and Reset buttons apply to all tabs of a given configurable item, but do not affect the unsaved settings of other items.

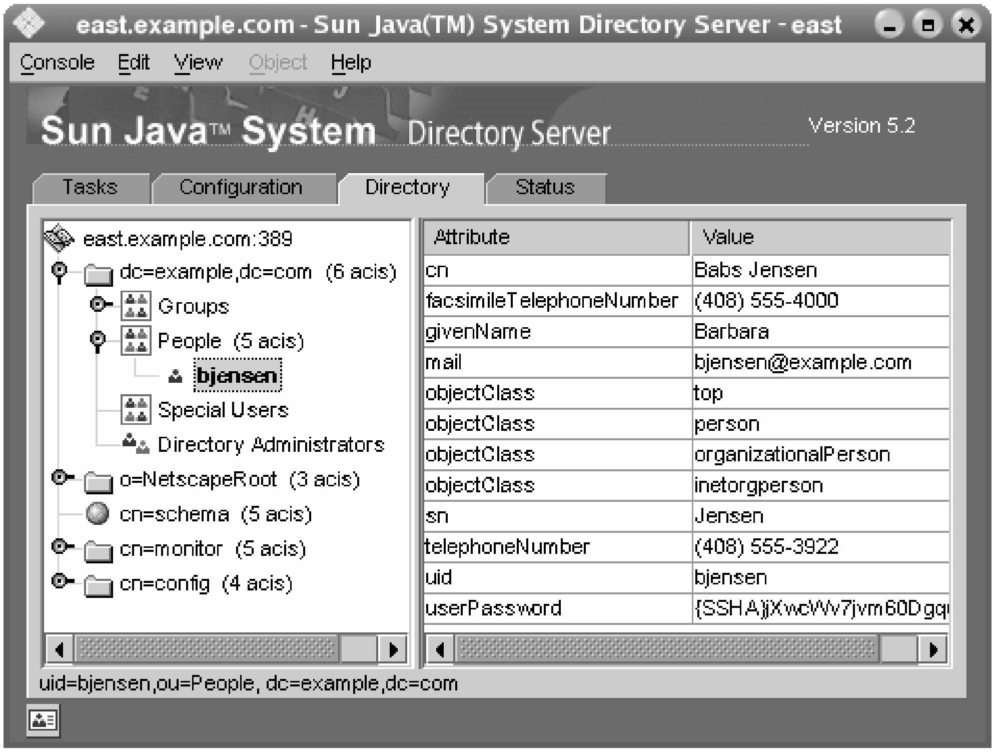
Most text fields will only allow you to enter values that have the correct syntax for the setting. By default, the label of the setting and the value that you type will be highlighted in red until its syntax is correct. The Save button will be disabled until all settings have valid syntax. You may choose italic font for highlighting incorrect values, as described in "Visual Configuration Preferences" on page 36.

Directory Tab

The Directory Tab of the console displays the directory entries as a tree for easy navigation. In this tab, all entries and the attributes they contain can be browsed, displayed and edited.

NOTE If you plan to browse lists of thousands of entries, create browsing indexes for faster access. Refer to "Browsing Indexes for the Console" on page 385 for instructions.

Figure 1-4 Directory Tab of the Directory Server Console


east.example.com - Sun Java(TM) System Directory Server - east
Console Edit View Object Help
Sun Java™ System Directory Server
Version 5.2
Tasks Configuration Directory Status

east.example.com:389
- dc=example,dc=com (6 acis)
  - Groups
  - People (5 acis)
    - bjensen
  - Special Users
  - Directory Administrators
- o=NetscapeRoot (3 acis)
- cn=schema (5 acis)
- cn=monitor (5 acis)
- cn=config (4 acis)

Attribute	Value
cn	Babs Jensen
facsimileTelephoneNumber	(408) 555-4000
givenName	Barbara
mail	bjensen@example.com
objectClass	top
objectClass	person
objectClass	organizationalPerson
objectClass	inetorgperson
sn	Jensen
telephoneNumber	(408) 555-3922
uid	bjensen
userPassword	{SSHA}jXwcWv7jvm60Dgq

uid=bjensen,ou=People, dc=example,dc=com

If the bind DN given during the login has sufficient access rights, the configuration entries are viewed as normal entries and may be modified directly. However, you should always use the dialogs available through the Configuration Tab to change configuration settings safely.

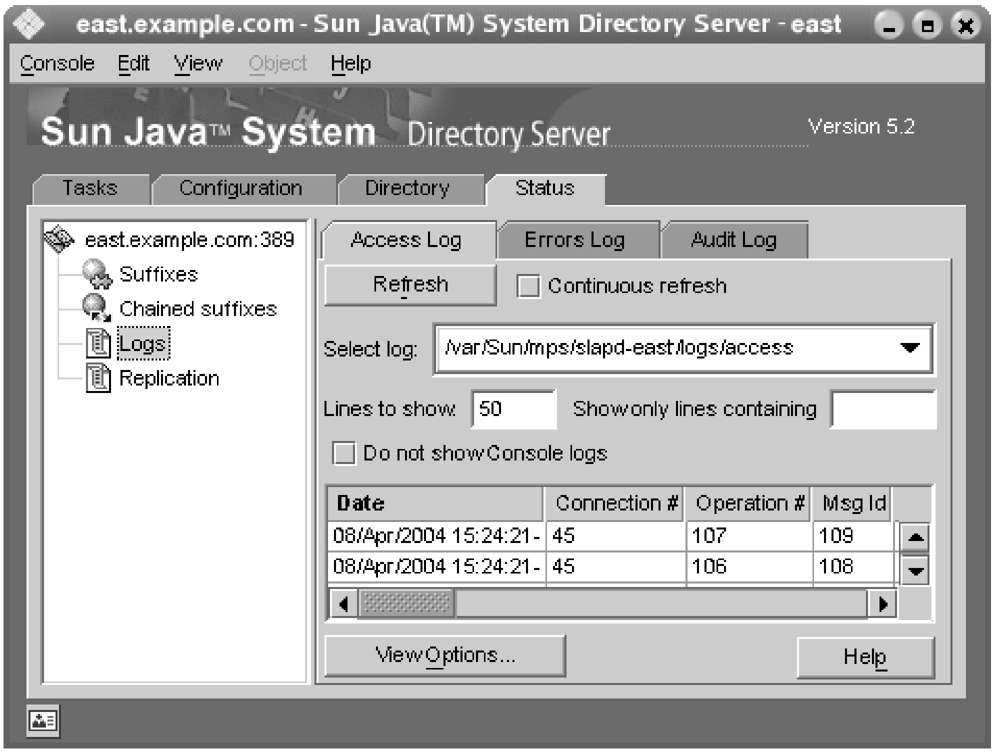
Several options are available through the View menu to change the layout and contents of the Directory Tab. New layout options include viewing all entries in a single tree, including leaf entries, and also displaying attributes in the right-hand pane. The default is to view leaf entries on the right and not in the left-hand tree.

The View>Display options enable ACI counts, role counts, and inactivation state icons for all entries in the directory tree. In Figure 1-4, ACI counts and leaf entries are displayed in the left-hand tree, and attribute values for the selected entry are displayed in the right-hand pane. For more information, see "Directory Tree View Options" on page 36.

Status Tab

The status tab displays server statistics and log messages. The tree on the left lists all status items, and when selected, the contents of each are displayed in the right-hand pane. For example, the following figure shows a table of log entries.

Figure 1-5 Status Tab of Directory Server Console



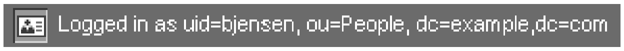
Select log: /var/Sun/mps/slapd-east/logs/access

Lines to show: 50 Show only lines containing:

Date	Connection #	Operation #	Msg Id
08/Apr/2004 15:24:21 -	45	107	109
08/Apr/2004 15:24:21 -	45	106	108

Viewing the Current Bind DN From the Console

You can view the bind DN you used to log in to Directory Server Console by clicking the login icon in the lower-left corner of the display. The current bind DN then appears next to the login icon as shown here:



Logged in as uid=bjensen, ou=People, dc=example,dc=com

Changing Your Login Identity

When you create or manage entries from Directory Server Console, and when you first access Server Console, you are given the option to log in by providing a bind DN and a password. This identifies who is accessing the directory tree and determines the access permissions granted to perform operations.

You can log in with the Directory Manager DN when you first start Server Console. At any time, you can choose to log in as a different user, without having to stop and restart the Console.

To change your login in Server Console:

1. On Directory Server Console, select the Tasks tab and click the button next to the label “Log on to the Directory Server as a New User.” Or, when in another console tab, select the Console>Log in as New User menu item.

   A login dialog box appears.

2. Enter the new DN and password and click OK.

   Enter the full distinguished name of the entry with which you want to bind to the server. For example, if you want to bind as the Directory Manager, then enter the following DN in the Distinguished Name text box:

   ```
   cn=Directory Manager
   ```

The Directory Manager DN and password are further explained in the following section.

Using the Online Help

The online help provides context-sensitive information for most tabs and dialogs of Directory Server Console. The Help button is usually located in the bottom right-hand corner of these interfaces. The keyboard shortcut for invoking the context-sensitive help on any screen is always Alt-P.

Invoking the online help will display an HTML-based page in the Console's built-in browser. From there, you may click the Launch in Browser button to open the same page in an external browser such as Mozilla. Within the online help, links to further information will also open an external browser window.

Each online help page gives an explanation of the fields and buttons contained in the corresponding tab or dialog. Use this information to guide you when interpreting, entering or modifying values through the console.

The help system for Directory Server is dependent on Administration Server. If you are running Directory Server Console on a machine remote to your Administration Server, you will need to verify the following:

- You may need to configure the connection restrictions enforced on the Administration Server to allow access from your machine, as described in "Network Settings" in Chapter 6 of the *Administration Server Administration Guide*.
- If you wish to use an external browser to view the online help pages, and your browser is configured to use proxies, you must do one of the following:
    - Disable proxies in your browser configuration. In Mozilla, select the Edit>Preferences menu item. Then select the Advanced>Proxies category to access the proxy configuration. In Internet Explorer, select Internet Options from the Tools menu.
    - Configure the connection restrictions in the Administration Server to allow access from the proxy server.

CAUTION Configuring Administration Server to allow access from a proxy server creates a potential security hole in your system.

The Console Clipboard

Directory Server Console uses your system clipboard to copy, cut, and paste text. To reduce typing, you can copy the DN or URL of an entry into the clipboard when navigating within the Directory tab.

Before opening a dialog or another tab where you need to paste the DN or URL in a text field:

1. On the top-level Directory tab of Directory Server Console, browse through the tree and select (left-click) the entry whose DN or URL you want to copy.
2. Then select either Edit>Copy DN or Edit>Copy URL from the menu.

Console Settings

Directory Server Console provides many settings for customizing how information is displayed in the Configuration and Directory tabs.

Visual Configuration Preferences

When you modify configuration parameters and enter values in fields on the top-level configuration tab, Directory Server Console uses colored text to indicate valid input. For example, if you enable a feature that requires you to enter further configuration values, the labels of the required fields will appear red and then turn blue once you enter valid value.

By default the console uses red and blue colors, but you can modify this behavior as follows:

1. On any tab of Directory Server Console, select the Edit>Preferences menu item. In the Console Preferences dialog, select the Misc. tab.
2. Choose the radio button for the visual configuration indicator that you prefer. You may choose colored fonts or font appearances or both.
3. For a description of the settings on the other tabs of the Console Preferences dialog, see “Customizing Server Console” in Chapter 2 of the *Administration Server Administration Guide*.

   Then click OK to save your changes.
4. Exit all windows of Server Console and restart it.

Directory Tree View Options

On the top-level Directory tab of Directory Server Console, the items of the View menu allow you to display additional information in the directory tree and select what appears in the right-hand panel.

The following View options affect the contents of the Directory tab:

- Follow Referrals - When this checkbox is selected, the directory tree will show the entries and all children of the target of the referral, as if they were in the directory. When the checkbox is empty, referrals are shown as referral entries. For more information, see "Creating Smart Referrals" on page 81.
- Sort Objects - When this checkbox is empty, entries are displayed in the order in which they are returned by the server. When this checkbox is selected, entries at the same level in the directory tree are sorted according their display attribute describe below. For information on how to sort large subtrees without impacting server performance, see "Browsing Indexes for the Console" on page 385.

  Entries displayed by the following attributes will be sorted: `cn`, `givenname`, `o`, `ou`, `sn`, and then `uid`. Entries displayed by other attributes will not be sorted.
- Display>ACI Count - If an entry contains one or more access control instructions (ACIs) in the `aci` attribute, the directory tree will show how many beside the entry. For more information, see Chapter 6, "Managing Access Control."
- Display>Role Count - If an entry is a member of one or more roles, the directory tree will show how many beside the entry. For more information, see "Assigning Roles" on page 178.
- Display>Inactivation State - If a user or group entry has been deactivated to prevent binding to the server, the directory tree will show a red box and line through the entry's icon. For more information, see "Inactivating and Activating Users and Roles" on page 291.
- Layout>View Children - When you choose this layout option, the tree in the left-hand panel does not show leaf entries of the directory, and selecting a parent node in the left-hand panel displays all of its children, including leaf entries, in the right-hand panel. You may select entries in either panel.
- Layout>View Only Tree - With this layout option, the Directory tab has only one panel that displays a tree containing all entries in the directory.
- Layout>View Attributes - In this layout, the left-hand panel displays a tree containing all entries in the directory, and the right-hand panel displays the attributes and values stored in the entry selected in the tree.
- Display Attribute - Click this menu item to see the Display Attribute dialog and choose the label for entries displayed in the Directory tab. By default, the label is the value of the entry's first RDN attribute, for example `People`. For base entries that do not have an RDN, the label is entire DN, for example `dc=example,dc=com`.

To use a different attribute to display entries in the directory tree, choose the other radio button and select an attribute. Entries without the chosen attribute will still use the entry's first RDN attribute. By default, only the attribute value is used in the label. If you select the "Show attribute name" checkbox, the label will look like `ou=People`.

- Refresh - After certain operations you must refresh the display of the directory tree to view the new value. Selecting this item will reload the entire directory tree from the server.

Configuring LDAP Parameters

The LDAP parameters are the basic settings in your directory server, such as the distinguished name (DN) of the Directory Manager, the global read-only setting, the port configuration, and the ability to track all directory modification times.

Configuring the Directory Manager

The *Directory Manager* is the privileged server administrator, comparable to the root user in UNIX. Access control does not apply to the entry you define as Directory Manager. You initially defined this entry during installation. The default is `cn=Directory Manager`.

The DN of the directory manager is stored in the `nsslapd-rootDN` attribute and the password in the `nsslapd-rootpw` attribute of the `cn=config` branch.

Use Directory Server Console to change the Directory Manager DN, its password, and the encryption scheme used for this password:

1. Log in to the Console as Directory Manager.

   If you are already logged in to the Console, see "Changing Your Login Identity" on page 34 for instructions on how to log in as a different user.

2. On the top-level Configuration tab, select the server node at the root of the navigation tree, and select the Settings tab in the right-hand panel.

3. Enter the new distinguished name in the Directory Manager DN field. The default value is the one defined during installation.

4. From the Manager Password Encryption pull-down menu, select the storage scheme you want the server to use to store the password for Directory Manager.

5. Enter the new password and confirm it using the text fields provided.
6. Click Save.

Changing Directory Server Port Numbers

You can modify the port or secure port number of your user directory server using Directory Server Console or by changing the value of the `nsslapd-port` attribute under the `cn=config` entry.

If you want to modify the port or secure port for a Directory Server that contains the Sun Java System configuration information (`o=NetscapeRoot` subtree), you can do so through Directory Server Console.

If you change the configuration directory or user directory port or secure port numbers, you should be aware of the following repercussions:

- You need to change the configuration or user directory port or secure port number configured for the Administration Server. See "Network Settings" in Chapter 6 of the *Administration Server Administration Guide*.
- If you have other Sun Java System Servers installed that point to the configuration or user directory, you need to update those servers to point to the new port number.
- If you set a non-privileged port number, and Directory Server is installed on a machine to which other users have access, you may expose the port to a hijack risk by another application. In other words, another application can bind to the same address/port pair. This rogue application may then be able to process requests intended for Directory Server, and could be used to capture passwords used in the authentication process, to alter client requests or server responses, or to produce a denial of service attack. To avoid this security risk, use the `nsslapd-listenhost` attribute to specify the interface (address) on which Directory Server listens. For more information on this attribute, see "nsslapd-listenhost" in Chapter 3 of the *Directory Server Administration Reference*.
- Changing the port number via the console does not make the necessary changes to certain scripts and requires that these scripts be modified manually. See the *Directory Server Release Notes* for more information.

Use the following procedure to modify the port or secure port on which Directory Server listens for incoming LDAP requests. To modify the ports for DSML requests, see "Configuring DSML" on page 44.

1. On the top-level Configuration tab of Directory Server Console, select the root node with the server name, and select the Network tab in the right-hand panel.

   The tab displays the server's current port settings for the LDAP protocol.

2. Enter the port number you want the server to use for non-SSL communications in the Port field. The default value is 389.

3. If you have activated SSL on this server as described in Chapter 11, "Managing Authentication and Encryption," you may allow connections on a secure port:

   a. Select the option to use both secure and non secure ports.

   b. Enter the port number you want the server to use for SSL communications in the Secure Port field. The default value is 636.

      The encrypted port number that you specify must not be the same port number as you are using for normal LDAP communications.

4. Click Save and then restart the server.

See "Starting and Stopping Directory Server" on page 25 for information.

Setting Global Read-Only Mode

Each suffix in your directory may be placed in read-only mode independently and may return a specific referral if one is defined. Directory Server also provides a global read-only mode that will apply to all suffixes and may return a global referral when one is defined.

The global read-only mode is designed to allow administrators to prevent modifications to the directory contents while performing tasks such as reindexing the suffixes. For this reason, global read-only mode does not apply to the following configuration branches:

- `cn=config`
- `cn=monitor`
- `cn=schema`

These branches should be protected at all times by Access Control Instructions (ACIs) against modifications by non-administrative users, regardless of the read-only setting (see Chapter 6, "Managing Access Control.") Global read-only mode will prevent update operations on all other suffixes in the directory, including update operations initiated by the Directory Manager.

Read-only mode will also interrupt replication on a suffix if it is enabled. A master replica will no longer have any changes to replicate, although it will continue to replicate any changes that were made before read-only mode was enabled. A consumer replica will not receive updates until read-only mode is disabled. A master in a multi-master replication scenario will neither have any changes to replicate nor be able to receive updates from the other masters.

To enable or disable the global read-only mode:

1. On the top-level Configuration tab of Directory Server Console, select the root node in the configuration tree, then select the Settings tab in the right panel.
2. Select or deselect the "Server is read only" checkbox.
3. Click Save. The change will take effect immediately.

For information on placing an individual suffix in read-only mode, refer to "Setting Suffix Read-Only Mode" on page 158.

Tracking Modifications to Directory Entries

You can configure the server to maintain special attributes for newly created or modified entries:

- `creatorsName`—The distinguished name of the person who initially created the entry.
- `createTimestamp`—The timestamp for when the entry was created in GMT (Greenwich Mean Time) format.
- `modifiersName`—The distinguished name of the person who last modified the entry.

- `modifyTimestamp`—The timestamp for when the entry was last modified in GMT format.

NOTE When a client application creates or modifies entries in a chained suffix, the `creatorsName` and `modifiersName` attributes do not reflect the real creator or modifier of the entries. These attributes contain the name of the chaining proxy needed to bind to the remote server. For information on proxy authorization, refer to "Creating a Proxy Identity" on page 126.

When tracking modification times of replicated suffixes, the name and timestamp attributes are replicated as normal attributes. As a result, these attributes reflect the time of the original modification to the entry on the master server, not the time that the entry was replicated to a consumer.

To enable the Directory Server to track this information:

1. On the top-level Configuration tab of Directory Server Console, select the root node in the configuration tree, then select the Settings tab in the right-hand panel.
2. Select the "Track entry modification times" checkbox.

   The server will add the `creatorsName`, `createTimestamp`, `modifiersName`, and `modifyTimestamp` attributes to every newly created or modified entry. Existing entries will not contain the creation attributes.
3. Click Save and then restart the server.

   See "Starting and Stopping Directory Server" on page 25 for more information.

Verifying Plug-In Signatures

The verification of plug-in signatures is a new feature of Directory Server 5.2. Plug-ins provided with Directory Server each have a digital signature which may be verified by the server at startup. By default, the server will verify plug-in signatures, but it will load every plug-in regardless of the presence or validity of a signature.

Verifying signatures has the following advantages:

- A signature on a plug-in provided with Directory Server indicates that it has been rigorously tested and is officially supported.

- Using a checksum of the plug-in binary itself, the signature verification can detect whether the plug-in has been tampered with. Therefore the signature protects sensitive code that runs in the server itself.
- You may configure your server to load only the signed plug-ins, which may help detect problems with unsigned and unsupported plug-ins.

Configuring the Verification of Plug-In Signatures

1. On the top-level Configuration tab of Directory Server Console, select the Plugins node in the configuration tree. The current signature verification policy is displayed in the right-hand panel.
2. Select one of the following options:
   - Do not verify plug-in signatures - All plug-ins defined in the server configuration will be loaded regardless of their signature. No warnings or errors will be shown because of a plug-in signature.
   - Flag plug-ins with invalid signatures - All plug-ins defined in the server configuration will be loaded, but the server will verify the signature of each one. If a plug-in binary is altered in any way, the signature will no longer be valid, and the server will display a warning message on startup and in the error log. Plug-ins without signatures will also be flagged.

     This is the recommended option if you have custom, unsigned plug-ins. Your plug-ins will be loaded, but you will still be able to view the status of all signed plug-ins.
   - Reject plug-ins with invalid signatures - The server will verify the signature of all plug-ins defined in the configuration and will only load plug-ins with valid signatures. The server will display a warning message on startup and in the error log that indicates which plug-ins have an invalid signature or no signature.

     This is the most secure option, however, you will not be able to load custom, unsigned plug-ins.
3. Click Save, and then restart Directory Server as described in "Starting and Stopping Directory Server" on page 25.

Viewing the Status of a Plug-In

1. On the top-level Configuration tab of Directory Server Console, expand the Plugins node in the configuration tree, and select the plug-in you wish to verify. The current configuration of the plug-in is displayed in the right-hand panel.
2. The “Signature state” field shows the signature verification status of the plug-in with one of the following values:
    - Unknown - This signature state occurs in all plug-ins when the server is configured not to verify plug-in signatures. The following states are visible only if you verify plug-in signatures.
    - Valid signature - The plug-in configuration provides a signature that matches the checksum of the plug-in binary. This plug-in is officially supported. The following states are visible only if you flag but do not reject invalid signatures.
    - Invalid signature - The plug-in configuration contains a signature which does not match the checksum of the plug-in binary. This state indicates that the plug-in may have been tampered with.
    - No signature - The plug-in configuration did not provide a signature for the server to verify.

Configuring DSML

In addition to processing requests in the Lightweight Directory Access Protocol (LDAP), Directory Server also responds to requests sent in the Directory Service Markup Language version 2 (DSMLv2). DSML is another way for a client to encode directory operations, but the server processes DSML as any other request, with all of the same access control and security features. In fact, DSML processing allows many other types of clients to access your directory contents.

Directory Server supports the use of DSMLv2 over the Hypertext Transfer Protocol (HTTP/1.1) and uses the Simple Object Access Protocol (SOAP) version 1.1 as a programming protocol to transport the DSML content. For more information about these protocols and examples of DSML requests, see “Accessing the Directory Using DSMLv2” on page 103.

Enabling DSML Requests

Because LDAP is the standard protocol for accessing a directory, DSML requests are not enabled by default after installing Directory Server. If you want your server to respond to DSML requests sent over HTTP/SOAP, you must explicitly enable this feature.

To enable DSML requests on your server through the console:

1. On the top-level Configuration tab of Directory Server Console, select the root node in the configuration tree, and select the Network tab in the right-hand panel.
2. Select the Enable DSML checkbox and choose one of the following security options. The secure port options are only available if you have activated SSL, as described in Chapter 11, "Managing Authentication and Encryption."
    - Only non-secure port - Only DSML requests over unencrypted HTTP will be accepted on the non-secure port.
    - Only secure port - Only DSML requests over HTTPS will be accepted on the secure port.
    - Both secure and non-secure ports - Both ports will be active and clients may choose either one.
3. Then edit any of the following fields:
    - Port - The HTTP port for receiving DSML requests.
    - Encrypted Port - The HTTPS port using SSL to received encrypted DSML requests.
    - Relative URL - A relative URL that, when appended to the host and port, determines the full URL that clients must use to send DSML requests.

    By default, the server will process requests sent to the following URL:

    `http://`*host*`:80/dsml`
4. Click Save and you will be reminded that you must restart the server to begin responding to DSML requests.

To enable DSML requests through the command line:

1. Perform the following `ldapmodify` command to enable the DSML front-end plug-in and modify its settings. Modifying the `ds-hdsml-port`, `ds-hdsml-secureport`, and `ds-hdsml-rooturl` attributes is optional:

```
% ldapmodify -h host -p LDAPport -D "cn=Directory Manager" -wpasswd
dn:cn=DSMLv2-SOAP-HTTP,cn=frontends,cn=plugins,cn=config
changetype: modify
replace: nsslapd-pluginEnabled
nsslapd-pluginEnabled: on
-
replace: ds-hdsml-port
ds-hdsml-port: DSMLport
-
add: ds-hdsml-secureport
ds-hdsml-port: secureDSMLport
-
replace: ds-hdsml-rooturl
ds-hdsml-root: relativeURL
-
^D
```

According to the parameters and attribute values you defined, DSML clients may use the following URLs to send requests to this server:

`http://`*host*`:`*DSMLport*`/`*relativeURL*

`https://`*host*`:`*secureDSMLport*`/`*relativeURL*

2. When the DSML front-end plug-in has been modified, you must restart the server for the changes to take effect. However, before you restart the server, you may wish to configure the security and identity mappings for DSML authentication as described in the following sections.

Configuring DSML Security

In addition to the secure port setting described in the previous section, you may configure the level of security that is required to accept DSML requests. The `ds-hdsml-clientauthmethod` attribute of the DSML front-end plug-in determines what authentication methods are required of the client. This attribute may have the following values:

- `httpBasicOnly` - The server uses the contents of the HTTP Authorization header to find a user name that can be mapped to an entry in the directory. This process and its configuration are described in "DSML Identity Mapping" on page 48. With this setting, DSML requests to a secure HTTPS port are encrypted through SSL but do not use client certification.

- `clientCertOnly` - The server uses credentials from the client certificate to identify the client. With this value, all DSML clients must use the secure HTTPS port to send DSML requests and provide a certificate. The server checks that the client certificate matches an entry in the directory. See Chapter 11, "Managing Authentication and Encryption," for more information.
- `clientCertFirst` - The server will attempt to authenticate clients first with a client certificate if one is provided. Otherwise, the server will authenticate clients using the contents of the Authorization header.

If no certificate and no Authorization header is provided in the HTTP request, the server will perform that DSML request with anonymous binding. Anonymous binding is also used in the following cases:

- The client provides a valid Authorization header but no certificate when `clientCertOnly` is specified.
- The client provides a valid certificate but no Authorization header when `httpBasicOnly` is specified.

Regardless of the `ds-hdsml-clientauthmethod` attribute value, if a certificate is provided but it cannot be matched to an entry, or if the HTTP Authorization header is specified but cannot be mapped to a user entry, the DSML request will be rejected with error message 403: "Forbidden."

To set the DSML security requirements through the console:

1. On the top-level Configuration tab of the Directory Server console, select the root node in the configuration tree, and select the Encryption tab in the right-hand panel.

   You must have already configured and enabled SSL as described in Chapter 11, "Managing Authentication and Encryption."

2. Select one of the choices for the drop-down menu in the DSML Client Authentication field.
3. Click Save and then restart the server to enforce this new security setting.

To set the DSML security requirements through the command line:

1. Run the following `ldapmodify` command to edit the attribute of the DSML front-end plug-in:

```
% ldapmodify -h host -p LDAPport -D "cn=Directory Manager" -wpasswd
dn:cn=DSMLv2-SOAP-HTTP,cn=frontends,cn=plugins,cn=config
changetype: modify
replace: ds-hdsml-clientauthmethod
ds-hdsml-clientauthmethod: httpBasicOnly or
 clientCertOnly or clientCertFirst
^D
```

2. When the DSML front-end plug-in has been modified, you will need to restart the server to enforce this new security setting.

DSML Identity Mapping

When performing basic authentication without a certificate, Directory Server uses a mechanism called *identity mapping* to determine the bind DN to use when accepting DSML requests. This mechanism extracts information from the Authorization header of the HTTP request to determine the identity to use for binding. See "Identity Mapping" on page 408 for a complete description of this mechanism.

The default identity mapping for DSML-over-HTTP is given by the following entry in your server configuration:

```
dn:cn=default,cn=HTTP-BASIC, cn=identity mapping, cn=config
objectclass: top
objectclass: nsContainer
objectclass: dsIdentityMapping
cn: default
dssearchbasedn: ou=People,userRoot
dssearchfilter: (uid=${Authorization})
```

This mapping searches the `ou=People,`*userRoot* subtree for an entry whose `uid` attribute matches the user name given in the `Authorization` header. The *userRoot* is the suffix you defined when installing the directory, for example `dc=example,dc=com`.

Within the mapping entry attributes, you may use place-holders of the format `${`*header*`}` where *header* is the name of an HTTP header. The most common headers used in DSML mappings are:

- `${Authorization}` - This string is replaced with the user name contained in an HTTP Authorization header. An authorization header contains both a username and its password, but only the user name is substituted in this place-holder.
- `${From}` - This string is replaced with the email address that may be contained in an HTTP From header.

- `${host}` - This string is replaced with the hostname and port number in the URL of the DSML request, which are those of the server itself.

To have DSML requests perform a different identity mapping, define a new identity mapping for HTTP headers:

1. Edit the default DSML-over-HTTP identity mapping or create custom mappings for this protocol. See "Identity Mapping" on page 408 for the definition of the attributes in an identity mapping entry. These mapping entries must be located below the following entry:
`cn=HTTP-BASIC, cn=identity mapping, cn=config`.

You may create a new mapping entry in one of two ways:

  - ❍ Use the top-level Directory tab of the Directory Server console to create a new entry with the appropriate object classes, as described in "Managing Entries Using the Console" on page 54.
  - ❍ Use the `ldapmodify` tool to add this entry from the command line, as described in "Adding Entries Using ldapmodify" on page 72.

2. Restart Directory Server for your new mappings to take effect.

Custom mappings are evaluated first, and if no custom mapping is successful, then the default mapping is evaluated. If all mappings fail to determine the bind DN for the DSML request, the DSML request will be forbidden and rejected (error 403).

Chapter 2

Managing Directory Entries

This chapter discusses how to use Directory Server Console and the LDAP command-line utilities to manage the contents of your directory. It also describes how attributes are stored with the optional attribute encryption feature, and how to access your directory using DSML. When planning your directory deployment, you should characterize the types of data that the directory will contain. Read Chapter 2, "Planning and Accessing Directory Data," in the *Directory Server Deployment Planning Guide* before creating entries and modifying the default schema.

This chapter assumes some knowledge of LDAP schema and the object classes and attributes it defines. For an introduction to the schema and the definition of all object classes and attributes provided in Directory Server, refer to the "Object Class Reference" and "Attribute Reference" chapters in the *Directory Server Administration Reference*.

You cannot modify your directory unless the appropriate access control instructions (ACIs) have been defined. For further information, see Chapter 6, "Managing Access Control".

This chapter contains the following sections:

Configuration Entries

Directory Server stores all of its configuration information in the following file:

ServerRoot/`slapd-`*serverID*`/config/dse.ldif`

This file is in the LDAP Data Interchange Format (LDIF). LDIF is a textual representation of entries, attributes, and their values, and is a standard format described in RFC2849 (http://www.ietf.org/rfc/rfc2849.) The Directory Server configuration in the `dse.ldif` file consists of:

- The attributes and values of the `cn=config` entry.
- All of the entries in the subtree below `cn=config` and their attributes and values. Often, the presence of an entry or attribute is significant.
- The object classes and access control instructions (ACIs) of the root entry ("") and `cn=monitor` entry. The other attributes of these entries are generated by the server.

Directory Server makes all configuration settings readable and writable through LDAP. By default, the `cn=config` branch of the directory is accessible only to the directory administrators defined in the Administration Server and to the directory manager. These administrative users can view and modify the configuration entries just like any other directory entry.

You should avoid creating entries under the `cn=config` entry because they will be stored in the `dse.ldif` file, which is not the same highly scalable database as regular entries. As a result, if many entries, and particularly entries that are likely to be updated frequently, are stored under `cn=config`, performance will probably suffer. However, it can be useful to store special user entries such as the Replication Manager (supplier bind DN) entry under `cn=config`, in order to centralize configuration information.

Modifying the Configuration Using the Console

The recommended method for modifying the configuration is to use the top-level Configuration tab of Directory Server Console. The panels and dialogs of this tab provide task-based controls to help you set up your configuration quickly and efficiently. In addition, the console interface manages the complexity and interdependence of the configuration for you.

The console interface to the configuration is described in the procedures of this document that are titled "...Using the Console." These procedures explain how to use the panels and dialogs of the Configuration tab to achieve the specific management task. The interface itself makes it clear how to save your configuration and when you need to restart the server for your changes to take effect.

Modifying the Configuration From the Command Line

Because the `cn=config` subtree is accessible through LDAP, the `ldapsearch`, `ldapmodify` and `ldapdelete` commands can be used to view and modify the server configuration. The `cn=config` entries and all entries below it may be modified using the procedures and LDIF format described in "Managing Entries From the Command Line" on page 68.

However, you must know the meaning of these entries, the purpose of their attributes and the values which are allowed. These important considerations are explained in the procedures of this document that are titled "...From the Command Line." These procedures will show you an example of the configuration entries and attributes that you may set. For the complete description of all configuration entries and attributes, including the range of allowed values, see the *Directory Server Administration Reference*.

Modifying the configuration from the command line is thus not as straightforward as using the console. However, a few rare configuration settings are not available through the console, and only the command-line procedure will be given. You may also use the command-line procedures to automate your configuration tasks by writing scripts that use the command-line tools.

Modifying the dse.ldif File

The `dse.ldif` file contains the configuration that the server will read and use when it is started or restarted. The LDIF contents of this file are the `cn=config` entry and its subtree. The file is readable and writable only by the system user defined during installation.

Modifying the configuration by editing the contents of this file directly is more prone to error and is therefore not recommended. You should be aware of the following behavior:

- The `dse.ldif` file is read only once at startup. Thereafter, the server configuration is based on the in-memory LDAP image of the configuration entries. Modifications to the file while the server is running will be erased.
- Modifying the configuration using the console or from the command line changes the LDAP image of the configuration. Some directory features read the current configuration when invoked and do not require restarting the server.
- The server will write the `dse.ldif` file whenever the LDAP image of the configuration is changed. Some directory features only read their configuration when the server starts, and writing the file ensures the change will be present.

  The existing `dse.ldif` file will be copied to `dse.ldif.bak`, and the existing `dse.ldif.bak` will be overwritten. Therefore, any manual changes to the `dse.ldif` file will be lost if the configuration is changed through LDAP before the server is restarted.
- After every successful startup of the directory, the `dse.ldif` file is copied to `dse.ldif.startOK` in the same location. If your server cannot start because of a faulty configuration change, you will need to restore the `dse.ldif` from this file.

Managing Entries Using the Console

You can use the Directory tab and the entry editor dialogs on Directory Server Console to add, modify, or delete entries individually. If you want to operate on several entries simultaneously, see "Bulk Operations Using the Console" on page 68.

For information on starting Directory Server Console and navigating the user interface, refer to "Using Directory Server Console" on page 27.

Creating Directory Entries

Directory Server Console offers several custom templates for creating directory entries. Each template is a custom editor for a specific type of object class. Table 2-1 shows the object class that is used for each custom editor.

Table 2-1 Entry Templates and Corresponding Object Classes

Template	Object Classes
User	`inetOrgPerson` (for creation and editing) `organizationalPerson` (for editing) `person` (for editing)
Group	`groupOfUniqueNames` and possibly others for dynamic groups and certificate groups
Organizational Unit	`organizationalUnit`
Role	`nsRoleDefinition`, and others depending on choice of managed, filtered or nested role
Class of Service	`cosSuperDefinition`, and others depending on type of class of service
Password Policy	`passwordPolicy`
Referral	`referral`

These custom editors contain fields representing all the mandatory attributes, and some of the commonly used optional attributes of their respective object class. To create an entry using one of these templates, follow the instructions in "Creating an Entry Using a Custom Editor" on page 55. To create any other type of entry, refer to "Creating Other Types of Entries" on page 57.

Creating an Entry Using a Custom Editor

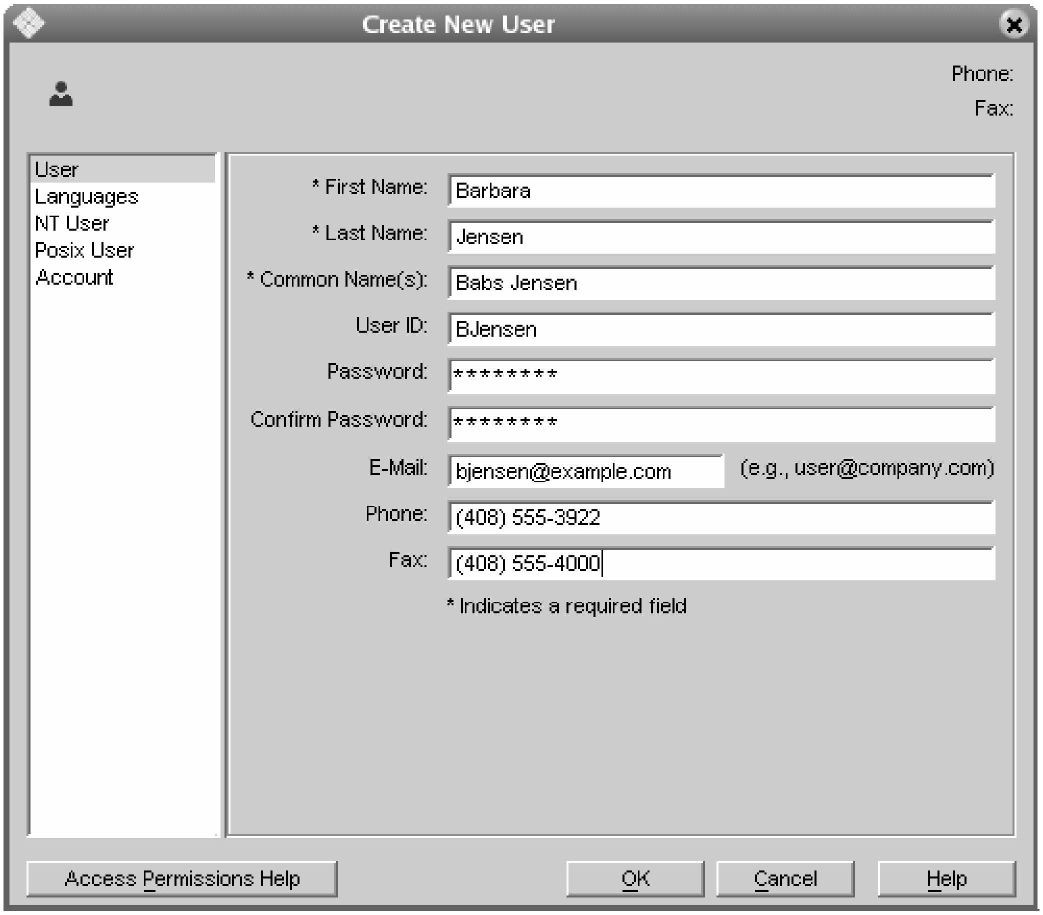
1. On the top-level Directory tab of Directory Server Console, expand the directory tree to display the entry that you wish to be the parent of the new entry.

2. Right-click the parent entry, select the New menu item, and then select the type of entry from the submenu: User, Group, Organizational Unit, Role, Class of Service, Password Policy, or Referral. Alternatively, you may left-click the parent entry to select it and then choose the type of entry from the Object>New menu. The custom editor dialog for the entry type you selected is displayed.

   The custom editor has a list of tabs in the left-hand column and the fields of each tab is displayed on the right. By default, all custom editors open with the topmost User or General tab selected, which contains the fields to name and describe the new entry.

   For example, the following figure shows the custom editor for user entries:

Figure 2-1 Directory Server Console - Custom Editor for User Entries



* First Name: Barbara

* Last Name: Jensen

* Common Name(s): Babs Jensen

User ID: BJensen

Password: ********

Confirm Password: ********

E-Mail: bjensen@example.com (e.g., user@company.com)

Phone: (408) 555-3922

Fax: (408) 555-4000

* Indicates a required field

3. Enter values in the fields of the custom editor for the attributes you wish to provide. You must enter a value for all of the mandatory attributes that are identified by an asterisk (*) beside the field name. You may leave any of the other fields blank. In fields that allow multiple values, you my type Return to separate the values.

   Click the Help button for further assistance with specific fields in the custom editor for your entry type. For an explanation of the Languages tab of the User and Organizational Unit editors, see “Setting Attributes for Language Support” on page 60.

For further instructions on creating groups, roles, and class of service entries, see Chapter 5, “Managing Identity and Roles.” For instructions on creating password policies, see Chapter 7, “Managing User Accounts and Passwords.” For instructions on creating referrals, see “Setting Referrals” on page 79.

4. Click OK to create your new entry and close the custom editor dialog. The new entry appears in the directory tree.
5. Custom editor dialogs do not provide fields for all optional attributes of their respective object classes. If you wish to add optional attributes that are not displayed in the custom editor, follow the instructions in “Modifying Entries With the Generic Editor” on page 60.

Creating Other Types of Entries

Follow these steps to create an entry of any object class other than those listed in Table 2-1 on page 55. You may also use this procedure to create an entry of any custom object classes you may have defined in the directory schema:

1. On the top-level Directory tab of Directory Server Console, expand the directory tree to display the entry that you wish to be the parent of the new entry.
2. Right-click the parent entry and select the New>Other item from the submenu. Alternatively, you may left-click the parent entry to select it and then select the Object>New>Other menu item.

   The New Object dialog will be displayed.
3. In the object class list of the New Object dialog, select an object class that defines your new entry, then click OK.

   If you selected an object class listed in Table 2-1 on page 55, the corresponding custom editor will be displayed (see “Creating an Entry Using a Custom Editor” on page 55). In all other cases, the generic editor is displayed.
4. When creating a new entry, the generic editor contains a field for each required attribute of the object class you selected. You must enter a value for all the required attributes. Some fields have a generic placeholder value such as `New`, which you should replace with a meaningful value for your entry.
5. To define other attributes that are allowed on the chosen object class, you must add them explicitly. To provide values for optional attributes:

   a. Click the Add Attribute button to display a list of allowed attributes.

   b. Select one or more attributes from the Add Attribute dialog and click OK.

   c. Enter values beside the new attribute name in the generic editor.

For further details about other controls in this dialog, see "Modifying Entries With the Generic Editor" on page 60.

6. By default, one of the required attributes is selected as the naming attribute and appears in the entry DN displayed in the generic editor. To change the naming attribute:

   a. Click the Change button to display the Change Naming Attribute dialog.

   b. In the table of attributes, select the checkbox beside one or more attributes you wish to use in the DN of your new entry.

   c. Click OK in the Change Naming Attribute dialog. The DN in the generic editor shows the new DN using the selected naming attributes.

7. Click OK in the generic editor to save the new entry.

   The new entry is displayed as a child of the parent entry in the directory tree.

Modifying Entries With a Custom Editor

For object classes listed in Table 2-1 on page 55, you have the option of editing the entry with either the corresponding custom editor or the generic editor. When using a custom editor, the most common fields are easily accessible, and the interface helps you define values for complex attributes such as those in a role or class of service definition.

The generic editor allows more advanced operations on an entry, such as adding object classes, adding allowed attributes, and handling multivalued attributes. To edit an entry with the generic editor, see "Modifying Entries With the Generic Editor" on page 60.

NOTE The custom editors can be used to edit *only* the object classes listed in Table 2-1 on page 55. Entries that contain other *structural* object classes, for example a custom class that inherits from `inetorgperson`, can only be edited through the generic editor.

Entries that contain *auxiliary* object classes in addition to one of the listed object classes can be managed with the custom editor. However, none of the attributes defined by the auxiliary class will be visible in the custom editor. For a definition of an auxiliary object class, see "Object Classes" in Chapter 8 of the *Directory Server Administration Reference*.

Invoking the Custom Editor

To edit an entry whose object class is listed in Table 2-1 on page 55:

1. On the top-level Directory tab of Directory Server Console, expand the directory tree to display the entry that you wish edit.

2. Double-click on the entry. Several alternate actions also invoke the custom editor of an entry:

   - Right-click the entry and select the “Edit With Custom Editor” item.

   - Left-click the entry to select it, then select the Object>Edit With Custom Editor menu item.

   - Left-click the entry to select it, then use the keyboard shortcut Control-P.

   The custom editor for the object class of your entry will be displayed. For example, the custom editor for User entries is shown in Figure 2-1 on page 56.

3. By default, all custom editors open with the topmost User or General tab selected, which contains the fields to name and describe the new entry. Edit or remove values in the fields of the custom editor for the attributes you wish to modify. You may modify but not remove the value of mandatory attributes that are identified by an asterisk (*) beside the field name. You may leave any of the other fields blank. In fields that allow multiple values, you my type Return to separate the values.

   Select the other tabs in the left-hand column to modify the values on the corresponding panel. Click the Help button for further assistance with specific fields in the custom editor for your entry type.

   For an explanation of the Languages tab of the User and Organizational Unit editors, see “Setting Attributes for Language Support” on page 60. The fields of the Account tab of user and group entries are described in Chapter 7, “Managing User Accounts and Passwords.” The NT User and Posix User tabs are provided for Directory Server Synchronization Services, please see your Sun representative for details.

   For further instructions on modifying groups, roles and class of service entries, see Chapter 5, “Managing Identity and Roles.” For instructions on modifying password policies, see Chapter 7, “Managing User Accounts and Passwords.” For instructions on modifying referrals, see “Setting Referrals” on page 79.

4. Click OK to save your changes to the entry and close the custom editor dialog. If you modified the naming attribute, for example the common name of a user entry, the change will be reflected in the directory tree.

Setting Attributes for Language Support

The custom editors for both user and organizational unit entries provide language support for internationalized directories.

1. Open the custom editor for your entry as described in "Invoking the Custom Editor" on page 59.
2. Click on the Languages tab in the left-hand column.
3. For user entries, you may set a preferred language using the drop-down list.
4. For both user and organizational unit entries, you may enter localized values in the given fields for any of the languages shown in the list. Select a language and then enter one or more values in that language. The language name appears in bold in the list when localized values are defined.

   Certain languages also have pronunciation fields where you may enter phonetical representation of the localized values.
5. Click OK to save your changes to the entry and close the custom editor dialog.

Modifying Entries With the Generic Editor

The generic editor enables you to view all readable attributes of an entry and to edit its writable attributes, according to the bind DN used to log into the console. It also enables you add and remove attributes, set multivalued attributes, and manage the object classes of the entry. When adding attributes, you may define subtypes for binary attributes and language support.

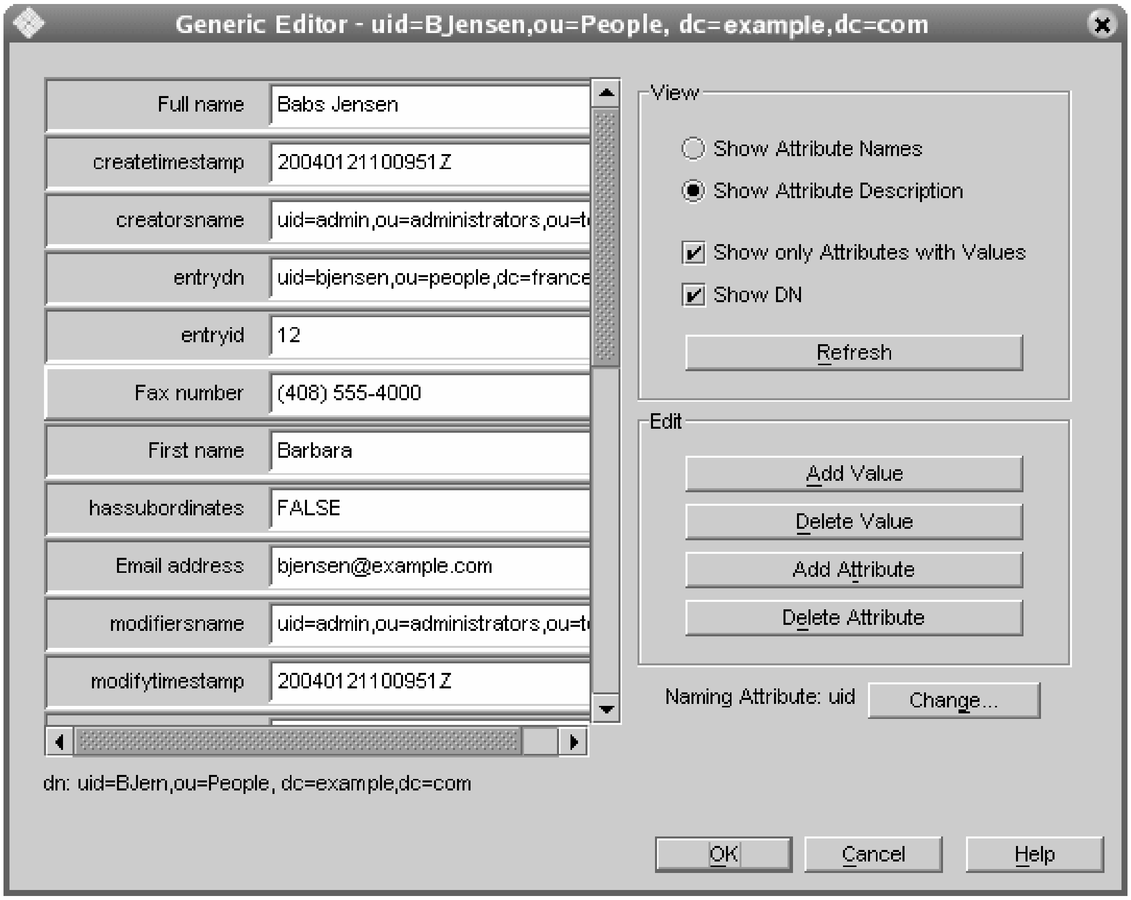
Invoking the Generic Editor

To invoke the generic editor for any entry in the directory:

1. On the top-level Directory tab of Directory Server Console, expand the directory tree to display the entry that you wish edit.
2. Right-click the entry and select the "Edit With Generic Editor" item. Several alternate actions also invoke the generic editor:
   - Left-click the entry to select it, then select the Object>Edit With Generic Editor menu item.
   - Double-click on the entry if its object class is *not* listed in Table 2-1 on page 55. The generic editor will be used by default for object classes that do not have a custom editor.

The generic editor is displayed, as shown in the following figure.

Figure 2-2 Directory Server Console - Generic Editor



Generic Editor - uid=BJensen,ou=People, dc=example,dc=com

Full name	Babs Jensen
createtimestamp	20040121100951Z
creatorsname	uid=admin,ou=administrators,ou=t
entrydn	uid=bjensen,ou=people,dc=france
entryid	12
Fax number	(408) 555-4000
First name	Barbara
hassubordinates	FALSE
Email address	bjensen@example.com
modifiersname	uid=admin,ou=administrators,ou=t
modifytimestamp	20040121100951Z

dn: uid=BJem,ou=People, dc=example,dc=com

View

Show Attribute Names [✓ Show Attribute Description]

[✓] Show only Attributes with Values

[✓] Show DN

Naming Attribute: uid

In the generic editor, the entry's attributes are listed alphabetically with a text box containing the value of each one. All attributes, including read-only and operational attributes are shown. The controls on the right allow you to modify the display in the editor and edit the list of attributes.

3. Optionally, you may modify the display of the generic editor using the controls in the View box:

- Select the Show Attribute Names option to view the names of attributes as they are first defined in the schema. The list of attributes will be rearranged so that they are listed alphabetically by name.

- Select the Show Attribute Description option to list attributes by their alternate name, if one is defined in the schema. The alternate name is usually a more explicit description of the attribute. The list of attributes will be rearranged so that they are listed alphabetically by description.
- Deselect the Show only Attributes with Values checkbox to list all attributes that are explicitly allowed by the schema for the entry's object classes. If the entry includes the `extensibleObject` object class, all attributes are implicitly allowed, but they are not listed. By default, only the attributes with a defined value are shown.
- Select or deselect the Show DN checkbox to toggle the display of the entry's distinguished name beneath the list of attributes.
- The Refresh button will access the server to update the values of all attributes according to the current contents of the entry.

CAUTION Clicking the Refresh button immediately removes any modifications you have made in the generic editor without saving them.

The controls for setting attribute values, managing object classes and changing the naming attribute of an entry are described in the following sections.

Modifying Attribute Values

1. Open the generic editor as described in "Invoking the Generic Editor" on page 60.
2. Scroll through the list of attributes and click on the value you wish to modify.

   The selected attribute is highlighted and an editing cursor appears in the text field containing the selected value.
3. Use the mouse and the keyboard to edit the text to the desired value. You may use your system's clipboard to copy, cut, and paste text in this field.

   If you cannot edit the contents of the text field, that attribute is read-only, or you do not have write permissions to modify it.
4. Edit any other values or perform other modifications as desired to this entry, then click OK to save your changes and close the generic editor.

Editing Multi-Valued Attributes

Attributes which are defined to be multi-valued in your directory schema may have more than one value field in the generic editor. See Chapter 9, "Extending the Directory Schema" for more information.

To add a new value to a multi-valued attribute:

1. Open the generic editor as described in "Invoking the Generic Editor" on page 60.
2. Scroll through the list of attributes and click on the attribute or one of its values. The selected attribute is highlighted and the Add Value button is activated. If this button is not activated, the selected attribute is not defined to be multi-valued, or it is read-only, or you do not have write permission to modify it.
3. Click the Add Value button. A new blank text field is displayed beside the attribute name in the list.
4. Enter a new value for this attribute in the new text field. You may use your system's clipboard to copy, cut, and paste text in this field.
5. Edit any other values or perform other modifications as desired to this entry, then click OK to save your changes and close the generic editor.

To remove a value of a multi-valued attribute:

1. Open the generic editor as described in "Invoking the Generic Editor" on page 60.
2. Scroll through the list of attributes and click on the specific value you wish to remove. The selected attribute is highlighted and the Delete Value button is activated. If this button is not activated, the selected attribute is read-only, or you do not have write permission to modify it.
3. Click the Delete Value button. The text field containing the selected value is removed.
4. Edit any other values or perform other modifications as desired to this entry, then click OK to save your changes and close the generic editor.

Adding an Attribute

Before you can add an attribute to an entry, the entry must contain an object class that either requires or allows the attribute. For more information, see "Managing Object Classes" on page 65 and Chapter 9, "Extending the Directory Schema."

To add an attribute to an entry:

1. Open the generic editor as described in "Invoking the Generic Editor" on page 60.
2. Make sure that the Show only Attributes with Values option is checked.
3. Click the Add Attribute button to display a dialog with a list of attributes. This list contains only attributes that are allowed by the object classes defined for the entry.
4. In the Add Attribute dialog, select the one or more attribute you wish to add.
5. Optionally, you may select either or both of the following subtypes from the drop-down lists at the top of the dialog:
   - Language subtype - Use this subtype to indicate the language used in the value of the attribute. You may add an attribute multiple times with a different languages to store localization information in your directory.

     Optionally, you may select the Pronunciation subtype in addition to a language to indicate that the value of this attribute contains a phonetic equivalent for the value in the given language.
   - Binary subtype - Assigning the binary subtype to an attribute indicates that the values should be transported over LDAP as binary data (opaque chunks of data) regardless of their actual syntax. This option should be used with caution. It is designed for complex syntaxes that do not have LDAP string representations, such as `userCertificate`. Do not use the binary subtype with attributes whose values are already considered binary.
6. Click OK once you have selected an attribute and its optional subtypes. The attribute is added alphabetically to the list in the generic editor.
7. Enter a new value for this attribute in the empty text field beside the new attribute name. You may use your system's clipboard to copy, cut, and paste text in this field.
8. Edit any other values or perform other modifications as desired to this entry, then click OK to save your changes and close the generic editor.

Removing an Attribute

To remove an attribute and all of its values from an entry:

1. Open the generic editor as described in "Invoking the Generic Editor" on page 60.

2. Scroll through the list of attributes and click on the attribute name you wish to remove. The selected attribute is highlighted and the Delete Attribute button is activated. If this button is not activated, the selected attribute is read-only, or you do not have write permission to modify it.

NOTE The generic editor allows you to remove attributes that are required by object classes that may be defined for this attribute. If you try to save the entry without a required attribute, the server will respond with an object class violation. Make sure your entry includes the required attributes for all object classes it defines.

---

3. Click the Delete Attribute button. The attribute and all of its text field values are removed.
4. Edit any other values or perform other modifications as desired to this entry, then click OK to save your changes and close the generic editor.

Managing Object Classes

The object classes of an entry are defined by the multi-valued `objectclass` attribute. The generic editor provides special dialogs when modifying this attribute to help you manage the defined object classes.

To add an object class to an entry:

1. Open the generic editor as described in "Invoking the Generic Editor" on page 60.
2. Scroll through the list of attributes and select the `objectclass` attribute. The Add Value button is activated. If this button is not activated, you do not have permission to modify this entry's object class.
3. Click the Add Value button.

   The Add Object Class dialog is displayed. It shows a list of object classes that you can add to the entry.
4. Select one or more object classes that you want to add to this entry and click OK. The object classes you selected will appear in the list of values for the `objectclass` attribute.
5. If the new object class has required attributes that did not already exist in your entry, the generic editor will add them automatically. You must provide a value for all of the required attributes.

6. Edit any other values or perform other modifications as desired to this entry, then click OK to save your changes and close the generic editor.

To remove an object class from an entry:

1. Open the generic editor as described in "Invoking the Generic Editor" on page 60.
2. Scroll through the list of attributes and click on the specific value of the `objectclass` attribute you wish to remove. The Delete Value button is activated if removing the selected object class is allowed by the schema and you have permission to modify this entry's object class.
3. Click the Delete Value button. The specific object class is removed.

   When you remove an object class, the generic editor will automatically remove any attributes that are not allowed or required by the remaining object classes. If one of the naming attributes was removed, another one will be selected automatically, and the console will inform you of this change.
4. Edit any other values or perform other modifications as desired to this entry, then click OK to save your changes and close the generic editor.

Renaming an Entry

The naming attributes are the attribute-value pairs of an entry that appear in its distinguished name (DN). The naming attributes are chosen from the existing attributes of an entry. Modify the naming attributes to rename an entry:

1. Open the generic editor as described in "Invoking the Generic Editor" on page 60.

   The text beside the Change button shows the current naming attributes for this entry. If the Show DN checkbox is selected, you can see these attributes in the DN below the list of attribute values.
2. Click on the Change button. If this button is not activated, you do not have permission to rename this entry.

   The Change Naming Attribute dialog is displayed.
3. Scroll through the list of attributes to choose the ones you wish to have in this entry's DN. Select or deselect the checkbox beside the attribute to add or remove from the naming attributes, respectively.

DNs of entries beneath the same parent must be unique. Therefore, you must choose naming attributes whose values or combination of values are unique. The server will refuse to save an entry if its DN is not unique. By convention, all entries such as those representing users should use the same naming attributes.

4. Click OK in the Change Naming Attribute dialog. The display in the generic editor shows the new DN of this entry.

5. Edit any other values or perform other modifications as desired to this entry, then click OK to save your changes and close the generic editor.

Deleting Directory Entries

To delete entries using Directory Server Console:

1. On the top-level Directory tab of Directory Server Console, expand the directory tree to display the entry that you wish to remove.

   You may also delete entire branches of the directory by selecting the root node of the subtree.

2. Right-click the entry and select the Delete item. Several alternate actions will also delete the entry:

   - Left-click the entry to select it, then select the Edit>Delete menu item. You may also use the Edit>Cut menu item if you wish to paste this entry elsewhere in the directory.

   - Left-click the entry to select it, then use the keyboard shortcut Control-D.

   When you have selected the View>Layout option to display children in the right-hand panel of Directory Server Console, you may select multiple entries for deletion using Control+click or Shift+click combinations.

3. Confirm that you wish to delete the entry or the subtree and all of its contents.

   The server deletes the entry or entries immediately. There is no undo. If you deleted more than one entry, the console will display an information dialog with the number of entries deleted and any errors that may have occurred.

Bulk Operations Using the Console

You can use an LDIF file to add multiple entries, to perform a mix of operations or to import an entire suffix. To add entries using an LDIF file and Directory Server Console:

1. Define the entries or operations in an LDIF file using the syntax shown in the previous sections. If you are only adding entries or initializing a suffix, you do not need `changetype` keywords, and your LDIF file may contain just entries. If you are performing a mix of operations, every DN should be followed by a `changetype` and, if applicable, the specific operation or attribute values.

2. Import the LDIF file from the Directory Server console. See "Importing LDIF Files" on page 159 for more information.

   If you are performing a mix of operations, be sure to deselect "Add only" on the Import LDIF dialog so that the server will perform all LDIF operations.

Managing Entries From the Command Line

The `ldapmodify` and `ldapdelete` command-line utilities provide full functionality for adding, editing, and deleting your directory contents. You can use them to manage both the configuration entries of the server and the data in the user entries. The utilities can also be used to write scripts to perform bulk management of one or more directories.

The `ldapmodify` and `ldapdelete` commands are used in procedures throughout this book. The following sections describe all basic operations you will need to perform these management procedures. Further functionality, all command-line options and return values of these commands are described in Chapter 4, "ldapmodify," and Chapter 5, "ldapdelete," of the *Directory Server Resource Kit Tools Reference*.

Input to the command-line utilities is always in LDIF, and can be provided provide either directly from the command-line or through an input file. The following section provides information about LDIF input, and subsequent sections describe the LDIF for each type of modification.

Providing LDIF Input

When providing LDIF input to the command-line utilities, there are special considerations to remember for command-line input, special characters, schema checking, and the ordering and size of entries. All directory data is stored using the UTF-8 encoding of Unicode. Therefore, any LDIF input you provide must also be UTF-8 encoded. The LDIF format is described in detail in Chapter 7, “LDAP Data Interchange Format Reference“ in the *Directory Server Administration Reference.*

NOTE Do not leave white space unintentionally at the end of an LDIF attribute value string. When Directory Server reads an attribute value ending in white space, it base 64 encodes the value.

Terminating LDIF Input on the Command Line

The `ldapmodify` and `ldapdelete` utilities read the LDIF statements that you enter after the command in exactly the same way as if they were read from a file. When you finish providing input, enter the character that your shell recognizes as the end of file (EOF) escape sequence.

- Typically, the EOF escape sequence is almost always Control-D (`^D`).

The following example shows how to terminate input to the `ldapmodify` command:

```
prompt> ldapmodify -h host -p port -D bindDN -w password
dn: cn=Barry Nixon,ou=People,dc=example,dc=com
changetype: modify
delete: telephonenumber
^D
prompt>
```

For simplicity and portability, examples in this document do not show prompts or EOF sequences.

Using Special Characters

When entering command options on the command line, you may need to escape characters that have special meaning to the command-line interpreter, such as space ( ), asterisk (*), backslash (\), and so forth. For example, many DNs contain spaces, and you must enclose the value in double quotation marks ("") for most UNIX shells:

```
-D "cn=Barbara Jensen,ou=Product Development,dc=example,dc=com"
```

Depending on your command-line interpreter, you should use either single or double quotation marks for this purpose. Refer to your operating system documentation for more information.

In addition, if you are using DNs that contain commas, you must escape the commas with a backslash (\). For example:

```
-D "cn=Patricia Fuentes,ou=People,o=example.com Bolivia\,S.A."
```

Note that LDIF statements after the `ldapmodify` command are being interpreted by the command, not by the shell, and therefore do not need special consideration.

Schema Checking

When adding or modifying an entry, the attributes you use must be required or allowed by the object classes in your entry, and your attributes must contain values that match their defined syntax.

When modifying an entry, Directory Server performs schema checking on the entire entry, not only the attributes being modified. Therefore, the operation may fail if any object class or attribute in the entry does not conform to the schema. For more information, see "Schema Checking" on page 355.

Ordering of LDIF Entries

In any sequence of LDIF text for adding entries, either on the command line or in a file, parent entries must be listed before their children. This way, when the server process the LDIF text, it will create the parent entries before the children entries.

For example, if you want to create entries in a People subtree that does not exist in your directory, then list an entry representing the People container before the entries within the subtree:

```
dn: dc=example,dc=com
dn: ou=People,dc=example,dc=com
...
People subtree entries
...
dn: ou=Group,dc=example,dc=com
...
Group subtree entries
...
```

You can use the `ldapmodify` command-line utility to create any entry in the directory, however, the root of a suffix or subsuffix is a special entry that must be associated with the necessary configuration entries. See "Creating Suffixes From the Command Line" on page 117, to add a new root suffix or subsuffix and its associated configuration entries.

Managing Large Entries

Before adding or modifying entries with very large attribute values, you may need to configure the server to accept them. To protect against overloading the server, clients are limited to sending data no larger than 2 MB by default.

If you add an entry larger than this, or modify an attribute to a value which is larger, the server will refuse to perform the operation and immediately close the connection. For example, binary data such as multi-media contents in one or more attributes of an entry may exceed this limit.

Also, the entry defining a large static group may contain so many members that their representation exceeds the limit. However, such groups are not recommended for performance reasons, and you should consider redesigning your directory structure. See "Managing Groups" on page 176 for more information.

To modify the size limit enforced by the server on data sent by clients:

1. Set a new value for the `nsslapd-maxbersize` attribute of the `cn=config` entry.

- To do this using the console, log on as Administrator or Directory Manager, and edit the `cn=config` entry according to the procedure in "Modifying Entries With the Generic Editor" on page 60. Set the `nsslapd-maxbersize` attribute to the maximum number of bytes that a client may send at once.

- To do this from the command line, use the following command:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: cn=config
changetype: modify
replace: nsslapd-maxbersize
nsslapd-maxbersize: sizeLimitInBytes
^D
```

  For more information, see "`nsslapd-maxbersize`" in Chapter 2 of the *Directory Server Administration Reference*.

2. Restart the server as described in "Starting and Stopping Directory Server" on page 25.

Error Handling

The command-line tools process all entries or modifications in the LDIF input sequentially. The default behavior is to stop processing when the first error occurs. Use the `-c` option to continue processing all input regardless of any errors. You will see the error condition in the output of the tool.

In addition to the considerations listed above, common errors are:

- Not having the appropriate access permission for the operation.
- Adding an entry with a DN that already exists in the directory.
- Adding an entry below a parent that does not exist.

For more information about error conditions and how to avoid them, see Chapter 4, "ldapmodify," and Chapte r5, "ldapdelete," of the *Directory Server Resource Kit Tools Reference*.

Adding Entries Using ldapmodify

You can add one or more entries to the directory by using the `-a` option of `ldapmodify`. The following example creates an structural entry to contain user and then creates a user entry:

```
ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
dn: ou=People,dc=example,dc=com
objectclass: top
objectclass: organizationalUnit
ou: People
description: Container for user entries

dn: uid=bjensen,ou=People,dc=example,dc=com
objectclass: top
objectclass: person
objectclass: organizationalPerson
objectclass: inetorgPerson
uid: bjensen
givenName: Barbara
sn: Jensen
cn: Babs Jensen
telephoneNumber: (408) 555-3922
facsimileTelephoneNumber: (408) 555-4000
mail: bjensen@example.com
userPassword: clearPassword
```

The `-D` and `-w` options give the bind DN and password, respectively, of a user with permissions to create these entries. The `-a` option indicates that all entries in the LDIF will be added. Then each entry is given by its DN and its attribute values, with a blank line between each entry. The `ldapmodify` utility will create each entry after it is entered and report any errors.

By convention, the LDIF of an entry lists the attributes in the following order:

- The list of object classes.
- The naming attribute or attributes. This is the attribute used in the DN, and it is not necessarily one of the required attributes.
- The list of required attributes for all object classes.
- Any allowed attributes that you wish to include.

When entering a value for the `userpassword` attribute, give the clear text version of the password. The server will encrypt this value and store only the encrypted value. Be sure to limit read permissions to protect clear passwords that appear in LDIF files.

You may also use an alternate form of the LDIF that does not require the -a option on the command line. The advantage of this form is that you may combine entry addition with entry modification statements shown in the next section.

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: ou=People,dc=example,dc=com
changetype: add
objectclass: top
objectclass: organizationalUnit
ou: People
description: Container for user entries

dn: uid=bjensen,ou=People,dc=example,dc=com
changetype: add
objectclass: top
objectclass: person
objectclass: organizationalPerson
objectclass: inetorgPerson
uid: bjensen
givenName: Barbara
sn: Jensen
cn: Barbara Jensen
```

```
telephoneNumber: (408) 555-3922
facsimileTelephoneNumber: (408) 555-4000
mail: bjensen@example.com
userPassword: clearPassword
```

The `changetype: add` keywords indicate that the entry with the given DN should be created with all of the subsequent attributes. All other options and LDIF conventions are the same.

In both examples you may use the `-f` *filename* option to read the LDIF from a file instead of from the terminal input. The LDIF file must contain the same format as used for the terminal input, according to the use of the `-a` option.

Modifying Entries Using ldapmodify

Use `changetype: modify` keywords to add, replace, or remove attributes and their values in an existing entry. When you specify `changetype: modify`, you must also provide one or more change operations to indicate how the entry is to be modified. The three possible LDIF change operations are shown in the following example:

```
dn: entryDN
changetype: modify
add: attribute
attribute: value
...
-
replace: attribute
attribute: newValue
...
-
delete: attribute
[attribute: value]
...
```

Use a hyphen (`-`) on a line to separate operations on the same entry and a blank line to separate groups of operations on different entries. You may also give several *attribute*: *value* pairs for each operation to add, replace with, or delete all of them together.

Adding an Attribute Value

The following example shows how you may use the same `add` LDIF syntax to add values to existing multivalued attribute and to attributes which do not exist yet:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: uid=bjensen,ou=People,dc=example,dc=com
changetype: modify
add: cn
cn: Babs Jensen
-
add: mobile
mobile: (408) 555-7844
mobile: (408) 555-7845
```

This operation may fail and the server will return an error if:

- The given value already exists for an attribute.
- The value does not follow the syntax defined for the attribute.
- The attribute type is not required or allowed by the entry's object classes.
- The attribute type is not multivalued and a value already exists for it.

Using the Binary Attribute Subtype

The *attribute*`;binary` subtype indicates that attribute values should be transported over LDAP as binary data, regardless of their actual syntax. This subtype is designed for complex syntaxes that do not have LDAP string representations, such as `userCertificate`. The binary subtype should not be used outside of this purpose.

Appropriate subtypes may be added to attribute names in any of the LDIF statements used with the `ldapmodify` command.

To enter a binary value, you may enter it directly in the LDIF text or read it from another file. The LDIF syntax for reading it from a file is shown in the following example:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
version: 1
dn: uid=bjensen,ou=People,dc=example,dc=com
changetype: modify
add: userCertificate;binary
userCertificate;binary:< file:///path/certFile
```

In order to use the `<` syntax to specify a filename, you must begin the LDIF statement with the line `version: 1`. When `ldapmodify` processes this statement, it will set the attribute to the value read from the entire contents of the given file.

Adding an Attribute with a Language Subtype

Language and pronunciation subtypes of attributes designate localized values. When you specify a language subtype for an attribute, the subtype is added to the attribute name as follows:

attribute;`lang-`*CC*

where *attribute* is an existing attribute type, and *CC* is the two-letter country code to designate the language. You may optionally add a pronunciation subtype to a language subtype to designate a phonetic equivalent for the localized value. In this case the attribute name becomes:

attribute;`lang-`*CC*;`phonetic`

To perform an operation on an attribute with a subtype, you must explicitly match its subtype. For example, if you want to modify an attribute value that has the `lang-fr` language subtype, you must include `lang-fr` in the modify operation as follows:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: uid=bjensen,ou=People,dc=example,dc=com
changetype: modify
replace: homePostalAddress;lang-fr
homePostalAddress;lang-fr: 34\, avenue des Champs-Elysées
```

Modifying an Attribute Value

The following example shows how you may modify a single-valued attribute and all values of a multi-valued attribute using the `replace` syntax in LDIF:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: uid=bjensen,ou=People,dc=example,dc=com
changetype: modify
replace: sn
sn: Morris
-
replace: cn
cn: Barbara Morris
cn: Babs Morris
```

When using the `replace` syntax, all current values of the specified attribute will be removed and all given values will be added.

Deleting an Attribute Value

The following example shows how to delete an attribute entirely and delete only one value of a multi-valued attribute:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: uid=bjensen,ou=People,dc=example,dc=com
changetype: modify
delete: facsimileTelephoneNumber
-
delete: cn
cn: Babs Morris
```

When using the `delete` syntax without specifying an *attribute: value* pair, all values of the attribute will be removed. If you specify an *attribute: value* pair, only that value will be removed.

Modifying One Value of a Multi-Valued Attribute

In order to modify one value of a multi-valued attribute with the `ldapmodify` command, you must perform two operations as shown in the following example:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: uid=bjensen,ou=People,dc=example,dc=com
changetype: modify
delete: mobile
mobile: (408) 555-7845
-
add: mobile
mobile: (408) 555-5487
```

Renaming an Entry Using ldapmodify

When you rename an entry, you modify its relative distinguished name (RDN), which is the left-most *attribute=value* pair in the entry's DN. This attribute is called the naming attribute and it must also exist with the same value among the entry's attributes.

When renaming an entry, you cannot change any other part of the DN such that the entry moves to a different subtree. To move an entry to a completely different branch you must create a new entry in the other subtree using the old entry's attributes, and then delete the old entry.

Also, you cannot rename an entry that has any children because the RDN of a parent is used in the DN of its children, and all entries in a DN must exist. To move an entire tree, you must recreate it in the new location.

Use the `changetype: modrdn` keywords to rename an entry with an LDIF statement. The following example will rename the `uid` naming attribute for Barbara Morris:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: uid=bjensen,ou=People,dc=example,dc=com
changetype: modrdn
newrdn: uid=bmorris
deleteoldrdn: 1
```

The `newrdn` line gives the new naming attribute using the *attribute=value* syntax. The `deleteoldrdn` line indicates whether the previous naming attribute should be removed from the entry at the same time (`1` is yes, `0` is no). In both cases, the new naming attribute will also be added to the entry.

Deleting Entries Using ldapdelete

Use the `ldapdelete` command-line utility to delete entries from the directory. This utility binds to the directory server and deletes one or more entries given by their DN. You must provide a bind DN that has permission to delete the specified entries.

For the same reason you cannot rename a parent entry, you cannot delete an entry that has children. The LDAP protocol forbids the situation where children entries would no longer have a parent. For example, you cannot delete an organizational unit entry unless you have first deleted all the entries that belong to the organizational unit.

CAUTION Do not delete the suffix `o=NetscapeRoot`. Administration Server uses this suffix to store information about installed Sun Java System servers. Deleting this suffix could force you to reinstall all of your Sun Java System servers, including Directory Server.

In the following example, there is only one entry in the organizational unit, so we can delete it and then the parent entry:

```
ldapdelete -h host -p port -D "cn=Directory Manager" -w password
uid=bjensen,ou=People,dc=example,dc=com
ou=People,dc=example,dc=com
```

Deleting Entries Using ldapmodify

You may also use the changetype: delete keywords to delete entries using the ldapmodify utility. All of the same limitations apply as when using ldapdelete described above. The advantage of the LDIF syntax for deleting entries is that you may perform a mix of operation in a single LDIF file.

The following example will perform the same delete operations as the previous example:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w  password
dn: uid=bjensen,ou=People,dc=example,dc=com
changetype: delete

dn: ou=People,dc=example,dc=com
changetype: delete
```

Setting Referrals

You can use referrals to tell client applications which server to contact if the information is not available locally. Referrals are pointers to a remote suffix or entry that Directory Server returns to the client in place of a result. The client must then perform the operation again on the remote server named in the referral. This redirection occurs in three cases:

- When a client application requests an entry that does not exist on the local server, the server returns the default referral.
- When an entire suffix has been taken offline for maintenance or security reasons, the server will return the referrals defined by that suffix. The suffix-level referrals are described in “Setting Access Permissions and Referrals” on page 121. Read-only replicas of a suffix also return referrals to the master servers when a client requests a write operation.
- You can create entries that are known as smart referrals. When a client specifically accesses a smart referral, the server will instead return the referral it defines. Directory Server Console can be configured to follow smart referrals automatically, so that they appear to be local entries on the top-level Directory tab.

In all cases, a referral is an LDAP URL that contains the hostname, port number and optionally a DN on another server. For more information, see Chapter 6, "LDAP URL Reference," in the *Directory Server Administration Reference*. For conceptual information on how you can use referrals in your directory deployment, see Chapter 5, "Distribution, Chaining, and Referrals," in the *Directory Server Deployment Planning Guide*.

The following sections describe the procedures for defining your directory's default referrals and defining smart referrals.

Setting the Default Referrals

Default referrals are returned to client applications that submit operations on a DN not contained within any of the suffixes maintained by your directory. Default referrals are sometimes called global referrals because they apply to all suffixes in the directory. The server will return all referrals that are defined, but the order in which they are returned is not defined.

Setting a Default Referral Using the Console

1. On the top-level Configuration tab of Directory Server Console, select the server node at the root of the configuration tree, and select the Network tab in the right-hand panel.
2. Select the Return Referral checkbox and enter an LDAP URL in the text field. Alternatively, click Construct URL to be guided through the definition of an LDAP URL. An example of an LDAP URL to a secure port is:

   ```
   ldaps://east.example.com:636/dc=example,dc=com
   ```

   You can enter multiple referral URLs separated by spaces and in quotes as follows:

   ```
   "ldap://east.example.com:389" "ldap://backup.example.com:389"
   ```

3. Click Save for your changes to take effect immediately.

Setting a Default Referral From the Command Line

Use the `ldapmodify` command-line utility to add or replace one or more default referrals to the `cn=config` entry in your directory configuration file. For example:

```
ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
dn: cn=config
changetype: modify
replace: nsslapd-referral
nsslapd-referral: ldap://east.example.com:389
nsslapd-referral: ldap://backup.example.com:389
```

You do not need to restart the server.

Creating Smart Referrals

Smart referrals allow you to map a directory entry or directory tree to a specific LDAP URL. Using smart referrals, you can refer client applications to a specific server or a specific entry on a specific server.

Often, a smart referral points to an actual entry with the same DN on another server. However, you may define the smart referral to any entry on the same server or on a different server. For example, you may define the entry with the following DN:

```
uid=bjensen,ou=People,dc=example,dc=com
```

to be a smart referral which points to another entry on the server `east.example.com`:

```
cn=Babs Jensen,ou=Sales,o=east,dc=example,dc=com
```

The way the directory uses smart referrals conforms to the standard specified in section 4.1.11 of RFC 2251 (`http://www.ietf.org/rfc/rfc2251.txt`).

Creating Smart Referrals Using the Console

1. On the top-level Directory tab of Directory Server Console, expand the directory tree to display the entry that you wish to be the parent of the smart referral.
2. Right-click the parent entry, and select the New>Referral menu item. Alternatively, you may left-click the parent entry to select it and then choose the Object>New>Referral menu item.

   The custom editor dialog for referral entries is displayed.
3. On the General tab of the editor, enter a name for the referral and select its naming attribute from the drop-down list. The name will be the value of the naming attribute you select. Optionally, you may enter a description string for this referral.

4. On the URLs tab of the editor, click the Construct button to define the URL of the smart referral. Enter the elements of an LDAP URL in dialog that appears.

   The elements of the URL include the host name and LDAP port number of the directory server that holds the referral entry, and the DN of the target entry on the server. By default, the target DN is the same DN as that of the smart referral entry. However, the target DN can be any suffix, subtree, or leaf entry.

5. Click OK in the LDAP URL construction dialog. The URL is displayed in the new referral text box.

6. Click Add beside the new referral text box to add the referral to the list.

7. You may defined more than one URL to return as referrals for this entry. Use the Construct, Add, Delete, and Change buttons to create and manage the Referral List.

8. Click the Referral Authentication button to display a dialog where you may set the credentials that Directory Server Console will use to bind when follow the referral to the remote server. You may define the bind DN and password that will be used when accessing a server. All referrals to the same server will use the same credentials.

9. Use the Add, Edit, and Delete buttons to manage the list of servers and corresponding credentials. Then click OK when you are done.

10. In the custom editor for referrals, click OK to save your smart referral entry.

    In the directory tree of the console, you should see the target subtree or entry in place of the smart referral entry. If you smart referral entry with a yellow warning icon, the URL or the credentials were invalid. Double click the entry, click Continue when you see the Referral Error, and modify the URL or Referral Authentication to fix the error.

Creating Smart Referrals From the Command Line

To create a smart referral, create an entry with `referral` and `extensibleObject` object classes. The referral object class allows the `ref` attribute that is expected to contain an LDAP URL. The `extensibleObject` object class allows you to use any schema attribute as the naming attribute, in order to match the target entry.

For example, define the following entry to return a smart referral instead of the entry `uid=bjensen`:

```
ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
dn: uid=bjensen,ou=People,dc=example,dc=com
objectclass: top
objectclass: extensibleObject
```

```
objectclass: referral
uid: bjensen
ref: ldap://east.example.com/cn=Babs%20Jensen,ou=Sales,
 o=east,dc=example,dc=com
```

NOTE Any information after a space in an LDAP URL is ignored by the server. For this reason, you must use `%20` instead of spaces in any LDAP URL you intend to use as a referral. Other special characters must be escaped.

Once you have defined the smart referral, modifications to the `uid=bjensen` entry will actually be performed on the `cn=Babs Jensen` entry on the other server. The `ldapmodify` command will automatically follow the referral, for example:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: uid=bjensen,ou=People,dc=example,dc=com
changetype: replace
replace: telephoneNumber
telephoneNumber: (408) 555-1234
```

In order to modify the smart referral entry, you must use the `-M` option of `ldapmodify`, for example:

```
ldapmodify -M -h host -p port -D "cn=Directory Manager" -w password
dn: uid=bjensen,ou=People,dc=example,dc=com
changetype: replace
replace: ref
ref: ldap://east.example.com/cn=Babs%20Jensen,ou=Marketing,
 o=east,dc=example,dc=com
```

Encrypting Attribute Values

Attribute encryption protects sensitive data while it is stored in the directory. Attribute encryption allows you to specify that certain attributes of an entry be stored in an encrypted format. This prevents data from being readable while stored in database files, backup files, and exported LDIF files.

With this feature, attribute values are encrypted before they are stored in the Directory Server database, and decrypted back to their original value before being returned to the client. You must use access controls to prevent clients from accessing such attributes without permission, and SSL to encrypt the attribute values when in transit between the client and Directory Server. For an architectural overview of data security in general and attribute encryption in particular, see Chapter 7, “Access Control, Authentication, and Encryption,” in the *Directory Server Deployment Planning Guide*.

Attribute encryption is active only when SSL is configured and enabled on the server. However, no attributes are encrypted by default. Attribute encryption is configured at the suffix level. This means that an attribute is encrypted for every entry in which it appears in a suffix. If you want to encrypt an attribute in an entire directory, you must enable encryption for that attribute in every suffix.

CAUTION Attribute encryption affects all data and index files associated with a suffix. If you modify the encryption configuration of an existing suffix, you *must* first export its contents, make the configuration change, and then re-import the contents. The console will help you perform these steps.

In addition, when turning on encryption, you must manually delete the database cache files that may still contain unencrypted values.

Preferably, you should enable any encrypted attributes before loading or creating data in a new suffix.

If you choose to encrypt an attribute that some entries use as a naming attribute, values that appear in the DN will not be encrypted, but values stored in the entry will be encrypted.

You may select the `userPassword` attribute for encryption, however this provides no real security benefit unless the password needs to be stored in the clear (as is the case for DIGEST-MD5 SASL authentication.) If the password already has an encryption mechanism defined in the password policy, further encryption provides little additional security but will impact performance of every bind operation.

When in storage, encrypted attributes are prefaced with a cipher tag that indicates the encryption algorithm used. An encrypted attribute using the DES encryption algorithm would appear as follows:

```
{CKM_DES_CBC}3hakc&jla+=snda%
```

Configuring Attribute Encryption Using the Console

1. Select the Configuration tab in Directory Server Console, expand the Data node, and select the suffix for which you wish to encrypt attribute values. Select the Attribute Encryption tab in the right panel.

   This tab contains a table listing the name and encryption scheme of all currently encrypted attributes for this suffix.

2. To enable encryption for an attribute:

   a. Click the Add Attribute button to display a list of attributes.

   b. Select the attribute you want to encrypt from the list and click OK. The attribute is added to the Attribute Name column of the table.

   c. Select the Encryption Scheme for this attribute from the drop-down list next to the attribute name.

3. To make an attribute no longer encrypted, select the attribute name from the table and click the Delete Attribute button.

4. Click Save. You will be prompted to export the contents of the suffix to an LDIF file before the configuration change is made.

5. Click Export suffix to open the export dialog or click Continue to modify the attribute encryption configuration without exporting. The new configuration will then be saved.

   If you have not already exported the suffix, you must do so now in order to save its contents. If the suffix contains encrypted attributes, you may leave them encrypted in the exported LDIF if you plan to reinitialize the suffix using this LDIF file in the next step.

   You will now be prompted to initialize the suffix from an LDIF file.

6. Click Initialize suffix now to open the initialization dialog and then enter the name of an LDIF file to load into the directory.

   If you exported your suffix with encrypted attributes in the previous step, you must use that file to initialize now, because the encrypted values will be unrecoverable once the suffix is reinitialized. As it is loaded and the indexes are created, all values of the specified attributes will be encrypted.

   Click Close if you do not wish to initialize the suffix at this time. You may import data at a later time using the procedures described in “Importing Data” on page 158.

7. If you have changed the configuration to encrypt one or more attributes, and these attributes had values before the import operation, some of those unencrypted values may still be visible in the database cache. To clear the database cache:

   a. Stop Directory Server as described in "Starting and Stopping Directory Server" on page 25.

   b. As root or having administrator privileges, delete the database cache files from your file system:

   ServerRoot/`slapd-`*serverID*`/db/__db.*`

   c. Start Directory Server again. The server will automatically create new database cache files.

Configuring Attribute Encryption From the Command Line

1. If the suffix on which you wish to configure attribute encryption contains any entries whatsoever, you must first export the contents of that suffix to an LDIF file. See "Exporting Data" on page 164 for more information.

   If the suffix contains encrypted attributes, you may leave them encrypted in the exported LDIF if you plan to reinitialize the suffix using this LDIF file in Step 5.

2. To enable encryption for an attribute, use the `ldapmodify` command to add the following configuration entry:

```
ldapmodify -a -h host -p port -D cn=Directory Manager -p password
dn: cn=attributeName, cn=encrypted attributes, cn=databaseName,
 cn=ldbm database, cn=plugins, cn=config
objectclass: top
objectclass: dsAttributeEncryption
cn: attributeName
dsEncryptionAlgorithm: cipherName
```

   where *attributeName* is the type name of the attribute to encrypt, *databaseName* is the symbolic name of the database corresponding to the suffix, and *cipherName* is one of the following:

   - `ckm_des_cbc` - DES block cipher
   - `ckm_des3_cbc` - Triple-DES block cipher

- `ckm_rc2_cbc` - RC2 block cipher
- `ckm_rc4` - RC4 stream cipher

3. To make an attribute no longer encrypted, use the `ldapmodify` command to modify the following configuration entry:

   ```
   ldapmodify -h host -p port -D cn=Directory Manager -p password
   dn: cn=attributeName, cn=encrypted attributes, cn=databaseName,
    cn=ldbm database, cn=plugins, cn=config
   changetype: modify
   replace: dsEncryptionAlgorithm
   dsEncryptionAlgorithm: clearText
   ```

   where *attributeName* is the type name of the attribute to encrypt, and *databaseName* is the symbolic name of the database corresponding to the suffix.

NOTE Do not delete the attribute encryption configuration entry. It will be removed automatically the next time the suffix is initialized.

4. If you have changed the configuration to encrypt one or more attributes, and these attributes had values before the import operation, some of those unencrypted values may still be visible in the database cache. To clear the database cache:

   a. Stop Directory Server as described in "Starting and Stopping Directory Server" on page 25.

   b. As root or having administrator privileges, delete the database cache files from your file system:

      ```
      ServerRoot/slapd-serverID/db/__db.*
      ```

   c. Start Directory Server again. The server will automatically create new database cache files. Performance of operations in this suffix may be slightly impacted until the cache is filled again.

5. Initialize the suffix with an LDIF file as described in "Importing Data" on page 158.

   As the file is loaded and the corresponding indexes are created, all values of the specified attributes will be encrypted.

Maintaining Referential Integrity

Referential integrity is a plug-in mechanism that ensures relationships between related entries are maintained. Several types of attributes, such as those for group membership contain the DN of another entry. Referential integrity can be used to ensure that when an entry is removed, all attributes which contain its DN are also removed.

For example, if a user's entry is removed from the directory and referential integrity is enabled, the server also removes the user from any groups of which the user is a member. If referential integrity is not enabled, the user must be manually removed from the group by the administrator. This is an important feature if you are integrating Directory Server with other Sun Java System products that rely on the directory for user and group management.

How Referential Integrity Works

When the referential integrity plug-in is enabled it performs integrity updates on specified attributes immediately after a delete or rename operation. By default, the referential integrity plug-in is disabled.

Whenever you delete or rename a user or group entry in the directory, the operation is logged to the referential integrity log file:

ServerRoot`/slapd-`*serverID*`/logs/referint`

After a specified time, known as the *update interval*, the server performs a search on all attributes for which referential integrity is enabled, and matches the entries resulting from that search with the DNs of deleted or modified entries present in the log file. If the log file shows that the entry was deleted, the corresponding attribute is deleted. If the log file shows that the entry was changed, the corresponding attribute value is modified accordingly.

When the default configuration of the referential integrity plug-in is enabled, it performs integrity updates on the `member`, `uniquemember`, `owner`, `seeAlso`, and `nsroledn` attributes immediately after every delete or rename operation. You can, however, configure the behavior of the referential integrity plug-in to suit your own needs:

- Record referential integrity updates in a different file.
- Modify the update interval. If you want to reduce the impact referential integrity updates has on your system, you may want to increase the amount of time between updates.

- Select the attributes to which you apply referential integrity. If you use or define attributes containing DN values, you may want the referential integrity plug-in to monitor them.

Configuring Referential Integrity

Use the following procedure to enable or disable referential integrity and configure the plug-in from Directory Server Console:

Configuring Referential Integrity From the Console

1. On the top-level Configuration tab of Directory Server Console, expand the Plugins node, and select the “referential integrity postoperation” plug-in.

   The settings for the plug-in are displayed in the right-hand panel.

2. Check the Enable plug-in check box to enable the plug-in, clear it to disable it.

3. Set the value of Argument 1 to modify the update interval in seconds. Common values are:

   - 0 - Update immediately after every operation. This is the default value. Be advised that immediate referential integrity checks after every delete and modify operation can significantly impact server performance.
   - 90 - Updates occur every 90 seconds
   - 3600 - Updates occur every hour
   - 10,800 - Updates occur every 3 hours
   - 28,800 - Updates occur every 8 hours
   - 86,400 - Updates occur once a day
   - 604,800 - Updates occur once a week

   Set a positive value, based on a compromise between integrity and overall performance.

4. Set the value of Argument 2 to the absolute path of the referential integrity log file you wish to use.

   Argument 3 is not used but it must be present.

5. The attributes monitored for referential integrity are listed beginning with Argument 4. Click the Add and Delete buttons to manage this list and add your own attributes.

NOTE For best performance, the attributes updated by the referential integrity plug-in should also be indexed. For information, see Chapter 10, “Indexing Directory Data.”

6. Click Save to save your changes.
7. For your changes to be taken into account, you must restart Directory Server.

Using Referential Integrity with Replication

There are certain limitations associated with the use of the referential integrity plug-in in a replication environment:

- It must be enabled on all servers containing master replicas.
- You must enable it with the same configuration on every master.
- It is not useful to enable it on servers containing only hub or consumer replicas.

To configure the referential integrity plug-in in a replication topology:

1. Make sure all replicas are configured and all replication agreements are defined.
2. Determine the set of attributes for which you will maintain referential integrity. Also determine the update interval you wish to use on your master servers.
3. Enable the referential integrity plug-in on all master servers using the same set of attributes and the same update interval. This procedure is described in “Configuring Referential Integrity” on page 89.
4. Ensure that the referential integrity plug-in is disabled on all consumer servers.

Using Referential Integrity With Legacy Replication

When replicating from a 4.x master to a 5.x consumer, with referential integrity enabled, you must reconfigure the referential integrity plug-in on the 4.x master to write referential integrity changes to the 4.x change log. This enables referential integrity changes to be replicated. *If you do not reconfigure the plug-in, referential integrity will not work correctly.*

To reconfigure the referential integrity plug-in in this environment:

1. Stop the 4.x server.

2. Open the `slapd.ldbm.conf` file located in *ServerRoot*/slapd-*ServerID/*config/.

3. Locate the line that begins

   ```
   plugin postoperation on "referential integrity postoperation"
   ```

4. Modify this line by changing the argument that appears just before the list of attributes from **0** to **1**.

   For example, change

   ```
   plugin postoperation on "referential integrity postoperation"
   "ServerRoot/lib/referint-plugin.dll" referint_postop_init 0
   "ServerRoot/slapd-serverID/logs/referint" 0 "member" "uniquemember"
   "owner" "seeAlso"
   ```

   to

   ```
   plugin postoperation on "referential integrity postoperation"
   "ServerRoot/lib/referint-plugin.dll" referint_postop_init 0
   "ServerRoot/slapd-serverID/logs/referint" 1 "member" "uniquemember"
   "owner" "seeAlso"
   ```

5. Save the `slapd.ldbm.conf` file.

6. Restart the server.

7. Reinitialize the 5.x consumer from the 4.x supplier.

Searching the Directory

You can locate entries in a directory using any LDAP client. Most clients provide some form of search interface that enables you to search the directory and retrieve entry information.

The access control that has been set in your directory determines the results of your searches. Common users typically do not “see” much of the directory, and directory administrators have full access to all data, including configuration.

Searching the Directory With ldapsearch

You can use the `ldapsearch` command-line utility to locate and retrieve directory entries. Note that the `ldapsearch` utility described in this section is not the utility provided with the Solaris platform, but is part of the Directory Server Resource Kit. For more information on this utility, refer to the *Directory Server Resource Kit Tools Reference*.

This utility opens a connection to the server with a specified a user identity (usually a distinguished name) and password, and locates entries based on a search filter. Search scopes can include a single entry, an entry's immediate subentries, or an entire tree or subtree.

Search results are returned in LDIF format.

ldapsearch Command-Line Format

When you use `ldapsearch`, you must enter the command using the following format:

`ldapsearch [`*optional_options*`] [`*search_filter*`] [`*optional_list_of_attributes*`]`

where

- *optional_options* represents a series of command-line options. These must be specified before the search filter, if any.
- *search_filter* represents an LDAP search filter as described in "LDAP Search Filters" on page 98. You must specify a search filter, unless you are supplying search filters in a file using the `-f` option.
- *optional_list_of_attributes* represents a list of attributes separated by a space. Specifying a list of attributes reduces the number of attributes returned in the search results. This list of attributes must appear after the search filter. For an example, see "Displaying Subsets of Attributes" on page 96. If you do not specify a list of attributes, the search returns values for all attributes permitted by the access control set in the directory (with the exception of operational attributes).

NOTE If you want operational attributes returned as a result of a search operation, you must explicitly specify them in the search command. To retrieve regular attributes in addition to explicitly specified operational attributes, use an asterisk (*) in the list of attributes in the ldapsearch command.

Using Special Characters

When using the `ldapsearch` command-line utility, you may need to specify values that contain characters that have special meaning to the command-line interpreter (such as space [ ], asterisk [*], backslash [\], and so forth). When you specify special characters, enclose the value in quotation marks (“”). For example:

```
-D "cn=Charlene Daniels,ou=People,dc=example,dc=com"
```

Depending on your command-line interpreter, use either single or double quotation marks for this purpose. Refer to your shell documentation for more information.

Commonly Used ldapsearch options

The following lists the most commonly used `ldapsearch` command-line options. If you specify a value that contains a space [ ], the value should be surrounded by double quotation marks, for example, `-b "ou=groups, dc=example,dc=com"`.

`-b`	Specifies the starting point for the search. The value specified here must be a distinguished name that currently exists in the database. This option is optional if the `LDAP_BASEDN` environment variable has been set to a base DN. The value specified in this option should be provided in double quotation marks. For example: `-b "cn=Charlene Daniels, ou=People, dc=example,dc=com"`
`-D`	Specifies the distinguished name with which to authenticate to the server. This option is optional if anonymous access is supported by your server. If specified, this value must be a DN recognized by Directory Server, and it must also have the authority to search for the entries. For example: `-D "uid=cdaniels, dc=example,dc=com"`
`-h`	Specifies the hostname or IP address of the machine on which Directory Server is installed. If you do not specify a host, `ldapsearch` uses the localhost. For example, `-h myServer`.

`-l`	Specifies the maximum number of seconds to wait for a search request to complete. Regardless of the value specified here, `ldapsearch` will never wait longer than is allowed by the server's `nsslapd-timelimit` attribute (except in the case of a persistent search.) For more information on persistent searches, see Chapter 3 "ldapsearch" in the *Directory Server Resource Kit Tools Reference*. For example, `-l 300`. The default value for the `nsslapd-timelimit` attribute is 3,600 seconds (1 hour.)
`-p`	Specifies the TCP port number that Directory Server uses. For example, `-p 5201`. The default is 389, and 636 when the SSL options are used.
`-s`	Specifies the scope of the search. The scope can be one of: • `base`—Search only the entry specified in the `-b` option or defined by the `LDAP_BASEDN` environment variable. • `one`—Search only the immediate children of the entry specified in the `-b` option. Only the children are searched; the actual entry specified in the `-b` option is not searched. • `sub`—Search the entry specified in the `-b` option and all of its descendants. That is, perform a subtree search starting at the point identified in the `-b` option. This is the default.
`-w`	Specifies the password associated with the distinguished name that is specified in the `-D` option. If you do not specify this option, anonymous access is used. For example, `-w diner892`.
`-x`	Specifies that the search results are sorted on the server rather than on the client. This is useful if you want to sort according to a matching rule, as with an international search. In general, it is faster to sort on the server rather than on the client, although server-side sorting uses server resources.
`-z`	Specifies the maximum number of entries to return in response to a search request. For example, `-z 1000`. Normally, regardless of the value specified here, `ldapsearch` never returns more entries than the number allowed by the server's `nsslapd-sizelimit` attribute. However, you can override this limitation by binding as the root DN when using this command-line argument. When you bind as the root DN, this option defaults to zero (0). The default value for the `nsslapd-sizelimit` attribute is 2,000 entries.

For detailed information on all `ldapsearch` utility options, refer to the *Directory Server Resource Kit Tools Reference*.

ldapsearch Examples

In the next set of examples, the following assumptions are made:

- You want to perform a search of all entries in the directory.
- The server is located on hostname **`myServer`**.
- The server uses port number **`5201`**.
- You are binding to the directory as **`Directory Manager`**, with a password of **`password`**.
- SSL is enabled for the server on port **`636`** (the default SSL port number).
- The suffix under which all data is stored is **`dc=example,dc=com`**.

Returning All Entries

Given the previous information, the following call will return all entries in the directory:

```
ldapsearch -h myServer -p 5201 -D "cn=directory manager" -w password
 -b "dc=example,dc=com" -s sub "(objectclass=*)"
```

`"(objectclass=*)"` is a search filter that matches any entry in the directory.

Specifying Search Filters on the Command Line

You can specify a search filter directly on the command line. If you do this, be sure to enclose your filter in quotation marks (“filter”). Also, do not specify the `-f` option. For example:

```
ldapsearch -h myServer -p 5201 -D "cn=directory manager" -w password
 -b "dc=example,dc=com" "(cn=Charlene Daniels)"
```

Searching the Root DSE Entry

The root DSE is a special entry that contains information related to the current server instance, such as a list of supported suffixes, available authentication mechanisms, and so forth. You can search this entry by supplying a search base of “”. You must also specify a search scope of `base` and a filter of `"(objectclass=*)"`. For example:

```
ldapsearch -h myServer -p 5201 -D "cn=directory manager" -w password
 -b "" -s base "(objectclass=*)"
```

Searching the Schema Entry

Directory Server stores all directory server schema in the special `cn=schema` entry. This entry contains information on every object class and attribute defined for your directory server.

You can examine the contents of this entry as follows:

```
ldapsearch -h myServer -p 5201 -D "cn=directory manager" -w password
 -b "cn=schema" -s base "(objectclass=*)"
```

NOTE For strict compliance, the location of the schema subentry for a given entry is specified by the `subschemaSubentry` operational attribute. In this version of Directory Server, the value of this attribute is always `cn=schema`.

Using LDAP_BASEDN

To make searching easier, you can set your search base using the `LDAP_BASEDN` environment variable. Doing this allows you to skip specifying the search base with the `-b` option (for information on how to set environment variables, see the documentation for your operating system).

Typically, you set `LDAP_BASEDN` to your directory's suffix value. Since your directory suffix is equal to the root, or topmost, entry in your directory, this causes all searches to begin from your directory's root entry.

For example, if you have set `LDAP_BASEDN` to `dc=example,dc=com`, you can search for `(cn=Charlene Daniels)` in your directory using the following command-line call:

```
ldapsearch -h myServer -p 5201 -D "cn=directory manager" -w password
 "(cn=Charlene Daniels)"
```

In this example, the default scope of `sub` is used because the `-s` option was not used to specify the scope.

Displaying Subsets of Attributes

The `ldapsearch` command returns all search results in LDIF format. By default, `ldapsearch` returns the entry's distinguished name and all of the attributes that you are allowed to read. You can set up the directory access control such that you are allowed to read only a subset of the attributes on any given directory entry.) Only operational attributes are not returned. If you want operational attributes returned as a result of a search operation, you must explicitly specify them in the search command. For more information on operational attributes, refer to Chapter 11, “Operational Attributes” in the *Directory Server Administration Reference*.

Suppose you do not want to see all of the attributes returned in the search results. You can limit the returned attributes to just a few specific attributes by specifying the ones you want on the command line immediately after the search filter. For example, to show the cn and sn attributes for every entry in the directory, use the following command:

```
ldapsearch -h myServer -p 5201 -D "cn=directory manager" -w password
 "(objectclass=*)" sn cn
```

This example assumes you set your search base with LDAP_BASEDN.

Searching Multi-Valued Attributes

During a search, Directory Server does not necessarily return multi-valued attributes in sorted order. For example, suppose you want to search for configuration attributes on cn=config requiring that the server be restarted before changes take effect.

```
ldapsearch -h myServer -p 5201 -D "cn=directory manager" -w password
 -b cn=config "(objectclass=*)" nsslapd-requiresrestart
```

The following result is returned:

```
dn: cn=config
nsslapd-requiresrestart: cn=config:nsslapd-port
nsslapd-requiresrestart: cn=config:nsslapd-secureport
nsslapd-requiresrestart: cn=config:nsslapd-plugin
nsslapd-requiresrestart: cn=config:nsslapd-changelogdir
nsslapd-requiresrestart: cn=config:nsslapd-changelogsuffix
nsslapd-requiresrestart: cn=config:nsslapd-changelogmaxentries
nsslapd-requiresrestart: cn=config:nsslapd-changelogmaxage
nsslapd-requiresrestart: cn=config:nsslapd-db-locks
nsslapd-requiresrestart: cn=config:nsslapd-return-exact-case
nsslapd-requiresrestart: cn=config,cn=ldbm database,cn=plugins,
  cn=config:nsslapd-allidsthreshold
nsslapd-requiresrestart: cn=config,cn=ldbm database,cn=plugins,
  cn=config:nsslapd-dbcachesize
nsslapd-requiresrestart: cn=config,cn=ldbm database,cn=plugins,
  cn=config:nsslapd-dbncache
nsslapd-requiresrestart: cn=config,cn=ldbm database,cn=plugins,
  cn=config:nsslapd-directory
nsslapd-requiresrestart:
cn=encryption,cn=config:nssslsessiontimeout
```

```
nsslapd-requiresrestart: cn=encryption,cn=config:nssslclientauth
nsslapd-requiresrestart: cn=encryption,cn=config:nssslserverauth
nsslapd-requiresrestart: cn=encryption,cn=config:nsssl2
nsslapd-requiresrestart: cn=encryption,cn=config:nsssl3
...
```

As shown here, the `nsslapd-requiresrestart` attribute takes multiple values. These values are not, however, in sorted order. If you develop an application that requires multi-valued attributes in sorted order, make sure that your application performs the sort.

Using Client Authentication When Searching

This example shows user `cdaniels` searching the directory using client authentication:

```
ldapsearch -h myServer -p 636 -b "dc=example,dc=com"
 -N  "cdanielsscertname" -Z -W certdbpassword
 -P /home/cdaniels/certdb/cert.db "(givenname=Richard)"
```

LDAP Search Filters

Search filters select the entries to be returned for a search operation. They are most commonly used with the `ldapsearch` command-line utility. When you use `ldapsearch`, you can place multiple search filters in a file, with each filter on a separate line in the file, or you can specify a search filter directly on the command line.

For example, the following filter specifies a search for the common name Lucie Du Bois:

```
(cn=Lucie Du Bois)
```

This search filter returns all entries that contain the common name Lucie Du Bois. Searches for common name values are not case sensitive.

When the common name attribute has values associated with a language tag, all of the values are returned. Thus, the following two attribute values both match this filter:

```
cn: Lucie Du Bois
```

```
cn;lang-fr: Lucie Du Bois
```

Search Filter Syntax

The basic syntax of a search filter is:

(*attribute operator value*)

For example:

```
(buildingname>=alpha)
```

In this example, `buildingname` is the attribute, >= is the operator, and **`alpha`** is the value. You can also define filters that use different attributes combined together with Boolean operators.

Search filters are described in detail in the following sections:

- Using Attributes in Search Filters
- Using Operators in Search Filters
- Using Compound Search Filters
- Search Filter Examples

Using Attributes in Search Filters

When searching for an entry, you can specify attributes associated with that type of entry. For example, when you search for people entries, you can use the `cn` attribute to search for people with a specific common name.

Examples of attributes that people entries might include:

- `cn` (the person's common name)
- `sn` (the person's surname, or last name, or family name)
- `telephoneNumber` (the person's telephone number)
- `buildingName` (the name of the building in which the person resides)
- `l` (the locality in which you can find the person)

For a listing of the attributes associated with types of entries, see the *Directory Server Administration Reference*.

Using Operators in Search Filters

The operators that you can use in search filters are listed in Table 2-2:

Table 2-2 Search Filter Operators

Search Type	Operator	Description
Equality	=	Returns entries containing attribute values that exactly match the specified value. For example, `cn=Bob Johnson`

Table 2-2 Search Filter Operators *(Continued)*

Search Type	Operator	Description

Substring	*=string* string*	Returns entries containing attributes containing the specified substring. For example,
		`cn=Bob*`
		`cn=*Johnson`
		`cn=*John*`
		`cn=B*John`
		(The asterisk (*) indicates zero (0) or more characters.)

Greater than or equal to	>=	Returns entries containing attributes that are greater than or equal to the specified value. For example, `buildingname >= alpha`
Less than or equal to	<=	Returns entries containing attributes that are less than or equal to the specified value. For example, `buildingname <= alpha`

Presence	=*	Returns entries containing one or more values for the specified attribute. For example,
		`cn=*`
		`telephonenumber=*`
		`manager=*`

Approximate	~=	Returns entries containing the specified attribute with a value that is approximately equal to the value specified in the search filter. For example,
		`cn~=suret`
		`l~=san fransico`
		could return
		`cn=sarette`
		`l=san francisco`
		The Approximate operator is experimental and works only with English language strings. It does not work with non-ASCII based strings, such as Ja or Zn.

Extended operators exist that extend searches to `dn` attributes (`cn:dn:=John`, for example) and provide support for internationalized searches.

Using Compound Search Filters

Multiple search filter components can be combined using Boolean operators expressed in prefix notation as follows:

(*Boolean-operator*(*filter*)(*filter*)(*filter*)...)

where *Boolean-operator* is any one of the Boolean operators listed in Table 2-3.

Boolean operators can be combined and nested together to form complex expressions, such as:

(*Boolean-operator*(*filter*)(*Boolean-operator*(*filter*)(*filter*)))

The Boolean operators available for use with search filters include the following:

Table 2-3 Search Filter Boolean Operators

Operator	Symbol	Description
AND	&	All specified filters must be true for the statement to be true. For example, `(&(filter)(filter)(filter)...)`
OR	|	At least one specified filter must be true for the statement to be true. For example, `(|(filter)(filter)(filter)...)`
NOT	!	The specified statement must not be true for the statement to be true. Only one filter is affected by the NOT operator. For example, `(!(filter))`

Boolean expressions are evaluated in the following order:

- Innermost to outermost parenthetical expressions first
- All expressions from left to right

Specifying Search Filters Using a File

You can enter search filters into a file instead of entering them on the command line. When you do this, specify each search filter on a separate line in the file. The `ldapsearch` command runs each search in the order in which it appears in the file.

For example, if the file contains:

```
(sn=Daniels)
(givenname=Charlene)
```

then `ldapsearch` first finds all the entries with the surname Daniels, and then all the entries with the givenname Charlene. If an entry is found that matches both search criteria, the entry is returned twice.

For example, suppose you specified the previous search filters in a file named searchdb, and you set your search base using LDAP_BASEDN. The following returns all the entries that match either search filter:

```
ldapsearch -h myServer -p 5201 -D "cn=directory manager" -w password
 -f searchdb
```

You can limit the set of attributes returned here by specifying the attribute names that you want at the end of the search line. For example, the following ldapsearch command performs both searches, but returns only the DN and the givenname and sn attributes of each entry:

```
ldapsearch -h myServer -p 5201 -D "cn=directory manager" -w password
 -f searchdb sn givenname
```

Specifying DNs that Contain Commas in Search Filters

When a DN within a search filter contains a comma as part of its value, you must escape the comma with a backslash (\). For example, to find everyone in the example.com Bolivia, S.A. subtree, use the following command:

```
ldapsearch -h myServer -p 5201 -D "cn=directory manager" -w password
-s base -b "o=example.com Bolivia\, S.A.,dc=example,dc=com"
"(objectclass=*)"
```

Search Filter Examples

The following filter searches for entries containing one or more values for the manager attribute. This is also known as a presence search:

```
(manager=*)
```

The following filter searches for entries containing the common name Ray Kultgen. This is also known as an equality search:

```
(cn=Ray Kultgen)
```

The following filter returns all entries that contain a description attribute that contains the substring X.500:

```
(description=*X.500*)
```

The following filter returns all entries whose organizational unit is Marketing and whose description field does not contain the substring X.500:

```
(&(ou=Marketing)(!(description=*X.500*)))
```

The following filter returns all entries whose organizational unit is Marketing and that have Julie Fulmer or Cindy Zwaska as a manager:

```
(&(ou=Marketing)(|(manager=cn=Julie Fulmer,ou=Marketing,
 dc=example,dc=com)(manager=cn=Cindy Zwaska,ou=Marketing,
 dc=example,dc=com)))
```

The following filter returns all entries that do not represent a person:

```
(!(objectClass=person))
```

Note that the previous filter will have a negative performance impact and should be used as part of a complex search. The following filter returns all entries that do not represent a person and whose common name is similar to printer3b:

```
(&(cn~=printer3b)(!(objectClass=person)))
```

Searching for Operational Attributes

If you want operational attributes returned as a result of a search operation, you must explicitly specify them in the search command.

```
ldapsearch -h myServer -p 5201 -D "cn=directory manager" -w password
 "(objectclass=*)" aci
```

To retrieve regular attributes in addition to explicitly specified operational attributes, specify "*" in addition to the operational attributes. For example:

```
ldapsearch -h myServer -p 5201 -D "cn=directory manager" -w password
 "(objectclass=*)" aci *
```

Accessing the Directory Using DSMLv2

The following examples indicate how to use DSML requests to access and search the directory. For a complete list of DSML-related attributes and information about the DSMLv2 standard, see the "Frontend Plugin Attributes," in Chapter 3 of the *Directory Server Administration Reference*.

This section contains the following examples:

- An Empty Anonymous DSML "Ping" Request
- Issuing a DSML Request to Bind as a Particular User
- A DSML Search Request

Note that the `content-length:` header in these examples contains the exact length of the DSMLv2 request. For these examples to function correctly, ensure that the editor you use respects these content lengths, or that you modify them accordingly.

An Empty Anonymous DSML “Ping” Request

The DSML front end is *disabled* by default. For information on how to enable it, refer to “Enabling DSML Requests” on page 45. To check whether the DSML front end is enabled, send an empty DSML batch request, as shown in Code Example 2-1:

Code Example 2-1 Empty Anonymous DSML Request

```
POST /dsml HTTP/1.1
content-length: 451
HOST: hostMachine
SOAPAction: ""
Content-Type: text/xml
Connection: close

<?xml version='1.0' encoding='UTF-8'?>
<soap-env:Envelope
   xmlns:xsd='http://www.w3.org/2001/XMLSchema'
   xmlns:xsi='http://www.w3.org/2001/XMLSchema-instance'
   xmlns:soap-env='http://schemas.xmlsoap.org/soap/envelope/'>

   <soap-env:Body>
      <batchRequest
          xmlns='urn:oasis:names:tc:DSML:2:0:core'
          requestID='Ping!'>
          <!-- empty batch request -->
      </batchRequest>
   </soap-env:Body>
</soap-env:Envelope>
```

The first section of this DSML request contains the HTTP method line (POST /dsml HTTP/1.1) followed by a number of HTTP headers. The HTTP method line specifies the HTTP method request and URL to be used by the DSML front end. `POST` is the only HTTP method request accepted by the DSML front end. The `/dsml` URL is the default URL for Directory Server, but can be configured with any other valid URL. The HTTP headers that follow, specify the remaining details of the DSML request.

- `content-length: 451`
  specifies the exact length of the SOAP/DSML request

- `HOST: hostMachine`
  specifies the name of the host Directory Server being contacted.
- `SOAPAction:`
  is mandatory and informs the directory that you want to perform a DSML request on the HTTP/SOAP stack. It may however, be left empty.
- `Content-Type: text/xml`
  must have a value of text/xml which defines the content as XML.
- `Connection: close`
  specifies that the connection will be closed once the request has been satisfied (the default HTTP/1.1 behavior is to maintain the connection open.)

The remainder of the request is the SOAP/DSML section. The DSML request begins with the XML prolog header:

```
<?xml version='1.0' encoding='UTF-8'?>
```

This specifies that the request must be encoded with the UTF-8 character set. The header is followed by the SOAP envelope and body elements that contain the mandatory inclusion of the XML schema, XML schema instance and SOAP namespaces.

The DSML batch request element marks the beginning of the DSML batch request, and is immediately followed by the mandatory inclusion of the DSMLv2 namespace:

```
xmlns='urn:oasis:names:tc:DSML:2:0:core'.
```

The request is optionally identified by the following request ID

```
requestID='Ping!'>
```

The empty batch request

```
<!-- empty batch request -->
```

is XML commented as such, and the SOAP/DSML batch request is closed using the close batch request, close SOAP body, and close SOAP envelope elements.

If the DSML front end is enabled, an empty DSML response is returned:

```
HTTP/1.1 200 OK
Cache-control: no-cache
Connection: close
Date: Mon, 09 Sep 2002 13:56:49 GMT
Accept-Ranges: none
Server: Sun-ONE-Directory/5.2
Content-Type: text/xml; charset="utf-8"
Content-Length: 500

<?xml version='1.0' encoding='UTF-8' ?>
<soap-env:Envelope
   xmlns:xsd='http://www.w3.org/2001/XMLSchema'
   xmlns:xsi='http://www.w3.org/2001/XMLSchema-instance'
   xmlns:soap-env='http://schemas.xmlsoap.org/soap/envelope/'
   >
<soap-env:Body>
<batchResponse
   xmlns:xsd='http://www.w3.org/2001/XMLSchema'
   xmlns:xsi='http://www.w3.org/2001/XMLSchema-instance'
   xmlns='urn:oasis:names:tc:DSML:2:0:core'
   requestID='Ping!'
   >
</batchResponse>
</soap-env:Body>
</soap-env:Envelope>
```

If nothing is returned, you can conclude that the front end is disabled.

Maximum limits exist for the number of clients connecting simultaneously to the directory and for the size of the DSML requests. The limit for the number of clients is specified by the `ds-dsml-poolsize` and `ds-dsml-poolmaxsize` attributes and the request size limit by the `ds-dsml-requestmaxsize` attribute. For more information on the DSML-related attributes, see the "Frontend Plug-In Attributes," section in Chapter 2 of the *Directory Server Administration Reference*.

Issuing a DSML Request to Bind as a Particular User

To issue a DSML request you can bind to the directory as a specified user or anonymously. To bind as a specified user, the request must include an HTTP authorization header containing a uid and a password that are mapped to a dn.

A sample HTTP authorization request follows:

```
POST /dsml HTTP/1.1
content-length: 578
Content-Type: text/xml; charset="utf-8"
HOST: hostMachine
Authorization: Basic ZWFzdGVyOmVnZw==
SOAPAction: ""
Connection: close

<?xml version='1.0' encoding='UTF-8'?>
<soap-env:Envelope
   xmlns:xsd='http://www.w3.org/2001/XMLSchema'
   xmlns:xsi='http://www.w3.org/2001/XMLSchema-instance'
   xmlns:soap-env='http://schemas.xmlsoap.org/soap/envelope/'>
   <soap-env:Body>
     <batchRequest
        xmlns='urn:oasis:names:tc:DSML:2:0:core'
        <extendedRequest>
          <requestName>1.3.6.1.4.1.4203.1.11.3</requestName>
        </extendedRequest>
     </batchRequest>
   </soap-env:Body>
</soap-env:Envelope>
```

In this example the HTTP authorization header transports the uid easter and the password egg, which, in clear, appears as `easter:egg`, and encoded in base64 as `Authorization: Basic ZWFzdGVyOmVnZw==`.

The `<extendedRequest>` tag is used to specify an LDAP Extended Operation. The `<requestName>` tag is used to specify the OID of the extended operation. In this example, the OID `1.3.6.1.4.1.4203.1.11.3` identifies the `whoami` extended operation. For more information on the `whoami` extended operation, see http://www.ietf.org/internet-drafts/draft-zeilenga-ldap-authzid-08.txt.

For anonymous access, no HTTP authorization header is required, although anonymous access is often subject to strict access controls, and possibly to data access restrictions. Similarly, you can issue DSML requests to perform LDAP operations by LDAP proxy.

Because DSML requests are managed on a batch basis, if you issue requests by LDAP proxy, the required DSML proxy authorization request must be the first in a given batch of requests.

A DSML Search Request

Code Example 2-2 shows a DSML base object search request on the root DSE entry.

Code Example 2-2 DSML Search Request

```
POST /dsml HTTP/1.1
HOST: hostMachine
Content-Length: 1081
Content-Type: text/xml
SOAPAction: ""
Connection: close

<?xml version='1.0' encoding='UTF-8'?>
<soap-env:Envelope
   xmlns:xsd='http://www.w3.org/2001/XMLSchema'
   xmlns:xsi='http://www.w3.org/2001/XMLSchema-instance'
   xmlns:soap-env='http://schemas.xmlsoap.org/soap/envelope/'
   >
   <soap-env:Body>
      <batchRequest
        xmlns='urn:oasis:names:tc:DSML:2:0:core'
        requestID='Batch of search requests'
        >
        <searchRequest
            dn=""
            requestID="search on Root DSE"
            scope="baseObject"
            derefAliases="neverDerefAliases"
            typesOnly="false"
            >
            <filter>
               <present name="objectClass"/>
            </filter>
            <attributes>
               <attribute name="namingContexts"/>
               <attribute name="supportedLDAPversion"/>
               <attribute name="vendorName"/>
               <attribute name="vendorVersion"/>
               <attribute name="supportedSASLMechanisms"/>
            </attributes>
        </searchRequest>
      </batchRequest>
   </soap-env:Body>
</soap-env:Envelope>
```

In this example:

- `dn=""`
  `requestID="search on Root DSE"`
  specifies that the search operation requests data under the root DSE entry (empty DN) and is identified with an optional request ID attribute.
- `scope="baseObject"`
  specifies that the search is a base object search.
- `derefAliases="neverDerefAliases"`
  specifies that the aliases should not be dereferenced while searching or locating the base object of the search. This is the only `derefAliases` value supported by Directory Server.
- `typesOnly="false"`
  specifies that both the attribute names and their values be returned. `typesOnly="true"` would return attribute names only. The default value for this attribute is false.

For the entry to match the filter, the presence of objectclass filter is used as follows:

```
<filter>
   <present name="objectClass"/>
</filter>
```

This is equivalent to the LDAP filter string (`objectclass=*`). The filter is followed by the list of desired attributes:

```
<attributes>
   <attribute name="namingContexts"/>
   <attribute name="supportedLDAPversion"/>
   <attribute name="vendorName"/>
   <attribute name="vendorVersion"/>
   <attribute name="supportedSASLMechanisms"/>
</attributes>
```

Chapter 3

Creating Your Directory Tree

The directory tree consists of all of the entries in your server, as identified by their distinguished name (DN). The hierarchical nature of the DN creates branches and leaves which structure the data in the tree. In order to manage the directory tree, it is defined administratively in terms of suffixes, subsuffixes, and chained suffixes. Directory Server Console provides the controls for creating and administering all of these elements, or you may use command-line tools.

For conceptual information on structuring directory data, and on suffixes in general, refer to Chapter 4, “The Directory Information Tree,” in the *Directory Server Deployment Planning Guide*.

This chapter includes the following sections:

Creating Suffixes

You can create both root suffixes and subsuffixes using either Directory Server Console or the command line.

Creating a New Root Suffix Using the Console

1. On the top-level Configuration tab of Directory Server Console, right-click on the Data node, and select New Suffix from the pop-up menu.

Alternatively, you may select the Data node and choose New Suffix from the Object menu.

The “New Suffix” dialog box is displayed.

2. Enter a unique suffix name in the Suffix DN field. The name must use the distinguished name format consisting of one or more attribute-value pairs separated by commas.

By convention, root suffixes use domain-component (`dc`) naming attributes. For example, you might enter `dc=example,dc=org` for a new suffix DN.

NOTE Suffix names contain attribute-value pairs in the DN format, but are treated as a single string. Therefore, all spaces are significant and are part of the suffix name.

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3. By default, the location of database files for this suffix is chosen automatically by the server. Also by default, the suffix will maintain only the system indexes, no attributes will be encrypted, and replication will not be configured.

To modify any of the defaults, click the Options button to display the new suffix options:

a. The name of the database is also the name of the directory containing database files. The default database name is the value of the first naming attribute in the suffix DN, possibly with a number appended for uniqueness. To use a different name, select the Use Custom radio button and enter a new, unique database name.

Database names may only contain ASCII (7-bit) alphanumeric characters, hyphens (-), and underscores (_). For example, you might name the new database `example_2`.

b. You may also choose the location of the directory containing database files. By default it is a subdirectory of the following path:

ServerRoot`/slapd-`*serverID*`/db`

Enter a new path or click Browse to find a new location for the database directory. The new path must be accessible on the directory server host.

   c. To speed up the configuration of your new suffix, you may choose to clone an existing suffix. Select the Clone Suffix Configuration and choose the suffix you wish to clone from the drop-down menu. Then select any of the following configurations to clone:

      - Clone index configuration - The new suffix will maintain the same indexes on the same attributes as the cloned suffix.
      - Clone attribute encryption configuration - The new suffix will enable encryption for the same list of attributes and the same encryption schemes as in the cloned suffix.
      - Clone replication configuration - The new suffix will be the same replica type as the cloned suffix, all replication agreements will be duplicated if it is a supplier, and replication will be enabled.

   d. Click OK when you have configured all of the new suffix options. The new suffix dialog will show all the options you chose.

4. Click OK in the new suffix dialog to create the new root suffix.

   The root suffix appears automatically under the Data branch. See "Managing Suffixes" on page 120, to further configure the new suffix.

   A new root suffix does not contain any entries, not even an entry for the suffix DN. Consequently, it will not be accessible in the directory nor visible in the Directory tab of the console until it has been initialized and given the appropriate access permissions.

   If you will initialize the suffix from an LDIF file you may skip the remaining steps. However, be sure the root entry in your LDIF file contains the access control instructions (ACIs) required by your deployment.

5. Select the top-level Directory tab of the console. The new suffix is not yet visible in the directory tree.

6. Only the directory manager has the right to create the top entry of a suffix. If you are not logged in as the directory manager, do so now by selecting the Console>Log in as New User menu item. Enter the DN and password of the directory manager to log in. By default, the directory manager DN is `cn=Directory Manager`.

7. Right-click on the root node of the directory tree, the one containing the server hostname and port. Select the New Root Object item from the pop-up menu and select the DN of the new root suffix.

   Alternatively, select the root node of the directory tree and then choose the New Root Object item from the Object menu.

8. In the New Object dialog that is displayed, select a single object class for the root object. This object class will determine what other attributes may be added to the root entry.

   By convention, root objects for suffix DNs containing `dc` naming attributes belong to the `domain` object class. Usually, root objects are simple objects and contain little data.

9. Click OK in the New Object dialog when you have selected the object class.

   The console now displays the generic editor for the new root object. The set of default ACIs is automatically added to the new object. See "Default ACIs" on page 209 for additional information. Add and edit any attribute values necessary for your topology, including any modifications to the set of ACIs.

10. When you have edited the entry, click OK in the Generic Editor to create the root object of the new suffix.

    The new suffix now appears in the directory tree and can be managed through the console, according to the rights given by the ACIs.

Creating a New Subsuffix Using the Console

The following procedure describes how to create a new subsuffix under an already existing root or subsuffix:

1. On the top-level Configuration tab of Directory Server Console, expand the Data node and any suffix node to display the parent suffix.

2. Right-click on the parent suffix node, and select New Subsuffix from the pop-up menu.

   Alternatively, you may select the parent suffix node and choose New Subsuffix from the Object menu.

   The "New Subsuffix" dialog box is displayed.

3. Enter a unique name in the Subsuffix RDNs field. The name must be in the relative distinguished name format consisting of one or more attribute-value pairs separated by commas, for example `ou=Contractors`.

   The line below the text box shows the complete DN of this subsuffix, consisting of the parent suffix DN appended to the RDNs.

NOTE Subsuffix names contain attribute-value pairs in the RDN format, but are treated as a single string. Therefore, all spaces are significant and are part of the suffix DN.

4. By default, the location of database files for this suffix is chosen automatically by the server. Also by default, the suffix will maintain only the system indexes, no attributes will be encrypted, and replication will not be configured.

   To modify any of the defaults, click the Options button to display the new suffix options:

   a. The name of the database is also the name of the directory containing database files. The default database name is the value of the first naming attribute in the RDN, possibly with a number appended for uniqueness. To use a different name, select the Use Custom radio button and enter a new, unique database name.

      Database names may only contain ASCII (7-bit) alphanumeric characters, hyphens (-), and underscores (_). For example, you might name the new database `temps-US`.

   b. You may also choose the location of the directory containing database files. By default it is a subdirectory of the following path:

      ServerRoot`/slapd-`*serverID*`/db`

      Enter a new path or click Browse to find a new location for the database directory. The new path must be accessible by the directory server application.

   c. To speed up the configuration of your new subsuffix, you may choose to clone an existing suffix, either its parent or any other suffix. Select the Clone Suffix Configuration and choose the suffix you wish to clone from the drop-down menu. Then select any of the following configurations to clone:

      - Clone index configuration - The new suffix will maintain the same indexes on the same attributes as the cloned suffix.

      - Clone attribute encryption configuration - The new suffix will enable encryption for the same list of attributes and the same encryption schemes as in the cloned suffix.

        - Clone replication configuration - The new suffix will be the same replica type as the cloned suffix, all replication agreements will be duplicated if it is a supplier, and replication will be enabled.

    d. Click OK when you have configured all of the new suffix options. The new subsuffix dialog will show all the options you chose.

5. Click OK in the new subsuffix dialog to create the subsuffix.

   The subsuffix appears automatically under its parent suffix in the Configuration tab. See "Managing Suffixes" on page 120, to further configure the new suffix.

   A new subsuffix does not contain any entries, not even an entry for the RDN. Consequently, it will not be accessible in the directory nor visible in the Directory tab of the console until it has been initialized and given the appropriate access permissions.

   If you initialize the suffix from an LDIF file you may skip the remaining steps. However, be sure the parent suffix and the new entries in your LDIF file contain the access control instructions (ACIs) required by your deployment.

6. On the top-level Directory tab of the console, expand the directory tree to display the parent of the subsuffix. The new subsuffix will not be visible yet.

7. Only the directory manager has the right to create the top entry of a suffix and subsuffix (ACI.) If you are not logged in as the directory manager, do so now by selecting the Console>Log in as New User menu item. Enter the DN and password of the directory manager to log in. By default, the directory manager DN is `cn=Directory Manager`.

8. Right-click on the parent of the subsuffix, and select the New item from the pop-up menu. In the list of new objects, select the type of object that corresponds to the RDN of the subsuffix. For example, choose the OrganizationalUnit item if you created the `ou=Contractors` subsuffix. If the object class of your subsuffix is not listed, select Other and choose it from list in the New Object dialog that is displayed. Alternatively, select the parent of the subsuffix and then choose the New item from the Object menu.

9. The console now displays the custom or generic editor for the new object. Add and edit any attribute values necessary for your topology, including any modifications to the set of ACIs.

10. When you have edited the entry, click OK in the Editor to create the entry for the new subsuffix.

    The new subsuffix now appears in the directory tree and can be managed through the console, according to the rights given by the ACIs.

Creating Suffixes From the Command Line

You may also use the `ldapmodify` command-line utility to create suffixes in your directory. Because root suffixes and subsuffixes are managed internally in the same way by the server, the procedure for creating them from the command line is nearly the same.

Although "cn=Directory Manager" is used in the following examples, the configuration entries can be created by any administrative user. However, the top entry of the suffix *must* be created by the directory manager.

1. Create the suffix configuration entry under `cn=mapping tree,cn=config` with the following command for a root suffix:

   ```
   ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
   dn: cn="suffixDN",cn=mapping tree,cn=config
   objectclass: top
   objectclass: extensibleObject
   objectclass: nsMappingTree
   cn: suffixDN
   nsslapd-state: backend
   nsslapd-backend: databaseName
   ^D
   ```

   For a subsuffix, use the same command with an additional attribute: `nsslapd-parent-suffix: "`*parentSuffixDN*`"`

   The *suffixDN* is the full DN of the new suffix. For a root suffix, the convention is to use the domain-component (`dc`) naming attribute, for example, `dc=example,dc=org`. In the case of a subsuffix, the *suffixDN* includes the RDN of the subsuffix and the DN of its parent suffix, for example `ou=Contractors,dc=example,dc=com`.

   The *databaseName* is a name for the internally managed database associated with this suffix. The name must be unique among the *databaseNames* of all suffixes, and by convention it is the value of the first naming component of the *suffixDN*. The *databaseName* is also the name of the directory containing database files for the suffix, and therefore should contain only ASCII (7-bit) alphanumeric characters, hyphens (-), and underscores (_).

   For a subsuffix, the *parentSuffixDN* is the exact DN of the parent suffix.

2. Create the database configuration entry with the following command:

```
ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
dn: cn=databaseName,cn=ldbm database,cn=plugins,cn=config
objectclass: top
objectclass: extensibleObject
objectclass: nsBackendInstance
cn: databaseName
nsslapd-suffix: suffixDN
^D
```

where *databaseName* and *suffixDN* must have the same value as those used in the previous step.

When this entry is added to the directory, the database module of the server will automatically create the database files in the following directory:

ServerRoot/`slapd-`*serverID*/`db/`*databaseName*

To make the server create the database files in another location, create the database configuration entry with the following attribute:

`nsslapd-directory:` *path*/*databaseName*

The server will automatically create a directory named *databaseName* in the give location to hold the database files.

3. Create the base entry of the root suffix or subsuffix.

For example, the base entry of the `dc=example,dc=org` root suffix can be created with the following command:

```
ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
dn: dc=example,dc=org
objectclass: top
objectclass: domain
dc: example
^D
```

You must include the first naming attribute of the DN and its value. You must also include all attributes that are required by the schema of the base entry's object class. By convention, root suffix DNs using domain-components (`dc`) have the `domain` object class, which does not require any other attributes.

You should also add access control instructions (ACI) attributes to a root suffix to enforce your access policy. The following are the `aci` attribute values you may add to allow anonymous reading, secure self-modification, and full administrator access:

```
aci: (targetattr != "userPassword") (version 3.0; acl
 "Anonymous access";
 allow (read, search, compare)userdn = "ldap:///anyone";)
aci: (targetattr != "nsroledn || aci || nsLookThroughLimit ||
 nsSizeLimit || nsTimeLimit || nsIdleTimeout ||
 passwordPolicySubentry || passwordExpirationTime ||
 passwordExpWarned || passwordRetryCount || retryCountResetTime
 || accountUnlockTime || passwordHistory ||
 passwordAllowChangeTime")(version 3.0; acl "Allow self entry
 modification except for nsroledn, aci, resource limit
 attributes, passwordPolicySubentry and password policy state
 attributes"; allow (write)userdn ="ldap:///self";)
aci: (targetattr = "*")(version 3.0; acl
 "Configuration Administrator";
 allow (all) userdn = "ldap:///uid=admin,ou=Administrators,
 ou=TopologyManagement, o=NetscapeRoot";)
aci: (targetattr ="*")(version 3.0;acl
 "Configuration Administrators Group";
 allow (all) (groupdn =
 "ldap:///cn=Configuration Administrators, ou=Groups,
 ou=TopologyManagement, o=NetscapeRoot");)
```

As an example of a subsuffix, the base entry for `ou=Contractors,dc=example,dc=com` can be created with the following command:

```
ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
dn: ou=Contractors,dc=example,dc=com
objectclass: top
objectclass: organizationalUnit
description: base of separate subsuffix for contractor identities
^D
```

You must include the naming attributes of the DN and their values. You must also include all attributes that are required by the schema of the base entry's object class, and you may add any others that are allowed. A subsuffix will have the access control defined by ACIs on its parent, provided the scope of those ACIs includes the new subsuffix. To define a different access policy on the subsuffix, specify your `aci` attributes when you create the base entry.

Managing Suffixes

Creating suffixes allows you to manage all of their contents together. This section explains how to manage access to the suffix, including disabling all operations, making the suffix read only and creating suffix-level referrals.

Many other directory administration tasks are configured at the suffix-level, but covered in separate chapters of this book:

- "Importing Data" on page 158.
- "Exporting Data" on page 164.
- "Managing Indexes" on page 376.
- "Encrypting Attribute Values" on page 83.
- "Managing Replication" on page 295.

Disabling or Enabling a Suffix

Sometime you may need to make a suffix unavailable for maintenance, or make its contents unavailable for security reasons. Disabling a suffix prevents the server from reading or writing the contents of the suffix in response to any client operations that try to access the suffix. If you have a default referral defined, that referral will be returned when clients attempt to access a disabled suffix.

Disabling or Enabling a Suffix Using the Console

1. On the top-level Configuration tab of Directory Server Console, expand the Data node and select the suffix you wish to disable.
2. In the right panel, select the Settings tab. By default, all suffixes are enabled when they are created.

   If you have enabled replication for this suffix, you will see a note informing you that the contents of this tab may be updated automatically. Disabling a suffix that is replicated will also interrupt replication to this suffix. As long as replication is not interrupted longer than the recover settings, the replication mechanism will resume updates to this replica when the suffix is enabled again. The replication recovery settings are the purge delay of this consumer replica and the maximum size and age of its supplier's change log (see "Advanced Consumer Configuration" on page 302).
3. Deselect the "Enable access to this suffix" checkbox to disable the suffix, or select the checkbox to enable it.

4. Click Save to apply the change and immediately disable or enable the suffix.
5. Optionally, you may set the global default referral that will be returned for all operations on this suffix while it is disabled. This setting is located on the Network tab of root node of the top-level Configuration tab. For more information, see "Setting a Default Referral Using the Console" on page 80.

Disabling or Enabling a Suffix From the Command Line

1. Edit the `nsslapd-state` attribute in the suffix's configuration entry with the following command:

   ```
   ldapmodify -h host -p port -D "cn=Directory Manager" -w password
   dn: cn="suffixDN",cn=mapping tree,cn=config
   changetype: modify
   replace: nsslapd-state
   nsslapd-state: disabled or backend
   ^D
   ```

   where *suffixDN* is the full string of the suffix DN as it was defined, including any spaces. Set the `nsslapd-state` attribute to the value `disabled` to disable the suffix and to the value `backend` to enable full access.

   The suffix will be disabled immediately when the command is successful.

2. Optionally, you may set the global default referral that will be returned for all operations on this suffix while it is disabled. For more information, see "Setting a Default Referral From the Command Line" on page 80.

Setting Access Permissions and Referrals

If you wish to limit access to a suffix without disabling it completely, you may modify the access permissions to allow read-only access. In this case you must define a referral to another server for write operations. You may also deny both read and write access and define a referral for all operations on the suffix.

Referrals can also be used to temporarily point a client application to a different server. For example, you might add a referral to a suffix so that the suffix points to a different server while backing up the contents of the suffix.

The replication mechanism relies on write permissions and referrals to configure the suffix for replication. Enabling replication, promoting a replica, or demoting a replica will modify the referral settings.

CAUTION If the suffix is replicated, modifying the referrals may affect the replicated behavior of this suffix.

Setting Access Permissions and Referrals Using the Console

1. On the top-level Configuration tab of the Directory Server console, expand the Data node and select the suffix where you wish to set a referral.

2. In the right panel, select the Settings tab. You will only be able to set permissions and referrals if the chained suffix is enabled. If you have enabled replication for this suffix, you will see a note informing you that the contents of this tab may be updated automatically.

3. Select one of the following radio buttons to set the response to any write operation on entries in this suffix:

- Process write and read requests - This radio button is selected by default and represents the normal behavior of a suffix. Referrals may be defined, but they will not be returned.
- Process read requests and return a referral for write requests - Select this radio button if you wish to make your suffix read-only and enter one or more LDAP URLs in the list to be returned as referrals for write requests.
- Return a referral for both read and write requests - Select this radio button if you wish to deny both read and write access. This behavior is similar to disabling access to the suffix, except that the referrals may be defined specifically for this suffix instead of using the global default referral.

4. Edit the list of referrals with the Add and Remove buttons. Clicking the Add button will display a dialog for creating an LDAP URL of a new referral. You may create a referral to the DN of any branch in the remote server. For more information about the structure of LDAP URLs, refer to Chapter 6, “LDAP URL Reference,” in the *Directory Server Administration Reference.*

You can enter multiple referrals. The directory will return all referrals in this list in response to requests from client applications.

5. Click Save to apply you changes and immediately begin enforcing the new permissions and referral settings.

Setting Access Permissions and Referrals From the Command Line

Referrals are labeled URLs, that is, an LDAP URL possibly followed by a space character and a label. Because space characters are significant, any space characters in the URL part of the referral must be escaped using `%20`.

In the following command, *suffixDN* is the full string of the suffix DN as it was defined, including any spaces. *LDAPURL* is a valid URL containing the hostname, port number and DN of the target, for example:

```
ldap://phonebook.example.com:389/ou=All%20People,dc=example,dc=com
```

1. Edit the suffix's configuration entry with the following command:

   ```
   ldapmodify -h host -p port -D "cn=Directory Manager" -w password
   dn: cn="suffixDN",cn=mapping tree,cn=config
   changetype: modify
   replace: nsslapd-state
   nsslapd-state: referral on update or referral
   -
   add: nsslapd-referral
   nsslapd-referral: LDAPURL
   ^D
   ```

   You may repeat the last change statement to add any number of LDAP URLs to the `nsslapd-referral` attribute.

   When the value of nsslapd-state is `referral on update`, the suffix is read-only and all LDAP URLs will be returned as referrals for write operations. When the value is `referral`, both read and write operations are denied and the referrals are returned for any request.

2. The suffix will become read-only or inaccessible and ready to return referrals immediately after the command is successful.

Deleting a Suffix

Deleting a suffix removes its entire branch from the directory. You may delete a parent suffix and keep its subsuffixes in the directory as new root suffixes.

CAUTION When you delete a suffix, you permanently remove all of its entries from the directory and remove all configuration of the suffix, including its replication configuration.

Deleting a Suffix Using the Console

1. On the Configuration tab of Directory Server Console, expand the Data node.
2. Right-click on the suffix you wish to remove, and select Delete from the pop-up menu.

   Alternatively, you may select the suffix node and choose Delete from the Object menu.
3. A confirmation dialog appears to inform you that all suffix entries will be removed from the directory.

   In addition for a parent suffix, you have the choice of recursively deleting all of its subsuffixes. Select "Delete this suffix and all of its subsuffixes" if you want to remove the entire branch. Otherwise, select "Delete this suffix only" if you want to remove only this particular suffix, and keep its subsuffixes in the directory.
4. Click OK to delete the suffix.

   A progress dialog box is displayed that tells you the steps being completed by the console.

Deleting a Suffix From the Command Line

To delete a suffix from the command line, use the `ldapdelete` command to remove its configuration entries from the directory.

If you wish to delete an entire branch containing subsuffixes, you must find the subsuffixes of the deleted parent and repeat the procedure for each of them and their possible subsuffixes.

1. Remove the suffix configuration entry using the following command:

   ```
   ldapdelete -h host -p port -D "cn=Directory Manager" -w password \
              -v 'cn="suffixDN",cn=mapping tree,cn=config'
   ```

   This command removes the suffix from the server, starting with the base entry at the *suffixDN*. Now the suffix is no longer visible nor accessible in the directory. The `-v` option specifies verbose output mode: additional information about the delete operation is displayed.
2. Remove the corresponding database configuration entry located in `cn=`*databaseName*`,cn=ldbm database,cn=plugins,cn=config` and all entries below it. The following command uses the `ilash` command to achieve this recursive delete.

```
% ilash -call "http://host:port/" -user "cn=Directory Manager"
[...]
Enter password for "cn=Directory Manager": password
[...]
[example,com]% dcd cn=config
[config]% ddelete -subtree \
"cn=databaseName,cn=ldbm database,cn=plugins,cn=config"

Removed cn=aci, cn=index, cn=databaseName, cn=ldbm database,
cn=plugins, cn=config

Removed cn=entrydn, cn=index, cn=databaseName, cn=ldbm database,
cn=plugins, cn=config

[...]

Removed cn=encrypted attributes, cn=databaseName, cn=ldbm database,
cn=plugins, cn=config

Removed cn=index, cn=databaseName, cn=ldbm database, cn=plugins,
cn=config

Removed cn=monitor, cn=databaseName, cn=ldbm database, cn=plugins,
cn=config

Removed cn=databaseName,cn=ldbm database,cn=plugins,cn=config
```

This output shows all of the index configuration entries that were associated with the database and that needed to be removed. When the database configuration is entirely deleted, the server will remove all database files and directories associated with this suffix.

Creating Chained Suffixes

Both root suffixes and subsuffixes may be chained to another server, and both procedures may be performed through the console or from the command line.

However, before you create any chained suffixes, you should create a proxy identity on the remote server. The local server will use the proxy identity to bind to the remote server when forwarding an operation through the chained suffix.

If you are configuring many chained suffixes with identical parameters, you should also set default values for the chaining parameters of new chained suffixes. At any time before or after creating chained suffixes, you may also set the chaining policy for LDAP controls and server components, as described in "Configuring the Chaining Policy" on page 138.

Creating a Proxy Identity

The proxy identity is a user on the remote server that the local server will use to bind and forward the chained operation. For security reasons you should never use the Directory Manager or the Administrative user (`admin`) for proxying.

Instead, create a new identity that will be used only for chained operations from a given server. Create this identity on all servers that will be chained and on all failover servers defined in "Creating Chained Suffixes Using the Console" on page 130 or "Modifying the Chaining Policy Using the Console" on page 141. The proxy identity must have full access to the chained suffix

Creating a Proxy Identity Using the Console

This procedure applies to the Directory Server Console connected to the remote server that is the target of a chained suffix.

1. On the top-level Directory tab of Directory Server Console, expand the directory tree.
2. Right-click on the `cn=config` entry and select New>User from the pop-up menu. Alternatively, select the `cn=config` entry and choose the New>User item from the Object menu.
3. Fill in the fields of the Create New User dialog with values to describe the proxy identity, for example:

First Name:	`proxy`
Last Name:	*host1*
Common Name:	*host1* `chaining proxy`
User ID:	*host1*`_proxy`
Password:	*password*
Confirm Password:	*password*

   where *host1* is the name of the server containing the chained suffix. You should use a different proxy identity for each server that has a suffix chained to this server.

4. Click OK to save this new proxy identity.

Creating a Proxy Identity From the Command Line

This procedure uses *host1* and *host2* to refer to the local server containing the chained suffix and the remote server that is the target of a chained suffix, respectively.

1. Use the following command to create the proxy identity on *host2*:

```
ldapmodify -a -h host2 -p port2 -D "cn=Directory Manager"-w password2
dn: uid=host1_proxy,cn=config
objectclass: top
objectclass: person
objectclass: organizationalPerson
objectclass: inetorgperson
uid: host1_proxy
cn: host1 chaining proxy
sn: host1
userpassword: password
description: proxy entry to be used for chaining fromhost1
^D
```

CAUTION You should perform the `ldapmodify` command through an encrypted port to avoid sending a clear password.

Setting Default Chaining Parameters

Chaining parameters determine how the server connects to a chained server and processes operations on that chained suffix. These parameters are configured on each chained suffix. Directory Server provides default values that are used every time a chained suffix is created. You may edit these default values to specify the chaining parameters on all new chained suffixes.

Every new chained suffix created after you modify the default parameters will have the values you specify. However, once a suffix is created you may only modify the parameters as described in "Managing Chained Suffixes" on page 138.

The attributes and default values for the chaining parameters are described below. Refer to "Chained Suffix Plug-in Attributes" in Chapter 2 of the *Directory Server Administration Reference* for a description of allowed values:

Client Return Parameters

- `nsReferralOnScopedSearch` - When on by default, clients searches with a scope entirely within the chained suffix will receive a referral to the remote server. This avoids transmitting the search results twice. When set to off, you should set the size and time limit parameters to avoid long searches on chained suffixes.

- `nsslapd-sizelimit` - This parameter determines the number of entries that will be returned in response to the chained search operation. The default size limit is 2000 entries. Set this parameter to a low value if you wish to limit broad searches involving the chained suffix. In any case, the operation will be limited by any size settings on the remote server.
- `nsslapd-timelimit` - This parameter controls the length of time for chained operation. The default time limit is 3600 seconds (one hour). Set this parameter to a low value if you wish to limit the time allowed for operations on the chained suffix. In any case, the operation will be limited by any time settings on the remote server.

Cascading Chaining Parameters

- `nsCheckLocalACI` - In single-level chaining, the local server does not check the access rights of the bound user on the chained suffix because that is the responsibility of the remote server. Therefore, the default value is `off`. However, intermediate servers in a cascading chain must set this parameter to `on` in order to check and limit the access rights of the proxy DN used by the server that is forwarding the chained operation.
- `nsHopLimit` - Loop detection relies on this parameter to define the maximum number of hops allowed. Any chained operation that reaches this number of hops will not be forwarded but instead abandoned under the assumption there is an accidental loop in the cascading topology.

Connection Management Parameters

- `nsOperationConnectionsLimit` - Maximum number of simultaneous LDAP operation connections that the chained suffix can establish with the remote server. The default value is 10 connections.
- `nsBindConnectionsLimit` - The maximum number of simultaneous bind connections that the chained suffix can establish with the remote server. The default value is 3 connections.
- `nsConcurrentBindLimit` - Maximum number of simultaneous bind operations per LDAP connection. The default value is 10 outstanding bind operations per connection.
- `nsBindRetryLimit` - Number of times a chained suffix attempts to rebind to the remote server upon error. A value of 0 indicates that the chained suffix will try to bind only once. The default value is 3 attempts.

- `nsConcurrentOperationsLimit` - Maximum number of simultaneous operations per LDAP connection. The default value is 10 operations per connection.
- `nsBindTimeout` - Amount of time, in seconds, before the bind attempts to the chained suffix will time out. The default value is 15 seconds.
- `nsAbandonedSearchCheckInterval` - Number of seconds before the server checks to see if an operation has been abandoned. The default value is 2 seconds.
- `nsConnectionLife` - How long a connection made between the chained suffix and remote server remains open so that it may be reused. It is faster to keep the connections open, but it uses more resources. For example, if you are using a dial-up connection you may want to limit the connection time. By default, connections are unlimited, which is defined by the value 0.

Error Detection Parameters

- `nsmaxresponsedelay` - Maximum amount of time a remote server may take to respond to the initiation of an LDAP request for a chained operation. This period is given in seconds. After this delay, the local server will test the connection. The default delay period is 60 seconds.
- `nsmaxtestresponsedelay` - Duration of the test to check whether the remote server is responding. The test is a simple search request for an entry which does not exist. This period is given in seconds. If no response is received during the test delay, the chained suffix assumes the remote server is down. The default test response delay period is 15 seconds.

  If you have defined only one remote server for this chained suffix, all chained operations to remote server will be blocked for 30 seconds to protect against overloading. If you have defined failover servers, chained operations will begin using the next alternate server defined.

Setting Default Chaining Parameters Using the Console

1. On the top-level Directory tab of the Directory Server console, expand the directory tree and select the following entry: `cn=default instance config,cn=chaining database,cn=plugins,cn=config`.
2. Double click this entry or select the Object>Edit with Generic Editor menu item. Modify the values of the desired attributes from the list above.
3. Click Save in the Generic Editor dialog, and the changes will take effect immediately.

Setting Default Chaining Parameters From the Command Line

1. Use the `ldapmodify` command to edit the entry `cn=default instance config,cn=chaining database,cn=plugins,cn=config`. All attributes of this entry become the default values of the parameters in a new chained suffix.

   For example, the following command will increase the default size limit to 5000 entries and decrease the default time limit to 10 minutes in new chained suffixes:

   ```
   ldapmodify -h host -p port -D "cn=Directory Manager" -w password
   dn: cn=default instance config,cn=chaining database,
    cn=plugins,cn=config
   changetype: modify
   replace: nsslapd-sizelimit
   nsslapd-sizelimit: 5000
   -
   replace: nsslapd-timelimit
   nsslapd-timelimit: 600
   ^D
   ```

   Modifications to this entry will take effect immediately.

Creating Chained Suffixes Using the Console

The following procedure is nearly identical for creating chained root suffixes and chained subsuffixes:

1. Select the Configuration tab of Directory Server Console.

   - For a chained root suffix, right-click on the Data node, and select New Chained Suffix from the pop-up menu. Alternatively, you may select the Data node and choose New Chained Suffix from the Object menu.

   - For a chained subsuffix, expand the Data node and any suffix node to display the parent suffix. Right-click on the parent suffix node, and select New Chained Subsuffix from the pop-up menu. Alternatively, you may select the parent suffix node and choose New Chained Subsuffix from the Object menu.

     The "New Chained (Sub)Suffix" dialog is displayed.

2. Enter the DN of the entry on the remote server to which you want to chain. The remote entry does not necessarily have to be the base entry of a remote suffix:

- For a root suffix, enter the full DN of the remote entry in the Suffix DN field. You may enter any DN that is an entry in the remote directory tree. That entry will be the base of the chained root suffix and everything below it will be available through the chained suffix.
- For a subsuffix, enter the subsuffix RDNs of the entry that will be chained. That entry will be the base of the chained subsuffix. The complete subsuffix name that appears below the text field must be an entry that exists in the remote server.

3. Enter the hostname of the remote server containing the suffix data, including the domain if necessary.
4. Enter the port number for accessing the remote server and select the checkbox if this is the secure port. When using a secure port, the chaining operation will be encrypted over SSL. For more information, refer to "Chaining Using SSL" on page 137.

   The text at the bottom of the dialog will show the full URL of the remote server.
5. Enter the bind DN and password of the proxy identity on the remote server. The local server will use this DN as a proxy when accessing contents of the suffix on the remote server. For example, use the `uid=`*host1*`_proxy,cn=config` DN defined in "Creating a Proxy Identity" on page 126.

   You cannot use the DN of the Directory Manager on the remote server. Operations performed through the chained suffix will use this proxy identity in the `creatorsName` and `modifiersName` attributes. You may omit the proxy DN, in which case the local server will bind anonymously when accessing the remote server.
6. Click OK to create the chained suffix. The new suffix will appear in the configuration tree with the icon for chaining.
7. Click on the new chained suffix to select it, and select the Remote Server tab in the right-hand panel.
8. Optionally, you may define one or more failover servers for this chained suffix. If the server cannot contact the remote server, it will try each of the failover servers in the order defined until one of them responds. Failover servers must contain the same suffix that is being chained and allow the same bind DN for proxying.

   To define failover servers, enter more hostname and port number pairs, separated by spaces in the Remote Server URL field. This field has the following format:

   ```
   ldap[s]://hostname[:port][ hostname[:port]].../
   ```

9. At the bottom of the Remote Servers tab, the text box displays the ACI needed to allow the proxied operation through chaining. You must add this ACI to the entry with the *suffixDN* on the remote server. If you defined any failover servers, you should add the ACI to all of them. Use the Copy ACI button to copy the ACI text to your system's clipboard for pasting.

   Once this ACI is added to the base entry on the remote server, the chained suffix will be visible in the directory tree of the local server.

CAUTION You may need to define other ACIs on the same entry to restrict access to the remote server that is now exposed through chaining. See "Access Control Through Chained Suffixes" on page 136.

10. If you have configured the chaining policy for server components, you must also add ACIs that will allow those components to access the remote server. For example, if you allow the referential integrity plug-in to chain, you must add the following ACI to the base entry whose DN was given in Step 2:

```
aci: (targetattr "*")
 (target="ldap:///suffixDN")
 (version 3.0; acl "RefInt Access for chaining"; allow
 (read,write,search,compare) userdn = "ldap:///cn=referential
 integrity postoperation,cn=plugins,cn=config";)
```

Creating Chained Suffixes From the Command Line

You may also use the `ldapmodify` command-line utility to create chained suffixes in your directory. Because chained root suffixes and chained subsuffixes are managed internally in the same way by the server, the procedure for creating them from the command line is nearly the same.

1. Create the chained suffix entry under `cn=mapping tree,cn=config` with the following command for a chained root suffix:

```
ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
dn: cn=suffixDN,cn=mapping tree,cn=config
objectclass: top
objectclass: extensibleObject
objectclass: nsMappingTree
```

```
cn: suffixDN
nsslapd-state: backend
nsslapd-backend: databaseName
^D
```

For a chained subsuffix, use the same command with an additional attribute: `nsslapd-parent-suffix:` *parentSuffixDN*

In the case of a chained subsuffix, the *suffixDN* is the RDN of the subsuffix and the DN of its parent suffix, for example `l=Europe,dc=example,dc=com`. The *suffixDN* must be the DN of an entry available through the remote server, but it does not necessarily have to be the base entry of a remote suffix.

Suffix names are in the DN format but are treated as a single string. Therefore, all spaces are significant and are part of the suffix name. In order for the server to access the remote entry, the *suffixDN* string must respect the same spacing used in the remote suffixes.

The *databaseName* is used by the chaining plug-in component to identify this chained suffix. The name must be unique among the *databaseNames* of all suffixes, and by convention it is the value of the first naming component of the *suffixDN*. Unlike a local suffix, chained suffixes do not have any database files on the local server.

For a subsuffix, the *parentSuffixDN* is the exact DN of the parent suffix. The parent may be either a local suffix or a chained suffix.

2. Create the chaining configuration entry with the following command:

```
ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
dn: cn=databaseName,cn=chaining database,cn=plugins,cn=config
objectclass: top
objectclass: extensibleObject
objectclass: nsBackendInstance
cn: databaseName
nsslapd-suffix: suffixDN
nsfarmserverurl: LDAPURL
nsmultiplexorbinddn: proxyDN
nsmultiplexorcredentials: ProxyPassword
^D
```

where *databaseName* and *suffixDN* must have the same value as those used in the previous step. The *LDAPURL* is the URL of the remote server, but it does not include any suffix information. The URL may include failover servers listed in the following format:

```
ldap[s]://hostname[:port][ hostname[:port]].../
```

All remote servers listed in the LDAP URL must contain the *suffixDN*. For information about specifying a secure port, refer to "Chaining Using SSL" on page 137.

The *proxyDN* is the DN of the proxy identity on the remote server. The local server will use this DN as a proxy when accessing contents of the suffix on the remote server. Operations performed through the chained suffix will use this proxy identity in the `creatorsName` and `modifiersName` attributes. If no proxy DN is specified, the local server will bind anonymously when accessing the remote server.

The *ProxyPassword* is the non-encrypted value of the password for the proxy DN. The password will be encrypted when it is stored in the configuration file. For example:

```
nsmultiplexorbinddn: uid=host1_proxy,cn=config
nsmultiplexorcredentials: secret
```

CAUTION You should perform the `ldapmodify` command through an encrypted port to avoid sending a clear password.

The new entry will automatically include all of the chaining parameters with the default values defined in `cn=default instance config,cn=chaining database,cn=plugins,cn=config`. You may override any of these values by setting the attributes with different values when you create the chaining configuration entry. See "Setting Default Chaining Parameters" on page 127 for the list of attributes for which you may define values.

3. Use the following command to create an ACI on the remote entry. This ACI is needed to allow the proxied operation through chaining. For more information on ACIs, refer to Chapter 6, "Managing Access Control."

```
ldapmodify -h host2 -p port2 -D "cn=Directory Manager" -wpassword2
dn: suffixDN
changetype: modify
add: aci
aci: (targetattr=*)(target = "ldap:///suffixDN")(version 3.0;acl
 "Allows use of admin for chaining"; allow (proxy)
 (userdn="ldap:///proxyDN");)
^D
```

CAUTION You may need to define other ACIs on the same entry to restrict access to the remote server that is now exposed through this server. See "Access Control Through Chained Suffixes" on page 136.

4. If you have configured the chaining policy for sever components, you must also add ACIs that will allow those components to access the remote server. For example, if you allow the referential integrity plug-in to chain, you must add the following ACI to the base entry with the *suffixDN*:

```
aci: (targetattr "*")
 (target="ldap:///suffixDN")
 (version 3.0; acl "RefInt Access for chaining"; allow
 (read,write,search,compare) userdn = "ldap:///cn=referential
 integrity postoperation,cn=plugins,cn=config";)
```

The following commands give an example of creating a chained subsuffix. Note that commas in the suffixDN must be escaped with a backslash (\) only when they appear in the naming attribute in the DN.

```
ldapmodify -a -h host1 -p port1 -D "cn=Directory Manager" -wpassword1
dn: cn=l=Europe\,dc=example\,dc=com,cn=mapping tree,cn=config
objectclass: top
objectclass: extensibleObject
objectclass: nsMappingTree
cn: l=Europe,dc=example,dc=com
nsslapd-state: backend
nsslapd-backend: Europe
nsslapd-parent-suffix: dc=example,dc=com

dn: cn=Europe,cn=chaining database,cn=plugins,cn=config
objectclass: top
objectclass: extensibleObject
objectclass: nsBackendInstance
cn: Europe
nsslapd-suffix: l=Europe,dc=example,dc=com
nsfarmserverurl: ldap://host2:port2/
nsmultiplexorbinddn: uid=host1_proxy,cn=config
nsmultiplexorcredentials: proxyPassword
^D

ldapmodify -h host2 -p port2 -D "cn=Directory Manager" -wpassword2
dn: l=Europe,dc=example,dc=com
changetype: modify
changetype: modify
aci: (targetattr=*)(target =
 "ldap:///l=Europe,dc=example,dc=com")(version 3.0;acl
 "Allows use of admin for chaining"; allow (proxy)
 (userdn="ldap:///uid=host1_proxy,cn=config");)
^D
```

Access Control Through Chained Suffixes

When an authenticated user accesses a chained suffix, the server sends the user's identity to the remote server. Access controls are always evaluated on the remote server. Every LDAP operation evaluated on the remote server uses the original identity of the client application passed via the proxied authorization control. Operations succeed on the remote server only if the user has the correct access controls on the subtree contained on the remote server. This means that you need to add the usual access controls to the remote server with a few restrictions:

- You cannot use all types of access control.

  For example, role-based or filter-based ACIs need access to the user entry. Because you are accessing the data via chained suffixes, only the data in the proxy control can be verified. Consider designing your directory in a way that ensures the user entry is located in the same suffix as the user's data.

- All access controls based on the IP address or DNS domain of the client may not work, as the original domain of the client is lost during chaining.

  The remote server views the client application as being at the same IP address and in the same DNS domain as the chained suffix.

The following restrictions apply to the ACIs you create to use with chained suffixes:

- ACIs must be located on the same server as the groups they use. If the groups are dynamic, all users in the group must be located with the ACI and the group. If the group is static, it may refer to remote users.
- ACIs must be located on the same server as any role definitions they use and with any users intended to have those roles.
- ACIs that refer to values of a user's entry (for example, `userattr` subject rules) will work if the users are remote.

Though access controls are always evaluated on the remote server, you can also choose to have them evaluated on both the server containing the chained suffix and the remote server. This poses several limitations:

- During access control evaluation, contents of user entries are not necessarily available (for example, if the access control is evaluated on the server containing the chained suffix and the entry is located on a remote server).

  For performance reasons, clients cannot do remote inquiries and evaluate access controls.

- The chained suffix does not necessarily have access to the entries being modified by the client application.

  When performing a modify operation, the chained suffix does not have access to the full entry stored on the remote server. If performing a delete operation, the chained suffix is only aware of the entry's DN. If an access control specifies a particular attribute, then a delete operation will fail when being conducted through a chained suffix.

By default, access controls set on the server containing the chained suffix are not evaluated. To override this default, use the `nsCheckLocalACI` attribute in the `cn=`*databaseName*`,cn=chaining database,cn=plugins,cn=config` entry. However, evaluating access controls on the server containing the chained suffix is not recommended unless using cascading chaining. For more information, see "Configuring Cascading Chaining" on page 152.

Chaining Using SSL

You can configure the server to communicate with the remote server using SSL when performing an operation on a chained suffix. Using SSL with chaining involves the following steps:

1. Enable SSL on the remote server.
2. Enable SSL on the server that contains the chained suffix.

   For more information on enabling SSL, refer to Chapter 11, "Managing Authentication and Encryption."
3. Specify SSL and the secure port of the remote server in the procedure for creating or modifying a chained suffix.

   When using the console, select the secure port checkbox in the chained suffix creation or configuration procedures. See "Creating Chained Suffixes Using the Console" on page 130 or "Modifying the Chaining Policy Using the Console" on page 141.

   When using the command-line procedures, specify an LDAPS URL and the secure port of the remote server, for example: `ldaps://example.com:636/`. See "Creating Chained Suffixes From the Command Line" on page 132 or "Modifying the Chaining Policy From the Command Line" on page 142.

When you configure the chained suffix and remote server to communicate using SSL, this does not mean that the client application making the operation request must also communicate using SSL. The client may use either port of either the LDAP or DSML protocol.

Managing Chained Suffixes

This section describes how to update and delete existing chained suffixes and control the chaining mechanism.

Configuring the Chaining Policy

The chaining policy of the server determines which LDAP controls will be propagated to chained servers and which server components are allowed to access chained suffixes. You should be aware of these settings and their influence on operations involving chained suffixes. The chaining policy applies to all chained suffixes on the server.

The default settings are intended to allow the transparent completion of normal operations. However, if your operations involve LDAP controls, or you are using server components such as the referential integrity plug-in, you should ensure the chaining policy is configured for your needs.

It is best to configure the chaining policy before creating any chained suffixes, so that the policy will be applied as soon as chained suffixes are enabled. However, you may also modify the policy at any later time.

Chaining Policy of LDAP Controls

LDAP controls are sent by clients as part of a request to modify the operation or its results in some way. The server chaining policy determines which controls the server will forward to a chained suffix along with the operation. By default, the following controls are forwarded to the remote server of a chained suffix:

Table 3-1 LDAP Controls Allowed to Chain by Default

OID of the Control	Name and Description of the Control
1.2.840.113556.1.4.473	Server side sorting - Associated with a search to sort the resulting entries according to their attribute values.[1]
1.3.6.1.4.1.1466.29539.12	Chaining loop detection - Tracks of the number of times the server chains with another server. When the count reaches a number you configure, the operation is abandoned, and the client application is notified. For more information, see "Transmitting LDAP Controls for Cascading" on page154 .
2.16.840.1.113730.3.4.2	Managed DSA for smart referrals - Returns smart referrals as entries rather than following the referral. This allows you to change or delete the smart referral itself.

Table 3-1 LDAP Controls Allowed to Chain by Default *(Continued)*

OID of the Control	Name and Description of the Control
2.16.840.1.113730.3.4.9	Virtual list view (VLV) - Provides partial results to a search rather than returning all resulting entries at once.[1]

1. Server side sorting and VLV controls are supported through chaining only when the scope of the search is a single suffix. Chained suffixes cannot support VLV controls when a client application makes a request to multiple suffixes.

The following table lists the other LDAP controls you may allow to chain by configuring the chaining policy:

Table 3-2 LDAP Controls That May be Chained

OID of the Control	Name and Description of the Control
1.3.6.1.4.1.42.2.27.9.5.2	Get effective rights request - Asks the server to return information about access rights and ACIs relating to the entries and attributes in the result.
2.16.840.1.113730.3.4.12	Proxied authorization (old specification) - Allows the client to assume another identity for the duration of a request.[1]
2.16.840.1.113730.3.4.14	Search on specific database- Used with search operations to specify that the search must be done on the database which is named in the control.
2.16.840.1.113730.3.4.16	Authentication request - Provided with a bind request to ask the server to provide its certificate in the bind response.
2.16.840.1.113730.3.4.17	Real attribute only request - Indicates that the server should return only attributes that are truly contained in the entries returned and that it does not need to resolve virtual attributes.
2.16.840.1.113730.3.4.18	Proxied authorization (new specification) - Allows the client to assume another identity for the duration of a request.[1]
2.16.840.1.113730.3.4.19	Virtual attributes only request - Indicates that the server should return only attributes generated by the roles and class of service features.

1. Applications may use either control for proxied authorization. You should have the same chaining policy for both of these OIDs. For more information, see "Transmitting LDAP Controls for Cascading" on page 154.

Chaining Policy of Server Components

A component is any feature or functional unit of the server that uses internal operations. For example, plug-ins are considered to be components. To perform their task, most components must access the directory contents, either the configuration data or the user data stored in the directory.

By default, no server components are allowed to chain. You must explicitly allow chaining if you want them to access chained suffixes. The components that may access chained data are listed by their DN below.

As described in "Creating Chained Suffixes Using the Console" on page 130, you must grant certain rights in an ACI on the remote server to allow chaining. When chaining server components, you must allow search, read, and compare in this ACI so that the server components may perform these operations. In addition, certain components require write permission on the remote server, as explained in the list:

- `cn=ACL Plugin,cn=plugins,cn=config` - The ACL plug-in implements the access control feature. Operations used to retrieve and update ACI attributes are not chained because it is not safe to mix local and remote ACI attributes. However, requests used to access user entries may be chained. For further information on the limitations surrounding ACIs and chaining see "ACI Limitations" on page 208.

- `cn=old plugin,cn=plugins,cn=config` - This plug-in represents all Directory Server 4.x plug-ins and whether or not they are allowed to chain. The 4.x plug-ins share the same chaining policy. You may need to set ACIs on the remote server depending upon the operations performed by the 4.x plug-ins.

- `cn=resource limits,cn=components,cn=config` - This component sets resource usage limits based on the user bind DN. You can enforce resource limits on users whose identity is stored in a chained suffix when this component is allowed to chain.

- `cn=certificate-based authentication,cn=components,cn=config` - This component is used when the SASL-external bind method is used. It retrieves the user certificate from the remote server.

CAUTION Allowing certificate-based authentication from chained suffixes may create a security hole. If other suffixes are chained to remote servers that are not trusted, a certificate on an untrusted server could be used for authentication.

- `cn=referential integrity postoperation,cn=plugins,cn=config` - This plug-in ensures that the removal of an entry is propagated to other entries that might have referenced its DN, such as lists of group members. Using this plug-in with chaining helps simplify the management of static groups when the group members are located in chained suffixes. When this plug-in accesses chained suffixes, it requires write permission on the remote server.
- `cn=uid uniqueness,cn=plugins,cn=config` - The UID uniqueness plug-in ensures that all new values of a specified attribute are unique on the server. Allowing this plug-in to chain will ensure uniqueness in the entire directory tree.

NOTE The following components cannot be chained:

- Roles plug-in
- Password policy component
- Replication plug-ins

Modifying the Chaining Policy Using the Console

1. On the Configuration tab of Directory Server Console, select the Data node, and in the right-hand panel, select the Chaining tab.
2. Select one or more LDAP controls from the right-hand list and click Add to allow them to chain. Create the list of controls that you allow to chain by using the Add and Delete buttons.

   LDAP controls are listed by their OID. See “Chaining Policy of LDAP Controls” on page 138, for the name and description of each control.
3. Server components allowed to chain are listed in the bottom of the same tab. Select one or more component names from the right-hand list and click Add to allow them to chain. Create the list of components that you allow to chain by using the Add and Delete buttons.

   See “Chaining Policy of Server Components” on page 140 for a description of each component.
4. Click Save to save your chaining policy.
5. Restart the server in order for the changes to take affect.

Modifying the Chaining Policy From the Command Line

The `cn=config,cn=chaining database,cn=plugins,cn=config` entry contains the attributes for the chaining policy configuration. Use the `ldapmodify` command to edit this entry:

1. Modify the multivalued `nsTransmittedControls` attribute so that it contains the OIDs of all LDAP controls you allow to chain. Refer to the "Chaining Policy of LDAP Controls" on page 138 for the OID of all controls that may be chained.

   For example, the following command adds the effective rights control to the list of chained controls:

   ```
   ldapmodify -h host -p port -D "cn=Directory Manager" -w password
   dn: cn=config,cn=chaining database,cn=plugins,cn=config
   changetype: modify
   add: nsTransmittedControls
   nsTransmittedControls: 1.3.6.1.4.1.42.2.27.9.5.2
   ^D
   ```

   If your client applications use custom controls and you wish to allow them to chain, you may also add their OID to the `nsTransmittedControls` attribute.

2. Modify the multivalued `nsActiveChainingComponents` attribute so that it contains the DNs of all server components you allow to chain. Refer to the "Chaining Policy of Server Components" on page 140 for a description of each component.

   For example, the following command adds the referential integrity component to the list of chained components:

   ```
   ldapmodify -h host -p port -D "cn=Directory Manager" -w password
   dn: cn=config,cn=chaining database,cn=plugins,cn=config
   changetype: modify
   add: nsActiveChainingComponents
   nsActiveChainingComponents: cn=referential integrity
    postoperation,cn=components,cn=config
   ^D
   ```

3. Once you have modified the chaining policy configuration entry, you must restart the server for your changes to take affect.

Disabling or Enabling a Chained Suffix

Sometime you may need to make a chained suffix unavailable for maintenance or for security reasons. Disabling a suffix prevents the server from contacting the remote server in response to any client operations that try to access the suffix. If you have a default referral defined, that referral will be returned when clients attempt to access a disabled suffix.

Disabling or Enabling a Chained Suffix Using the Console

1. On the top-level Configuration tab of Directory Server Console, expand the Data node and select the chained suffix you wish to disable.
2. In the right panel, select the Settings tab. By default, all chained suffixes are enabled when they are created.
3. Deselect the "Enable access to this suffix" checkbox to disable the suffix, or select the checkbox to enable it.
4. Click Save to apply the change and immediately disable or enable the suffix.
5. Optionally, you may set the global default referral that will be returned for all operations on this suffix while it is disabled. This setting is located on the Network tab of root node of the top-level Configuration tab. For more information, see "Setting a Default Referral Using the Console" on page 80.

Disabling or Enabling a Suffix From the Command Line

1. Edit the `nsslapd-state` attribute in the chained suffix entry with the following command:

   ```
   ldapmodify -h host -p port -D "cn=Directory Manager" -w password
   dn: cn=suffixDN,cn=mapping tree,cn=config
   changetype: modify
   replace: nsslapd-state
   nsslapd-state: disabled or backend
   ^D
   ```

   where *suffixDN* is the full string of the suffix DN as it was defined, including any spaces or backslashes (\) to escape commas in the value. Set the `nsslapd-state` attribute to the value `disabled` to disable the suffix and to the value `backend` to enable full access.

   The suffix will be disabled immediately when the command is successful.

2. Optionally, you may set the global default referral that will be returned for all operations on this suffix while it is disabled. For more information, see "Setting a Default Referral From the Command Line" on page 80.

Setting Access Permissions and Referrals

If you want to limit access to a chained suffix without disabling it completely, you can modify the access permissions to allow read-only access. In this case you must define a referral to another server for write operations. You can also deny both read and write access and define a referral for all operations on the suffix.

For more information on referrals in general, refer to Chapter 5, "Distribution, Chaining, and Referrals," in the *Directory Server Deployment Planning Guide*.

Setting Access Permissions and Referrals Using the Console

1. On the top-level Configuration tab of Directory Server Console, expand the Data node and select the chained suffix where you wish to set a referral.
2. In the right panel, select the Settings tab. You will only be able to set permissions and referrals if the chained suffix is enabled.
3. Select one of the following radio buttons to set the response to any write operation on entries in this suffix:
    - Process write and read requests - This radio button is selected by default and represents the normal behavior. Both read and write operations will be forwarded to the remote server and the results will be returned to the client. Referrals may be defined, but they will not be returned to clients.
    - Process read requests and return a referral for write requests - The server will forward only read requests and return their results to the client. Enter one or more LDAP URLs in the list to be returned as referrals for write requests.
    - Return a referral for both read and write requests - Enter one or more LDAP URLs in the list to be returned as referrals for all operations. This behavior is similar to disabling access to the suffix, except that the referrals may be defined specifically for this suffix instead of using the global default referral.

4. Edit the list of referrals with the Add and Remove buttons. Clicking the Add button will display a dialog for creating an LDAP URL of a new referral. You may create a referral to the DN of any branch in the remote server. For more information about the structure of LDAP URLs, refer to Chapter 6, “LDAP URL Reference,” in the *Directory Server Administration Reference*.

   You can enter multiple referrals. The directory will return all referrals in this list in response to requests from client applications.

5. Click Save to apply you changes and immediately begin enforcing the new permissions and referral settings.

Setting Access Permissions and Referrals Using the Console

In the following command, *suffixDN* is the full string of the chained suffix as it was defined, including any spaces. *LDAPURL* is a valid URL containing the hostname, port number and DN of the target, for example:

```
ldap://alternate.example.com:389/ou=People,dc=example,dc=com
```

1. Edit the chained suffix entry with the following command:

   ```
   ldapmodify -h host -p port -D "cn=Directory Manager" -w password
   dn: cn=suffixDN,cn=mapping tree,cn=config
   changetype: modify
   replace: nsslapd-state
   nsslapd-state: referral on update or referral
   -
   add: nsslapd-referral
   nsslapd-referral: LDAPURL
   ^D
   ```

   You may repeat the last change statement to add any number of LDAP URLs to the `nsslapd-referral` attribute.

   When the value of nsslapd-state is `referral on update`, the suffix is read-only and all LDAP URLs will be returned as referrals for write operations. When the value is `referral`, both read and write operations are denied and the referrals are returned for any request.

2. The suffix will become read-only or inaccessible and ready to return referrals immediately after the command is successful.

Modifying the Chaining Parameters

Once you have defined a chained suffix, you may modify the parameters that control chaining. You may specify how to access the remote server, change the DN used for proxying, or even change the remote server. You may also modify performance parameters that control how the server establishes and maintains connections to chained servers.

Modifying the Chaining Parameters Using the Console

1. On the top-level Configuration tab of Directory Server Console, expand the Data node and select the chained suffix you wish to modify.

2. In the right panel, select the Remote Server tab.

3. To change the name or port of the remote server, modify the Remote Server(s) URL field. The URL contains the hostname and optional port number of on or more remote servers in the following format:

   `ldap[s]://`*hostname*`[:`*port*`][` *hostname*`[:`*port*`]]...`/

   The URL it does not include any suffix information. For information about specifying a secure port, refer to "Chaining Using SSL" on page 137. The servers in URL will be contacted in the order listed when the first one fails to respond to a chained request. All remote servers listed in the LDAP URL must contain the *suffixDN* that is the base entry of the chained suffix.

4. To change the DN of the proxy user, enter a new value in the Bind DN field. Enter and confirm the corresponding password for this DN in the Password fields.

   The *proxyDN* is the DN of a user on the remote server. The local server will use this DN as a proxy when accessing contents of the suffix on the remote server. Operations performed through the chained suffix will use this proxy identity in the `creatorsName` and `modifiersName` attributes. If no proxy DN is specified, the local server will bind anonymously when accessing the remote server.

5. The text box at the bottom of the tab shows the ACIs required to allow chaining of this suffix. If you changed the remote server URL, you must add the ACI to the entry with the *suffixDN* on the new remote server or servers. If you modified the proxy DN, you should update the ACI on all chained servers. Use the Copy ACI button to copy the ACI text to your system's clipboard for pasting.

6. Select the Limits & Controls tab to configure the parameters for chained requests. The cascading chaining parameters are described in "Configuring Cascading Chaining" on page 152.

7. Set the Control Client Return parameters to limit the size and time of a chained operation:

   ❍ Return Referral on Scoped Search - A search whose scope is entirely within the chained suffix is inefficient because the results are transmitted twice. By default, the server will instead return a referral to the chained server, forcing the client to perform the search directly on the chained server. If you deselect this option, you should set the following parameters to limit the size of results that will be chained.

   ❍ Size Limit or No Size Limit - This parameter determines the number of entries that will be returned in response to the chained search operation. The default size limit is 2000 entries. Set this parameter to a low value if you wish to limit broad searches involving the chained suffix. In any case, the operation will be limited by any size settings on the remote server.

   ❍ Time Limit or No Time Limit - This parameter controls the length of time for chained operations. The default time limit is 3600 seconds (one hour). Set this parameter to a low value if you wish to limit the time allowed for operations on the chained suffix. In any case, the operation will be limited by any time settings on the remote server.

8. Set the Connection Management parameters to control how the server manages the network connection and the binding with the remote server:

   ❍ Maximum LDAP connection(s). Maximum number of simultaneous LDAP operation connections that the chained suffix can establish with the remote server. The default value is 10 connections.

   ❍ Maximum bind connection(s). The maximum number of simultaneous bind connections that the chained suffix can establish with the remote server. The default value is 3 connections.

   ❍ Maximum binds per connection. Maximum number of simultaneous bind operations per LDAP connection. The default value is 10 outstanding bind operations per connection.

   ❍ Maximum bind retries. Number of times a chained suffix attempts to rebind to the remote server upon error. A value of 0 indicates that the chained suffix will try to bind only once. The default value is 3 attempts.

- Maximum operations per connection. Maximum number of simultaneous operations per LDAP connection. The default value is 10 operations per connection.
- Bind timeout or No bind timeout. Amount of time, in seconds, before the bind attempts to the chained suffix will time out. The default value is 15 seconds.
- Timeout before abandon or No Timeout. Number of seconds before the server checks to see if an operation has been abandoned. The default value is 2 seconds.
- Connection lifetime or Unlimited. How long a connection made between the chained suffix and remote server remains open so that it may be reused. It is faster to keep the connections open, but it uses more resources. For example, if you are using a dial-up connection you may want to limit the connection time. By default, connections are unlimited.

The error detection parameters are not available through the console. See "Modifying the Chaining Parameters From the Command Line" on page 148.

9. Click Save when you have finished setting your chaining parameters.

Modifying the Chaining Parameters From the Command Line

From the command line, you may set all of the same parameters as when using the console, and you may also configure the additional parameters described in "Error Detection Parameters" on page 129:

1. Edit the chaining configuration entry corresponding to the suffix you wish to modify with the following command:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: cn=databaseName,cn=chaining database,cn=plugins,cn=config
changetype: modify
replace: attributeName
attributeName: attributeValue
-
replace: attributeName2
attributeName2: attributeValue2
...
^D
```

The possible attribute names and values are described in the following steps. You may include several change statements in the command to change any number of parameters at once.

2. Modify the `nsfarmserverURL` attribute to change the name or port of the remote server. The value is a URL containing the hostname and optional port number of on or more remote servers in the following format:

   ```
   ldap[s]://hostname[:port][ hostname[:port]].../
   ```

   The URL it does not include any suffix information. For information about specifying a secure port, refer to "Chaining Using SSL" on page 137. The servers in URL will be contacted in the order listed when the first one fails to respond to a chained request. All remote servers listed in the LDAP URL must contain the *suffixDN* that is the base entry of the chained suffix.

3. Modify the `nsmultiplexorBindDN` and `nsmultiplexorCredentials` attributes to change the DN used for proxy access to the remote server.

   The local server will use this DN as a proxy when accessing contents of the suffix on the remote server. Operations performed through the chained suffix will use this proxy identity in the `creatorsName` and `modifiersName` attributes. If no proxy DN is specified, the local server will bind anonymously when accessing the remote server.

4. If you modify the proxy DN or its credentials, you must create the corresponding ACI on the remote server. This ACI is needed to allow the proxied operation through chaining:

   ```
   ldapmodify -h host2 -p port2 -D "cn=Directory Manager" -wpassword2
   dn: suffixDN
   changetype: modify
   add: aci
   aci: (targetattr=*)(target = "ldap:///suffixDN")(version 3.0;acl
    "Allows use of admin for chaining"; allow (proxy)
    (userdn="ldap:///proxyDN");)
   ^D
   ```

5. Set any of the attributes described in "Setting Default Chaining Parameters" on page 127 to control the connection and operation handling on the remote server. The cascading parameters are further described in "Configuring Cascading Chaining" on page 152.

Optimizing Thread Usage

You may also set the number of threads used globally by the server to take into account the thread resources used for chaining. Chained operations may take significantly longer because they must be forwarded to the remote server, but their threads are idle while the remote server processes the operation. If your chained servers add significant delays, you should increase the number of threads so that more are available to process local operations in the meantime.

By default, the number of threads used by the server is 30. However, when using chained suffixes, you can improve performance by increasing the number of threads available for processing operations. The number of threads you need depends on the number of chained suffixes, the number and types of operations on them, and the average time needed to process the operations on the remote server.

In general you should increase the number of threads by 5 to 10 per chained suffix, assuming the chained suffix is the target of the same number of operations as local suffixes.

Setting Thread Resources Using the Console

1. On the top-level Configuration tab of Directory Server Console, click on the Performance node and select the Miscellaneous tab in the right-hand panel.
2. Enter a new value for the Max number of threads field.
3. Click OK to save your changes, and confirm the message that you will need to restart the server for the changes to take effect.
4. Restart the directory server to use the new number of threads.

Setting Thread Resources From the Command Line

1. Edit the global configuration entry to modify the number of threads with the following command:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: cn=config
changetype: modify
replace: nsslapd-threadnumber
nsslapd-threadnumber: newThreadNumber
^D
```

2. Restart the directory server to use the new number of threads.

Deleting a Chained Suffix

Deleting a chained suffix will make it inaccessible through the local directory tree, but it will not delete the entries or suffix on the chained server. You may delete a parent suffix and keep its subsuffixes in the directory as new root suffixes.

Deleting a Chained Suffix Using the Console

1. On the Configuration tab of Directory Server Console, expand the Data node.
2. Right-click on the suffix you wish to remove, and select Delete from the pop-up menu.

   Alternatively, you may select the suffix node and choose Delete from the Object menu.
3. A confirmation dialog appears to inform you that entries accessible through this chained suffix will *not* be removed from the remote directory.

   In addition for a parent suffix, you have the choice of recursively deleting all of its subsuffixes. Select "Delete this suffix and all of its subsuffixes" if you want to remove the entire branch. Otherwise, select "Delete this suffix only" if you want to remove only this particular suffix, and keep its subsuffixes in the directory.
4. Click OK to delete the suffix.

   A progress dialog box is displayed that tells you the steps being completed by the console.

Deleting a Suffix From the Command Line

To delete a suffix from the command line, use the `ldapdelete` command to remove its configuration entries from the directory.

If you wish to delete an entire branch containing subsuffixes, you must find the subsuffixes of the deleted parent and repeat the procedure for each of them and their possible subsuffixes.

1. Remove the suffix configuration entry using the following command:

   ```
   ldapdelete -h host -p port -D "cn=Directory Manager" -w password
   cn=suffixDN,cn=mapping tree,cn=config
   ```

   This command makes the chained suffix and its remote entries no longer visible in the directory.

2. Remove the corresponding database configuration entry located in `cn=`*databaseName*`,cn=chaining database,cn=plugins,cn=config` and the monitor entry below it:

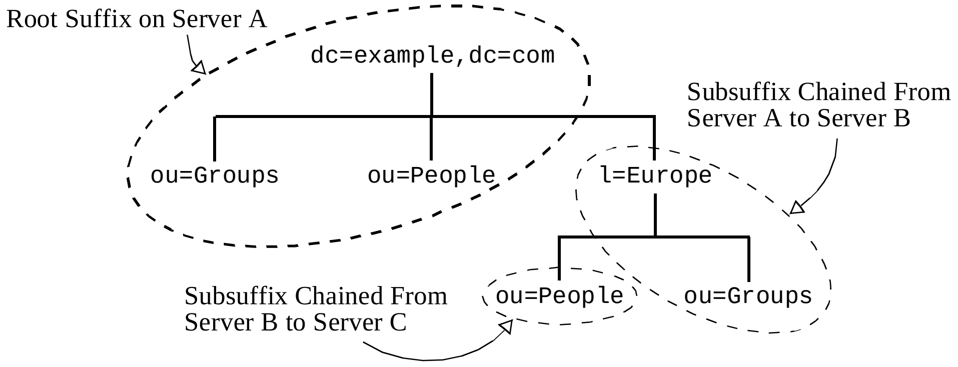
```
ldapdelete -h host -p port -D "cn=Directory Manager" -w password
cn=monitor,cn=dbName,cn=chaining database,cn=plugins,cn=config
cn=dbName,cn=chaining database,cn=plugins,cn=config
```

Configuring Cascading Chaining

In cascading chaining, a subtree being chained from one server may itself be a chained suffix or contain chained subsuffixes. When an operation involves the chained suffix in the one server, it will be forwarded to the intermediate server that will contact a third server, and so on. A cascading chain occurs any time more than one hop between servers is required to access all of the data in a directory tree.

For example, the following diagram show how access to the entry `ou=People, l=Europe,dc=example,dc=com` is chained from Server A to Server B and finally to Server C. Server A contains a root suffix `dc=example,dc=com`, and a chained subsuffix to Server B for the branch `l=Europe,dc=example,dc=com`. Server B contains the entry `l=Europe,dc=example,dc=com`, but the branch `ou=People, l=Europe,dc=example,dc=com` is a chained subsuffix to Server C. Server C actually contains the entry `ou=People, l=Europe,dc=example,dc=com`

Figure 3-1 Cascading Chaining With Three Servers


Root Suffix on Server A
dc=example,dc=com
Subsuffix Chained From Server A to Server B
ou=Groups
ou=People
l=Europe
Subsuffix Chained From Server B to Server C
ou=People
ou=Groups

Setting the Cascading Parameters

There are two chaining parameters to configure for cascading:

- All servers should configure loop detection so that any accidental loop in the chaining topology will be detected. If loop detection is not enabled, servers in a loop will forward an operation around and around until it overloads them.
- All intermediate chained suffixes should be configured to evaluate local ACIs which is usually not done on the first level of a chained suffix.

Setting the Cascading Parameters Using the Console

1. On the top-level Configuration tab of Directory Server Console, expand the Data node and select the chained suffix you wish to modify.
2. In the right panel, select the Limits & Controls tab where the Cascading Chaining parameters may be modified.
3. On all intermediate servers in a cascading chain, select the checkbox to check local ACIs.

   During single level chaining, this checkbox is not selected because a user's access rights are not evaluated on the first server but rather on the second server through the proxy. However, on the intermediate server of a cascading chain, you must enable ACI checking to allow perform access control before forwarding the operation again.
4. On all servers in a cascading chain, set the maximum number of hops that allows all chaining operations in your topology. Every time the same operation is forwarded to another chained suffix counts as a hop, and a chained suffix will not forward the operation any more if this limit is reached.

   You should set a number greater than the number of hops in your longest cascading chain. Any operation that reaches the limit will be aborted because the servers will assume it is an accidental loop in your topology.

   You must also set the chaining configuration to allow the loop detection control, as described in "Transmitting LDAP Controls for Cascading" on page 154.
5. Click Save when you have finished setting the cascading parameters.

Setting the Cascading Parameters From the Command Line

1. On all intermediate servers, edit the chaining configuration entry for the cascading suffix with the following command:

   ```
   ldapmodify -h host -p port -D "cn=Directory Manager" -w password
   dn: cn=databaseName,cn=chaining database,cn=plugins,cn=config
   changetype: modify
   replace: nsCheckLocalACI
   nsCheckLocalACI: on
   -
   changetype: modify
   replace: nsHopLimit
   nsHopLimit: maximumHops
   ^D
   ```

   You should set the *maximumHops* greater than the number of hops in your longest cascading chain. Any operation that reaches the limit will be aborted because the servers will assume it is an accidental loop in your topology. You must also set the chaining configuration to allow the loop detection control, as described in "Transmitting LDAP Controls for Cascading" on page 154.

2. On all other servers in a cascading chain, edit the chaining configuration entry for the cascading suffix with the following command:

   ```
   ldapmodify -h host -p port -D "cn=Directory Manager" -w password
   dn: cn=databaseName,cn=chaining database,cn=plugins,cn=config
   replace: nsHopLimit
   nsHopLimit: maximumHops
   ^D
   ```

   where *maximumHops* has the same definition as in the previous step.

Transmitting LDAP Controls for Cascading

By default, a chained suffix does not transmit the Proxy Authorization control. However, when one chained suffix contacts another, this control is needed to transmit the user identification required for access control on the remote server. The intermediate chained suffixes must allow this control to chain.

Recently, a second protocol was defined for the Proxy Authorization control. Because different server versions may use either control, you should configure all cascading servers to allow both the old and the new Proxy Authorization control to chain.

The Loop Detection control is also needed to prevent loops during cascading chaining. By default it is allow to be forwarded with chained operations, but you should verify this configuration. If a server does not allow this control to chain, any loop involving that server will not be detected.

Follow the steps in "Configuring the Chaining Policy" on page 138 to ensure that the following three controls are allowed to chain:

- 2.16.840.1.113730.3.4.12 - Proxy Authorization control (old specification)
- 2.16.840.1.113730.3.4.18 - Proxy Authorization control (new specification)
- 1.3.6.1.4.1.1466.29539.12 - Loop Detection control

Chapter 4

Backing Up and Restoring Data

The data managed by your directory server is often imported in bulk. Directory Server provides tools for importing and exporting entire suffixes. It also provides tools for making backups of all suffixes at once and for restoring all data from a backup.

You can backup and restore data using the plain-text LDAP Data Interchange Format (LDIF).

This chapter describes the following procedures for backing up and restoring directory data:

- Setting Suffix Read-Only Mode
- Importing Data
- Exporting Data
- Backing Up Data
- Restoring Data from Backups

NOTE If you are running more than one version of Directory Server, note that all examples in this chapter assume that Directory Server 5.2 is the default version. If this is not the case, you must either run the following command once to set 5.2 as the default version:

```
# /usr/sbin/directoryserver -d 5.2
```

or include the `-useversion` option each time you run the `directoryserver` command to specify the version, for example:

```
# /usr/sbin/directoryserver -useversion 5.2 ldif2db ...
```

Setting Suffix Read-Only Mode

Before performing certain export or backup operations on your Directory Server, you can enable read-only mode on any suffix to ensure you have a faithful image of the state of its contents at a given time. Also, before performing an import or restore operation, you must ensure that the suffixes affected by the operation are *not* in read-only mode.

Directory Server Console and the command-line utilities do not automatically put the directory in read-only mode before export or backup operations because this would make your directory unavailable for updates. However, if you have a multi-master configuration, you may enable read-only mode on one server, and your data will remain writable on the other masters.

To make a suffix read-only, follow the procedure described in "Setting Access Permissions and Referrals" on page 121. Alternatively, you may make the entire directory server unwritable, as described in "Setting Global Read-Only Mode" on page 40.

Importing Data

Directory Server provides two methods for importing data:

- Importing an LDIF file allows you to add, modify, and delete entries in bulk in any suffix of the directory.
- Initializing a suffix from an LDIF file deletes the current data in the suffix and replaces it with the contents of the LDIF file.

Both methods are available through Directory Server Console and using the command-line utilities.

NOTE All LDIF files you import must use UTF-8 character set encoding.

When importing LDIF, parent entries must either exist in the directory or be added first from the file. When initializing a suffix, the LDIF file must contain the root entry and all directory tree nodes of the corresponding suffix.

The following table shows the differences between an import and an initialization:

Table 4-1 Comparison of Importing Data Versus Initializing a Suffix

Domain of Comparison	Importing Data	Initializing Suffixes
Overwrites content	No	Yes
LDAP operations	Add, modify, delete	Add only
Performance	Slower	Fast
Response to server failure	Best effort (all changes made up to the point of the failure remain)	Atomic (all changes are lost after a failure)
LDIF file location	On client machine	Local to client or local to server
Imports configuration information (`cn=config`)	Yes	No

Importing LDIF Files

When you perform an import operation, Directory Server Console performs an `ldapmodify` operation to add new entries to the directory. Entries are specified in an LDIF file which may also contain update statements to modify or delete existing entries as part of the import operation.

The imported entries may target any suffix managed by your Directory Server and any chained suffix or chained sub-suffix defined in your configuration. As with any other operation that adds entries, the server will index all new entries as they are imported.

Importing LDIF Using the Console

You must be logged in as the Directory Manager or an Administrator in order to perform an import:

1. On the top-level Tasks tab of Directory Server Console, scroll to the bottom of the tab and click the button beside “Import from LDIF.”

   The Import LDIF dialog is displayed.

2. In the LDIF File field of the Import LDIF dialog, enter the full path to the LDIF file you want to import, or click Browse to select the file in the local file system.

   If you are accessing a directory on a remote machine, the field name appears as “LDIF file (on console machine).” This label reminds you that you are browsing the local file system, not that of the remote directory server machine.

3. Set the following options as desired:

   a. "Add only" - The LDIF file may contain modify and delete instructions in addition to the default add instructions. Select this checkbox if you want the console to perform only add instructions and ignore all others in the LDIF file.

   b. "Continue on error" - Select this checkbox if you want the console to continue with the import even if errors occur. For example, you might use this option if you are importing an LDIF file that contains some entries that already exist in the suffix. The console notes errors such as existing entries in the rejects file while performing the import operation.

      When this checkbox is not selected, the import operation will stop after the first error it encounters. All prior entries in the LDIF file will have been successfully imported and will remain in the directory.

4. In the "File for rejects" field, enter the full path to the file in which you want the console to record all entries it cannot import, or click Browse to select the file in the local file system.

   For example, the server cannot import an entry that already exists in the directory or an entry that has no parent object. The console will write the error message sent by the server in the rejects file.

   If you leave this field blank, the server will not record rejected entries.

5. Click OK to begin the import operation.

   Directory Server Console displays a dialog containing the status of the operation and the text of any errors that occur. If the "File for rejects" field is not blank, all error messages will also be written in the named file.

Importing LDIF From the Command Line

The `directoryserver ldif2ldap` command will import an LDIF file through LDAP and perform all operations it contains. Using this command you import data to all directory suffixes at the same time. The server must be running in order to import using `ldif2ldap`.

The full path of the command is:

```
# /usr/sbin/directoryserver -s serverID ldif2ldap
```

The following example performs an import using the `ldif2ldap` command. You do not need root privileges to run this command, but you must authenticate as a user with root permissions, such as Directory Manager. The last parameter specifies the name of the LDIF file to import.

```
# /usr/sbin/directoryserver -s example ldif2ldap \
  -D "cn=Directory Manager" -w password \
  -f /var/opt/mps/serverroot/slapd-example/ldif/demo.ldif
```

For more information about using this command, see "`ldif2ldap`" in Chapter 1 of the *Directory Server Administration Reference*.

Initializing a Suffix

Initializing a suffix overwrites the existing data in a suffix with the contents of an LDIF file which contains only entries for addition.

CAUTION If the server you are managing is a Configuration Directory Server, be careful not to overwrite the `o=NetscapeRoot` suffix when initializing suffixes from an LDIF file, unless you are restoring data. Otherwise, you will delete information that will require the reinstallation of all your Sun Java System servers.

You must be authenticated as the Directory Manager or Administrator to initialize a suffix. For security reasons only the Directory Manager and Administrators have access to the root entry of a suffix, for example `dc=example,dc=com`. Therefore, only these identities may import an LDIF file that contains a root entry.

Initializing a Suffix From the Console

CAUTION This procedure overwrites the data in your suffix.

1. On the top-level Configuration tab of Directory Server Console, expand the Data node to display the suffix you wish to initialize.
2. Right-click the suffix node and select Initialize from the pop-up menu. Alternatively, you may select the suffix node and then choose Initialize from the Object menu. The Initialize Suffix dialog is displayed.
3. In the "LDIF file" field, enter the full path to the LDIF file you want to use for initialization, or click Browse to locate it on your machine.

4. If you are operating the console from a machine local to the file being imported, skip to step 6. If you are operating the console from a machine remote to the server containing the LDIF file, select one of the following options:

   on console. Indicates that the LDIF file is located on the machine on which you are running the console. In this case, you can browse for the file.

   on server. Indicates that the LDIF file is located on a remote server. In this case, the Browse button is disabled. By default, the console looks for the file in the following directory:

   ServerRoot`/slapd-`*serverID*`/ldif`

5. Click OK.

6. Confirm that you wish to overwrite the data in your suffix. The suffix initialization will proceed and any errors will be reported in a dialog.

Initializing a Suffix Using the ldif2db Command

The `directoryserver ldif2db` command initializes a suffix and overwrites the existing data. This command requires you to shut down the server before proceeding with the import.

By default, the command first saves and then merges any existing `o=NetscapeRoot` configuration information with the `o=NetscapeRoot` configuration information in the files being imported.

CAUTION This command overwrites the data in your suffix.

To import LDIF with the server stopped:

1. As root from the command line, stop the server with the following command:

   ```
   # /usr/sbin/directoryserver -s serverID stop
   ```

2. Run the import command:

   ```
   # /usr/sbin/directoryserver -s serverID ldif2db ...
   ```

3. Start the server as follows:

   ```
   # /usr/sbin/directoryserver -s serverID start
   ```

The following example uses the `ldif2db` command to import two LDIF files into a single suffix.

```
/usr/sbin/directoryserver -s example ldif2db -n Database1 \
 -i /var/opt/mps/serverroot/slapd-example/ldif/demo.ldif \
 -i /var/opt/mps/serverroot/slapd-example/ldif/demo2.ldif
```

Table 4-2 Description of ldif2db Options Used in the Example

Option	Description
`-n`	Specifies the name of the database into which you are importing the data. CAUTION: If you specify a database that does not correspond to the suffix contained in the LDIF file, all of the data contained in the database is deleted and the import fails. Make sure that you do not misspell the database name.
`-i`	Specifies the full path name of the LDIF file(s) to be imported. This option is required. You can use multiple `-i` arguments to import more than one LDIF file at a time. When you import multiple files, the server imports the LDIF files in the order specified on the command line.

For more information about using this command, see "ldif2db" in Chapter 1 of the *Directory Server Administration Reference*.

Initializing a Suffix Using ldif2db-task

As with the `ldif2db` command, the `directoryserver ldif2db-task` command overwrites the data in a specified suffix. This script requires the server to be running in order to perform the import.

The command for this script is:

```
# /usr/sbin/directoryserver -s serverID ldif2db-task ...
```

The following example imports an LDIF file using `ldif2db-task`. You do not need root privileges to run the command, but you must authenticate as a user with root permissions, such as Directory Manager.

```
/usr/sbin/directoryserver -s example ldif2db-task \
  -D "cn=Directory Manager" -w password -n Database1 \
  -i /var/opt/mps/serverroot/slapd-example/ldif/demo.ldif
```

The following table describes the `ldif2db-task` options used in the example:

Table 4-3 Description of ldif2db-task Options Used in the Example

Option	Description
`-D`	Specifies a user DN with root permissions, such as Directory Manager.

Table 4-3 Description of ldif2db-task Options Used in the Example

Option	Description
`-w`	Specifies the password of the user.
`-n`	Specifies the name of the database into which you are importing the data. CAUTION: If you specify a database that does not correspond to the suffix contained in the LDIF file, all of the data contained in the database is deleted and the import fails. Make sure that you do not misspell the database name.
`-i`	Specifies the full path name of the LDIF file(s) to be imported. This option is required. You can use multiple `-i` arguments to import more than one LDIF file at a time. When you import multiple files, the server imports the LDIF files in the order specified on the command line.

For more information about using this command, see “`ldif2db-task`” in Chapter 1 of the *Directory Server Administration Reference*.

Exporting Data

You can export the contents of your directory using LDIF. Exporting data can be useful for the following:

- Backing up the data in your server.
- Copying your data to another directory server.
- Exporting your data to another application.
- Repopulating suffixes after a change to your directory topology.

The export operations do not export the configuration information (`cn=config`).

CAUTION Do not stop the server while an export operation is in progress.

Exporting the Entire Directory to LDIF Using the Console

You can export some or all of your directory data to LDIF, depending on the location of the final exported file. When the LDIF file is on the server, you can export only the data contained in the local suffixes on the server. If the LDIF file is remote to the server, you can export all of the suffixes and chained suffixes.

To export directory data to LDIF from Directory Server Console while the server is running:

1. On the top-level Tasks tab of Directory Server Console, scroll to the bottom of the tab and click the button beside "Export to LDIF."

   The Export dialog is displayed.

2. If you are running the console on a machine remote to the server, two radio buttons are displayed beneath the LDIF file field. Select "on console machine" to indicate that you are exporting to an LDIF file in the machine from which you run the console. Select "on server machine" to indicate that you are exporting to an LDIF file located on the server's machine.

3. Enter the full path and file name of the LDIF file in the "LDIF file" field, or click Browse to locate the file.

   If you have selected "on server machine", the Browse button is disabled. When the Browse button is not enabled, the file is stored by default in the following directory:

   ServerRoot`/slapd-`*serverID*`/ldif`

4. If you want to export the whole directory, select the "All suffixes" radio button.

   If you want to export only a subtree of the directory, select the "Subtree" radio button and then enter the DN at the base of the subtree in the text box.

   You can also click Browse to select a subtree.

5. Click OK to export the directory contents to the file.

Exporting a Single Suffix to LDIF Using the Console

To export one suffix to LDIF from Directory Server Console while the server is running:

1. On the top-level Configuration tab of Directory Server Console, expand the Data node to display the suffix you wish to export.
2. Right-click the suffix node and select Export from the pop-up menu. Alternatively, you may select the suffix node and then choose Export from the Object menu.

   The Export Suffix dialog is displayed.
3. In the “LDIF file” field, enter the full path to the LDIF file, or click Browse to locate it on your machine.

   When the Browse button is not enabled, by default the file is stored in the following directory:

   ServerRoot`/slapd-`*serverID*`/ldif`
4. If the suffix is replicated you may select the checkbox to Export Replication Information. This feature is only necessary if you will use the exported LDIF to initialize another replica of this suffix.
5. If attribute encryption is enabled for this suffix, you may select the checkbox to Decrypt attributes. In order to do so, you must provide the password that protects the server’s certificate database. Select the option to enter the password or to enter the name of a file containing the password. If you cannot provide the password to decrypt attribute values, the encrypted values will appear in the LDIF output.
6. Click OK to export the contents of the suffix to the file.

Exporting to LDIF From the Command Line

You can export any suffix or subtree of the directory to LDIF using the `directoryserver db2ldif` command. This script exports all of your suffix contents or a part of their contents to an LDIF file, when the server is either running or stopped.

To export the contents of a database to an LDIF file, use the following command:

```
# /usr/sbin/directoryserver -s serverID db2ldif ...
```

The following example exports two suffixes to a single LDIF file:

```
/usr/sbin/directoryserver -s example db2ldif \
     -a /var/opt/mps/serverroot/slapd-example/output.ldif \
     -s "dc=example,dc=com" -s "o=NetscapeRoot"
```

The following table describes the `db2ldif` options used in this example:

Table 4-4 Description of db2ldif Options Used in the Example

Option	Description
`-a`	Defines the name of the output file in which the server saves the exported LDIF. This file is stored by default in the *ServerRoot*`/slapd-`*serverID* directory.
`-s`	Specifies the suffix or subtree to include in the export. You may use multiple `-s` arguments to specify multiple suffixes or subtrees.

The `db2ldif` command may also be used with the `-r` option to export replicated suffixes to an LDIF file. The resulting LDIF will contain attribute subtypes that are used by the replication mechanism. This LDIF file can then be imported on the consumer server to initialize the consumer replica, as described in "Initializing Replicas" on page 315.

The server must not be running when using the `db2ldif` command with the `-r` option. You must stop the server first and start it afterwards, or use the `db2ldif.pl` script with the `-r` option that does not require the server to be stopped.

For more information about using this script, see "db2lidf" in Chapter 1 of the *Directory Server Administration Reference*.

Backing Up Data

Backing up data saves a snapshot of the contents of your directory in case the database files later become corrupted or deleted. You can back up suffixes using Directory Server Console or a command-line script.

CAUTION Never stop the server during a backup operation.

All backup procedures described here store a copy of the server files on the same host by default. You should then copy and store your backups on a different machine or file system for greater security.

NOTE You cannot use these backup methods to back up a chained suffix on a remote server. Separate servers must be backed up independently.

Backing Up Your Server Using the Console

When you back up your server from Directory Server Console, the server copies all of the database contents and associated index files to a backup location. You can perform a backup while the server is running.

To back up your server from the console:

1. On the top-level Tasks tab of Directory Server Console, click the button beside "Back up Directory Server".

   The Backup Directory Server dialog box is displayed.

2. In the Directory text box, enter the full path of the directory where you want to store the backup. If you are running the console on the same machine as the directory, click Browse to find a local directory.

   Or click "Use Default" to store the backup in the following directory:

   ServerRoot`/slapd-`*serverID*`/bak/`*YYYY_MM_DD_hh_mm_ss*

   where *serverID* is the name of your directory server and the directory name is generated to contain the time and date the backup was created.

3. Click OK to create the backup.

Backing Up Your Server From the Command Line

You can back up your server from the command line using the `directoryserver db2bak` command. This command works whether or not the server is running.

You cannot back up configuration information using this backup method. For information on backing up the configuration information, refer to "Backing Up the dse.ldif Configuration File" on page 169.

To back up your directory, use the following command:

```
# /usr/sbin/directoryserver -s serverID db2bak backupDir
```

The *backupDir* parameter specifies the directory where the backup should be stored. The default backup directory name is generated from the current date: `YYYY_MM_DD_hh_mm_ss`. For more information about using this command, refer to "db2bak" in Chapter 1 of the *Directory Server Administration Reference*. For information on designing a backup strategy for your deployment, see "Planning a Backup Strategy," in Chapter 9 of the *Directory Server Deployment Planning Guide*.

Backing Up the dse.ldif Configuration File

Directory Server automatically backs up the `dse.ldif` configuration file. When you start Directory Server, it automatically creates a backup of the `dse.ldif` file in a file named `dse.ldif.startOK` in the following directory:

ServerRoot`/slapd-`*serverID*`/config`

When you make modifications to the `cn=config` branch, the file is first backed up to a file named `dse.ldif.bak` in the `config` directory before the server writes the modifications to the `dse.ldif` file. Make copies of either of these files if you need to save your configuration.

Restoring Data from Backups

The following procedures describe how to restore suffixes in your directory using Directory Server Console or the command line. Your server must have been backed up using the procedures described in "Backing Up Data" on page 167. Before restoring suffixes involved in replication agreements, please read "Restoring Replicated Suffixes" on page 170.

CAUTION Do not stop the server during a backup or restore operation.

Restoring your server overwrites any existing database files and thus loses any modifications of the data since the backup.

Restoring Replicated Suffixes

Suffixes that are replicated between supplier servers and consumer servers require special consideration before being restored. If possible, you should update the suffix through the replication mechanism instead of restoring it from a backup. This section explains how and when to restore a replica, and how to ensure that it is synchronized with other replicas after the operation. For further information on using backup and restore to initialize a replica, see "Initializing Replicas" on page 315.

Restoring the Supplier in a Single-Master Scenario

A suffix that is a single-master supplier contains the authoritative data for the entire replication topology. Therefore, restoring this suffix is equivalent to reinitializing all data in the entire topology. You should restore a single master only if you want to reinitialize all data from the contents of the backup to be restored.

If the single master data is not recoverable due to an error, you may consider using the data on one of the consumers because it may contain updates that are more recent than a backup. In this case, you need to export the data from the consumer replica to an LDIF file, and reinitialize the master from the LDIF file.

Whether you restore a backup or import an LDIF file on a master replica, you must then reinitialize all of the hubs and consumer replicas that receive updates from this replica. A message is logged to the supplier servers' log files to remind you that reinitialization of the consumers is required.

Restoring a Supplier in a Multi-Master Scenario

In multi-master replication, the other masters each contain an authoritative copy of the replicated data. You cannot restore an old backup which may be out of date with the current replica contents. If possible you should allow the replication mechanism to bring the master up to date from the contents of the other masters.

If that is not possible, you should only restore a multi-master replica in one of the following ways:

- The simplest way is not to restore a backup, but to reinitialize the intended master from one of the other masters. This insures that the latest data is sent to the intended master and that the data will be ready for replication. See "Initializing a Replica Using the Console" on page 320 or "Initializing a Replica From the Command Line" on page 321.

- For replicas with millions of entries, it can be faster to use the new binary copy feature to restore a more recent backup taken from one of the other masters. See "Initializing a Replica Using Binary Copy" on page 323.
- If you have a backup of your master that is not older than the maximum age of the change log contents on *any* of the other masters, then it may be used to restore this master. See "Advanced Multi-Master Configuration" on page 308, for a description of change log age. When the old backup is restored, the other masters will use their change logs to update this master with all modifications that have been processed since the backup was saved.

Regardless of how you restore or reinitialize, the master replica will remain in read-only mode after the initialization. This behavior allows the replica to synchronize with the other masters, after which time you may allow write operations, as described in "Convergence After Multi-Master Initialization" on page 317.

The advantage of allowing all replicas to converge before allowing write operations on the restored or reinitialized master is that none of the hub or consumer servers will require reinitialization.

Restoring a Hub

This section applies only in situations where the replication mechanism cannot automatically bring a hub replica up to date, for example if the database files become corrupted or if replication has been interrupted for too long. In these cases, you will need to restore or reinitialize the hub replica in one of the following ways:

- The simplest way is not to restore a backup, but to reinitialize the hub from one of the master replicas. This ensures that the latest data is sent to the hub and that the data will be ready for replication. See "Initializing a Replica Using the Console" on page 320 or "Initializing a Replica From the Command Line" on page 321.
- For replicas with millions of entries, it can be faster to use the new binary copy feature to restore a more recent backup taken from another hub replica. See "Initializing a Replica Using Binary Copy" on page 323. If there is no other hub replica to copy, you must reinitialize the hub as described in the previous paragraph or restore it as described in the next paragraph, if possible.
- If you have a backup of your hub that is not older than the maximum age of the change log contents on *any* of its suppliers, either hub or master replicas, then it may be used to restore this hub. See "Advanced Multi-Master Configuration" on page 308, for a description of change log age. When the old backup is restored, its suppliers will use their change logs to update this hub with all modifications that have been processed since the backup was saved.

NOTE Regardless of how you restore or reinitialize the hub replica, you *must* then reinitialize all consumers of this hub, including any other levels of hubs.

Restoring a Dedicated Consumer

This section applies only in situations where the replication mechanism cannot automatically bring a dedicated consumer replica up to date, for example if the database files become corrupted or if replication has been interrupted for too long. In these cases, you will need to restore or reinitialize the consumer in one of the following ways:

- The simplest way is not to restore a backup, but to reinitialize the consumer from one of its suppliers, either a master or a hub replica. This ensures that the latest data is sent to the consumer and that the data will be ready for replication. See "Initializing a Replica Using the Console" on page 320 or "Initializing a Replica From the Command Line" on page 321.

- For replicas with millions of entries, it can be faster to use the new binary copy feature to restore a more recent backup taken from another consumer replica. See "Initializing a Replica Using Binary Copy" on page 323. If there is no other consumer to copy, you must reinitialize the replica as described in the previous paragraph or restore it as described in the next paragraph, if possible.

- If the backup of your consumer is not older than the maximum age of change log contents on *any* of its suppliers, either hub or master replicas, then it may be used to restore the consumer. See "Advanced Multi-Master Configuration" on page 308, for a description of change log age. When the old backup is restored, its suppliers will use their change logs to update this consumer with all modifications that have been processed since the backup was saved.

Restoring Your Server Using the Console

You can restore corrupted directory data from a previously generated backup using Directory Server Console. To restore data using the console, Directory Server must be running. However, the corresponding suffixes will be unavailable for processing operations during the restore.

To restore your server from a previously created backup:

1. On the top-level Tasks tab of Directory Server Console, click the button beside "Restore Directory Server".

   The Restore Directory dialog box is displayed.

2. Select the backup from the Available Backups list, or enter the full path to a valid backup in the Directory text box.

   The Available Backups list shows all of the backups located in the default directory:

   ServerRoot/`slapd-`*serverID*/`bak`

3. Click OK to restore your server.

Restoring Your Server from the Command Line

You can restore your server from the command line using the following scripts:

- Using the `directoryserver bak2db` command. This command requires the server to be shut down.
- Using the `directoryserver bak2db-task` command . This command requires the server to be running.

Using the bak2db Command

To restore your directory from the command line while the server is shut down:

1. As root from the command line, stop the server with the following command:

   ```
   # /usr/sbin/directoryserver -s serverID stop
   ```

2. Use the `bak2db` command with the full path of the backup directory:

   ```
   # /usr/sbin/directoryserver -s serverID bak2db backupDir
   ```

3. Start the server as follows:

   ```
   # /usr/sbin/directoryserver -s serverID start
   ```

The following example restores a backup from the default backup directory:

```
/usr/sbin/directoryserver -s example bak2db \
        /var/opt/mps/serverroot/slapd-example/bak/2003_07_01_11_34_00
```

For more information, refer to "bak2db" in Chapter 1 of the *Directory Server Administration Reference*.

Using bak2db-task

To restore your directory from the command line while the server is running, use the following command:

```
# /usr/sbin/directoryserver -s serverID bak2db-task ...
```

The following example restores a backup using the `bak2db-task` command. The `-a` option gives the full path of the backup directory.

```
/usr/sbin/directoryserver -s example bak2db-task\
  -D "cn=Directory Manager" -w password \
  -a /var/opt/mps/serverroot/slapd-example/bak/2003_07_01_11_34_00
```

For more information, refer to “bak2db-task” in Chapter 1 of the *Directory Server Administration Reference*.

Restoring the dse.ldif Configuration File

The directory creates two backup copies of the `dse.ldif` file in the following directory:

ServerRoot/`slapd-`*serverID*/`config`

The `dse.ldif.startOK` file records a copy of the `dse.ldif` file at server start up. The `dse.ldif.bak` file contains a backup of the most recent changes to the `dse.ldif` file. Copy the file with the most recent changes to your directory.

To restore the `dse.ldif` configuration file:

1. As root from the command line, stop the server with the following command:

   ```
   # /usr/sbin/directoryserver -s serverID stop
   ```

2. Change to the directory containing the configuration files, for example:

   ```
   # cd /var/mps/serverrot/slapd-serverID/config
   ```

3. Overwrite the `dse.ldif` file with a backup configuration file known to be good. For example, you might type the following:

   ```
   cp dse.ldif.startOK dse.ldif
   ```

4. Start the server with the following command:

   ```
   # /usr/sbin/directoryserver -s serverID start
   ```

Chapter 5

Managing Identity and Roles

Beyond the hierarchical structure of data in a directory, managing entries that represent users often requires creating groups and sharing common attribute values. Directory Server provides this advanced entry management functionality through groups, roles and class of service (CoS).

Groups are entries that name other entries, either as a list of members or as a filter for members. Roles provide the same functionality, and more, through a mechanism that generates the `nsrole` attribute on each member of a role. CoS also generates a virtual attribute, allowing entries to share a common attribute value without having to store it in each entry.

Directory Server provides the ability to perform searches based on the values of the roles and CoS virtual attributes. Filter strings used in any operation may include the `nsRole` attribute or any attribute generated by a CoS definition and perform any of the comparison operations on the value of this attribute. However, virtual CoS attributes cannot be indexed and therefore any search involving a CoS-generated attribute will be unindexed. This may consume a large amount of resources in terms of time and memory.

To take full advantage of the features offered by roles and class of service, you should determine your directory topology in the planning phase of your directory deployment. Refer to Chapter 4, “The Directory Information Tree,” in the *Directory Server Deployment Planning Guide* for a description of these mechanisms and how they can simplify your topology.

This chapter contains the following sections:

- Managing Groups
- Assigning Roles
- Defining Class of Service (CoS)

Managing Groups

Groups enable you to associate entries for ease of administration, such as for defining ACIs. Group definitions are special entries that either name their members in a static list or give a filter which defines a dynamic set of entries.

The scope of possible members of a group is the entire directory, regardless of where the group definition entries are located. To simplify administration, all group definition entries are usually stored in a single location, usually `ou=Groups` under the root suffix.

The entry that defines a static group inherits from either the `groupOfNames` or the `groupOfUniqueNames` object class. Group members are listed by their DN as multiple values of the `member` or `uniqueMember` attributes.

The entry that defines a dynamic group inherits from the `groupOfURLs` object class. Group membership is defined by one or more filters given in the multi-valued `memberURL` attribute. The members in a dynamic group are the entries that match any one of the filters whenever they are evaluated.

The following sections describe how to create and modify both static and dynamic groups using the console.

Adding a New Static Group

1. On the top-level Directory tab of Directory Server Console, right-click the entry in the directory tree where you want to add the new group, and select the New>Group item.

   Alternatively, select the entry and choose the New>Group item from the Object menu.

2. In the Create New Group dialog, you must type a name for your new group in the “Group Name” field, and you can add an optional description of the group in the “Description” field. The group name will become the value of the `cn` (common name) attribute for the new group entry and will appear in its DN.

3. Click Members in the left-hand list of the dialog. In the right panel, the Static Group tab is selected by default.

4. Click Add to add new members to the group. The standard “Search users and groups” dialog box appears.

5. In the Search drop-down list, select Users and enter a string to search for, and then click Search. Click the Advanced button to search specific attributes or specific attribute values.

   Select one or more of the entries in the results and click OK. Repeat this step to add all of the members you want to add to this static group.

NOTE Static group members may be remote due to chaining. You can use the referential integrity plug-in to ensure that deleted member entries are automatically deleted from the static group entry. For more information about using referential integrity with chaining, refer to "Configuring the Chaining Policy" on page 138.

6. Click Languages in the left-hand list to give your group a name and descriptions string in another language. These will be displayed when the console is using the corresponding locale.

7. Click OK to create your new group. It appears as one of the children of the entry where it was created.

Adding a New Dynamic Group

1. On the top-level Directory tab of Directory Server Console, right-click the entry in the directory tree where you want to add the new group, and select the New>Group item.

   Alternatively, select the entry and choose the New>Group item from the Object menu.

2. In the Create New Group dialog, type a name for your new group in the "Group Name" field. You may add an optional description of the group in the "Description" field. The group name will become the value of the `cn` (common name) attribute for the new group entry and appear in its DN.

3. Click Members in the left-hand list of dialog and select the Dynamic Group tab in the right panel.

4. Click Add to create an LDAP URL containing the filter string that will define group members. The standard "Construct and Test LDAP URL" dialog box is displayed.

5. Enter an LDAP URL in the text field or select Construct to be guided through the construction of an LDAP URL containing the filter for your group. Click Test to view the list of entries that are returned by this filter.

   Click OK when you have constructed the URL. Repeat this step to add all of the URLs containing the filters that define your dynamic group.

6. Click Languages in the left-hand list to give your group a name and descriptions string in another language. These will be displayed when the console is using the corresponding locale.

7. Click OK to create your new group. It appears as one of the children of the entry where it was created.

Modifying a Group Definition

1. On the top-level Directory tab of Directory Server Console, double-click the entry representing the group you want to modify.

   Alternatively, select the entry and choose Open from the Object menu.

2. In the Edit Entry dialog, make your changes to the group information in the General, Members, or Languages categories. You may add or remove members of a static group or add, edit, or remove the URLs containing filters for a dynamic group.

3. Click OK when you are done modifying the group definition.

   To view your changes in the console, select Refresh from the View menu.

Removing a Group Definition

To remove either type of group, simply delete the entry that defines it.

Assigning Roles

Roles are an alternate grouping mechanism designed to be more efficient and easier to use for applications. Roles are defined and administered like groups, but in addition, member entries also have a generated attribute that indicates the roles in which they participate. For example, an application can simply read the roles of an entry, rather than select a group and browse the members list.

By default, the scope of a role is limited to the subtree where it is defined. Directory Server 5.2 introduces extended scoping of the nested role, allowing it to nest roles located in other subtrees and have members anywhere in the directory. For details on extending role scope, see "Example of a Nested Role Definition" on page 187

About Roles

Each role has *members*, or entries that possess the role. As entries are retrieved from the directory, the roles mechanism automatically generates the `nsRole` attribute in every entry that is a member of any role. This multi-valued attribute contains the DN of all role definitions of which the entry is a member. The `nsRole` attribute is a computed attribute that is not stored with the entry itself, but is returned to the client application as a normal attribute in operation results.

Directory Server supports three types of roles:

- Managed role - The administrator assigns a managed role by adding the `nsRoleDN` attribute to the desired member entries. The value of this attribute is the DN of the role definition entry. A managed role is similar to a static group except that membership is defined in each entry and not in the role definition entry.
- Filtered role - These are equivalent to dynamic groups: they define a filter string in their `nsRoleFilter` attribute. The scope of a filtered role is the subtree in which it is located, rooted at the parent of its definition entry. When the server returns an entry in the scope of a filtered role that matches its filter, that entry will contain the generated `nsRole` attribute identifying the role.
- Nested role - These are roles that name other role definitions, including other nested roles. The set of members of a nested role is the union of all members of the roles it contains. Nested roles may also define extended scope to include the members of roles in other subtrees.

Roles enable client applications to determine all role membership of an entry by directly reading its `nsRole` attribute. This simplifies client processing and optimizes directory usage. Roles can be used in combination with the CoS mechanism to generate other attributes for role members (see "Creating Role-Based Attributes" on page 202). Roles can be used to define access control (see "Defining Role Access - roledn Keyword" on page 227). Roles also support other functionality such as activating or deactivating all of their members at once (see "Inactivating and Activating Users and Roles" on page 291).

Searching the nsRole Attribute

Directory Server permits the use of the `nsRole` attribute in any search filter. You can search for a particular value for this attribute using any of the comparison operators. When searching `nsRole` attribute, keep in mind the following considerations:

- Searches involving the `nsRole` attribute may take significantly longer because all roles must be evaluated before the entries can be filtered.
- Directory Server is optimized for equality searches on membership in specific in managed roles. For example, the following search will be nearly as fast as a search on real attributes:

  ```
  (&(objectclass=person)
    (nsRole=cn=managersRole,ou=People,dc=example,dc=com)
  ```
- The `nsRoleDN` attribute used to define managed role membership is indexed by default in all suffixes. Optimizations for searching managed role membership will be lost if indexing for this attribute is disabled.
- Searching for entries containing a filtered role involves an internal search using the role filter. This internal operation will be fastest if all attributes that appear in the role filter are indexed in all suffixes in the scope of the role.

Permissions on the nsRole Attribute

The `nsRole` attribute may only be assigned by the roles mechanism and is never writable nor modifiable by any directory user. However, you should keep in mind the following considerations:

- The `nsRole` attribute is potentially readable by any directory user, and you can define access controls to protect it against reading.
- The `nsRoleDN` attribute defines managed role membership and you should decide whether users may add or remove themselves from the role. See "Example of a Managed Role Definition" on page 185 for the ACI that prevents users from modifying their own roles.
- Filtered roles determine membership through filters that are based on the existence or the values of attributes in user entries. Define the user permissions of these attributes carefully, to control who may define membership in the filtered role.

For more information about how to use roles in your directory, refer to "Managed, Filtered, and Nested Roles," in Chapter 4 of the *Directory Server Deployment Planning Guide*.

Assigning Roles Using the Console

This section describes the procedures for creating and modifying roles through Directory Server Console.

Creating a Managed Role

Managed roles have a role definition entry and members are designated by adding the `nsRoleDN` attribute to each member entry. To create and add members to a managed role using the console:

1. On the top-level Directory tab of Directory Server Console, right-click the entry in the directory tree where you want to add the new role definition, and select the New>Role item.

   Alternatively, select the entry and choose the New>Role item from the Object menu.

2. In the Create New Role dialog, you must type a name for your new role in the “Role Name” field, and you may add an optional description of the role in the “Description” field. The group name will become the value of the `cn` (common name) attribute for the new role entry and appear in its DN.

3. Click Members in the left-hand list of the dialog. In the right pane, the Managed Role radio button is selected by default.

4. Click Add below the list of members to add new members to the role. The standard “Search users and groups” dialog box appears.

5. In the Search drop-down list, select Users and enter a string to search for, and then click Search. Click the Advanced button to search specific attributes or specific attribute values.

   Select one or more of the entries in the results and click OK. Repeat this step to add all of the members you want to add to this managed role.

6. When you have finished adding entries to the role, click OK. The new role appears in the directory tree with the icon for a managed role, and all member entries will be given the attribute `nsRoleDN` with the value of the DN of this new role entry.

7. Once the role is created, you can also assign this role to any entry by adding the `nsRoleDN` attribute to the entry with the value of the DN of the role entry.

Creating a Filtered Role

Entries are members of a filtered role if they possess attributes or attribute values that are selected by the LDAP filter in the role’s definition.

NOTE The filter string of a filtered role may be based on any attribute, except other virtual attributes generated by the CoS mechanism (see "About CoS" on page 188).

To create and add members to a filtered role using the console:

1. On the top-level Directory tab of Directory Server Console, right-click the entry in the directory tree where you want to add the new role definition, and select the New>Role item.

   Alternatively, select the entry and choose the New>Role item from the Object menu.

2. In the Create New Role dialog, you must type a name for your new role in the "Role Name" field, and you may add an optional description of the role in the "Description" field. The role name will become the value of the `cn` (common name) attribute for the new role entry and appear in its DN.

3. Click Members in the left-hand list of the dialog and select the Filtered Role radio button in the right-hand panel.

4. Enter an LDAP filter in the text field to define the filter that will determine role members. Alternatively, click Construct to be guided through the construction of an LDAP filter.

5. If you click Construct, the Construct LDAP Filter dialog appears. Disregard the LDAP Server Host, Port, Base DN, and Search scope fields, because you cannot specify these in a filtered role definition.

   a. Search only for users in a filtered role. This will add the component `(objectclass=person)` to the filter. If you do not want this component, you must edit the LDAP filter in the text field of the Create New Role dialog.

   b. Refine the filter by selecting an attribute from the "Where" drop-down list and setting the matching criteria. To add additional filters, click More. To remove unnecessary filters, click Fewer.

   c. Click OK to use your filter in the filtered role definition. You can then edit the filter in the text field to modify any component.

6. Click Test to try your filter. A Filter Test Result dialog will display the entries that currently match your filter.

7. Click OK to create the new role entry. The new role appears in the directory tree with the icon for a filtered role.

Creating a Nested Role

Nested roles enable you to create roles that contain other roles and to extend the scope of existing roles. Before you create a nested role, another role must exist. When you create a nested role, the console displays a list of the roles available for nesting. A nested role may contain another nested role, up to 30 levels of nesting. Beyond this fixed limit, the server will log an error when evaluating the role.

To create and add members to a nested role using the console:

1. On the top-level Directory tab of Directory Server Console, right-click the entry in the directory tree where you want to add the new role definition, and select the New>Role item.

   Alternatively, select the entry and choose the New>Role item from the Object menu.

2. In the Create New Role dialog, you must type a name for your new role in the "Role Name" field, and you may add an optional description of the role in the "Description" field. The role name will become the value of the `cn` (common name) attribute for the new role entry and appear in its DN.

3. Click Members in the left-hand list of the dialog and select the Nested Role radio button in the right panel.

4. Click Add to add existing roles to the list of nested roles. In the Role Selector dialog box that appears, select one or more roles from the list of available roles and click OK.

5. Click OK to create the nested role entry. The new role appears in the directory with the icon for a nested role.

6. To modify the scope of the nested role, use the command-line procedure shown in "Example of a Nested Role Definition" on page 187.

Viewing and Editing an Entry's Roles

1. On the top-level Directory tab of Directory Server Console, browse the directory tree to display the entry for which you want to view or edit a role.

2. Right-click the entry and select Set Roles from the pop-up menu. Alternatively, you may left-click the entry to select it and choose Set Roles from the Object menu.

   The Set Roles dialog is displayed.

3. Select the Managed Roles tab to display the managed roles to which this entry belongs. You may perform the following actions:

- To add a new managed role, click Add and select an available role from the Role Selector window. Click OK in the Role Selector window.
- To remove a managed role, select it and click Remove.
- To edit a managed role associated with an entry, select it in the table and click Edit. The role is displayed in the custom editor for Roles. Make any changes to the role and click OK to save the new role definition.

4. Select the Other Roles tab to view the filtered or nested roles to which this entry belongs. To change role membership in a filtered or nested role, you must edit the role definition:
   - Select the role and click Edit to display the custom editor for Roles. Make changes to the role and click OK to save the new role definition.
5. Click OK once you have finished modifying the roles to save your changes.

Modifying a Role Entry

1. On Directory Server Console, select the Directory tab.
2. Browse the navigation tree to locate the definition entry of an existing role. Roles are children of the entry where they were created. Double-click the role.

   The Edit Entry dialog box appears.
3. Click General in the left pane to change the role name and description.
4. Click Members in the left pane to change the members of managed and nested roles or to change the filter of a filtered role.
5. Click OK to save your changes.

Deleting a Role

Deleting a role deletes only the entry of the role definition, not its members.

To delete a role:

1. In Directory Server Console, select the Directory tab.
2. Browse the navigation tree to locate the definition entry of your role. Roles are children of the entry where they were created.
3. Right-click the role and select Delete.

   A dialog box appears asking you to confirm the deletion. Click Yes.
4. The Deleted Entries dialog box appears to inform you that the role was successfully deleted. Click OK.

NOTE Deleting a role deletes the role entry but does not delete the nsRoleDN attribute for each role member. To do this, enable the Referential Integrity Plug-In and configure it to manage the nsRoleDN attribute. For more information, see "Maintaining Referential Integrity" on page 88.

Managing Roles From the Command Line

Roles are defined in entries that the directory administrator can access through command-line utilities. Once you create a role, you assign members to it as follows:

- Members of a managed role have the nsRoleDN attribute in their entry.
- Members of a filtered role are entries that match the filter specified in the nsRoleFilter attribute.
- Members of a nested role are members of the roles specified in the nsRoleDN attributes of the nested role definition entry.

All role definitions inherit from the LDAPsubentry and nsRoleDefinition object classes. The following table lists additional object classes and associated attributes specific to each type of role.

Table 5-1 Object Classes and Attributes Used to Define Roles

Role Type	Object Classes	Attributes
Managed Role	nsSimpleRoleDefinition nsManagedRoleDefinition	Description (optional)
Filtered Role	nsComplexRoleDefinition nsFilteredRoleDefinition	nsRoleFilter Description (optional)
Nested Role	nsComplexRoleDefinition nsNestedRoleDefinition	nsRoleDN Description (optional)

Example of a Managed Role Definition

To create a role that will be assigned to all marketing staff, run the following ldapmodify command:

```
ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
dn: cn=Marketing,ou=marketing,ou=People,dc=example,dc=com
objectclass: top
objectclass: LDAPsubentry
objectclass: nsRoleDefinition
objectclass: nsSimpleRoleDefinition
objectclass: nsManagedRoleDefinition
cn: Marketing
description: managed role for marketing staff
```

Notice that the `nsManagedRoleDefinition` object class inherits from the `LDAPsubentry`, `nsRoleDefinition` and `nsSimpleRoleDefinition` object classes.

Assign the role to a marketing staff member named Bob by updating his entry with the following `ldapmodify` command:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w secret
dn: cn=Bob Arnold,ou=marketing,ou=People,dc=example,dc=com
changetype: modify
add: nsRoleDN
nsRoleDN: cn=Marketing,ou=marketing,ou=People,dc=example,dc=com
```

The `nsRoleDN` attribute present in the entry indicates that the entry is a member of a managed role identified by the DN of its role definition. To allow users to modify their own `nsRoleDN` attribute, but to prevent them from adding or removing the `nsManagedDisabledRole`, add the following access control instruction (ACI):

```
aci: (targetattr="nsRoleDN")(targattrfilters="add=nsRoleDN:
 (!(nsRoleDN=cn=AdministratorRole,dc=example,dc=com)),
 del=nsRoleDN:(!(nsRoleDN=cn=nsManagedDisabledRole,dc=example,
 dc=com)")(version3.0;aci "allow mod of nsRoleDN by self except
 for critical values"; allow(write) userdn="ldap:///self";)
```

Example of a Filtered Role Definition

To set up a filtered role for sales managers, assuming they all have the `isManager` attribute, run the following `ldapmodify` command:

```
ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
dn: cn=ManagerFilter,ou=sales,ou=People,dc=example,dc=com
objectclass: top
objectclass: LDAPsubentry
objectclass: nsRoleDefinition
objectclass: nsComplexRoleDefinition
```

```
objectclass: nsFilteredRoleDefinition
cn: ManagerFilter
nsRoleFilter: (isManager=True)
Description: filtered role for sales managers
```

Notice that the `nsFilteredRoleDefinition` object class inherits from the `LDAPsubentry`, `nsRoleDefinition`, and `nsComplexRoleDefinition` object classes. The `nsRoleFilter` attribute specifies a filter that will find all employees in the `ou=sales` organization that have subordinates, for example:

```
ldapsearch -h host -p port -D "cn=Directory Manager" -w password \
-b "ou=People,dc=example,dc=com" -s sub "(cn=*Fuentes)"
dn: cn=Carla Fuentes,ou=sales,ou=People,dc=example,dc=com
cn: Carla Fuentes
isManager: TRUE
...
nsRole: cn=ManagerFilter,ou=sales,ou=People,dc=example,dc=com
```

NOTE The filter string of a filtered role may be based on any attribute, except other virtual attributes generated by the CoS mechanism (see "About CoS" on page 188).

When filtered role members are user entries, you may choose to restrict their ability to add or remove themselves from the role by protecting the filtered attributes with access control instructions (ACIs).

Example of a Nested Role Definition

The roles nested within the nested role are specified using the `nsRoleDN` attribute. To create a role that contains both the marketing staff and sales manager members of the roles created in the previous examples, use the following command:

```
ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
dn: cn=MarketingSales,ou=marketing,ou=People,dc=example,dc=com
objectclass: top
objectclass: LDAPsubentry
objectclass: nsRoleDefinition
objectclass: nsComplexRoleDefinition
objectclass: nsNestedRoleDefinition
cn: MarketingSales
nsRoleDN: cn=ManagerFilter,ou=sales,ou=People,dc=example,dc=com
nsRoleDN: cn=Marketing,ou=marketing,ou=People,dc=example,dc=com
nsRoleScopeDN: ou=sales,ou=People,dc=example,dc=com
```

Notice the `nsNestedRoleDefinition` object class inherits from the `LDAPsubentry`, `nsRoleDefinition`, and `nsComplexRoleDefinition` object classes. The `nsRoleDN` attributes contain the DN of the marketing managed role and the sales managers filtered role. Both of the users in the previous examples, Bob and Carla, would be members of this new nested role.

The scope of this filter includes the default scope, which is the subtree where it is located, and the subtree below any values of the `nsRoleScopeDN` attribute. In this case, the `ManagerFilter` is in the `ou=sales,ou=People,dc=example,dc=com` subtree, and this subtree must be added to the scope.

Defining Class of Service (CoS)

The Class of Service (CoS) mechanism generates virtual attributes as an entry is retrieved for a client application. CoS simplifies entry management and reduces storage requirements.

As with groups and roles, CoS relies on helper entries in your directory and may be configured through the console or through the command line. The following sections describe CoS and provide the procedures for managing CoS in both ways.

NOTE Any search operation may test the existence of a CoS generated attribute or compare its value. The names of the virtual attributes may be used in any filter string, whether from a client search operation or an internal filter used in a filtered role. Directory Server also supports virtual attributes in VLV (virtual list view) operations and in server-side sorting controls, just like any real attribute.

About CoS

A CoS defines a virtual attribute and its value for any entry within the scope of the CoS, called the *target entries*. Each CoS is comprised of the following entries in your directory:

- CoS Definition Entry - Identifies the type of CoS you are using and the name of the CoS attribute that will be generated. Like the role definition entry, it inherits from the `LDAPsubentry` object class. The scope of the CoS is the entire subtree below the parent of the CoS definition entry. Multiple definitions may exist for the same CoS attribute which may therefore be multivalued.

- Template Entry - Contains the values of one or more virtual attributes. All entries within the scope of the CoS will use the values defined here. There may also be multiple template entries in which case the generated attribute may be multivalued.

There are three types of CoS, each of which corresponds to a different interaction between the CoS definition and template entries:

- Pointer CoS - The CoS definition entry directly identifies the template entry by its DN. All target entries will have the same value for the CoS attribute as given in the template.
- Indirect CoS - The CoS definition identifies an attribute, called the indirect specifier, whose value in a target entry must contain the DN of a template. With indirect CoS, each target entry may use a different template and thus have a different value for the CoS attribute.
- Classic CoS - The CoS definition identifies the base DN of the template and a specifier, which is the name of an attribute in target entries. The specifier attribute must contain an RDN (relative domain name) that when combined with the template base DN, determines the template containing the CoS values.

The CoS definition entry is an instance of the `cosSuperDefinition` object class and also inherits from one of the following object classes to specify the type of CoS:

- `cosPointerDefinition`
- `cosIndirectDefinition`
- `cosClassicDefinition`

The CoS definition entry contains the attributes specific to each type of CoS for naming the virtual CoS attribute, the template DN, and the specifier attribute in target entries, if needed. By default, the CoS mechanism will not override the value of an existing attribute with the same name as the CoS attribute. However, the syntax of the CoS definition entry allows you to control this behavior.

The CoS template entry is an instance of the `cosTemplate` object class. The CoS template entry contains the value or values of the attributes generated by the CoS mechanism. The template entries for a given CoS are stored in the directory tree at the same level as the CoS definition.

When possible, definition and template entries should be located in the same place for easier management. Also, you should name them in a way that suggests the functionality they provide. For example, a definition entry DN such as `cn=ClCosGenerateEmployeeType,ou=People,dc=example,dc=com` is more descriptive than `cn=ClassicCos1,ou=People,dc=example,dc=com`.

"Managing Attributes with Class of Service," in Chapter 4 of the *Directory Server Deployment Planning Guide* describes each type of CoS in more detail and provides examples and deployment considerations. For more information about the object classes and attributes associated with each type of CoS, refer to "Managing CoS From the Command Line" on page 194.

CoS Limitations

The creation and administration of CoS definition and template entries are subject to the following limitations. Further limitations related to the deployment of CoS virtual attributes are described in "CoS Limitations," in Chapter 4 of the *Directory Server Deployment Planning Guide.*

Searches involving CoS generated attributes are unindexed. Any search filter may test the existence or compare the value of a virtual attribute. *However*, virtual attributes cannot be indexed and any filter component that involves a CoS generated attribute will result in an unindexed search with significant impact on performance. Note that Directory Server 5.2 introduces hash tables that speed up searches on schemes with more than ten classic CoS template entries. This facility is enabled by default. For information on how to disable the facility, see "Class of Service Plug-in," in Chapter 2 of the *Directory Server Administration Reference.*

Restricted subtrees. You cannot create CoS definitions in the `cn=config` nor in the `cn=schema` subtrees. Therefore, these entries cannot contain virtual attributes.

Restricted attribute types. You must not generate the following attribute types with the CoS mechanism, because they will not have the same behavior as real attributes of the same name:

- `userPassword` - A CoS-generated password value cannot be used to bind to the directory server.
- `aci` - The directory server will not apply any access control based on the contents of a virtual ACI value defined by CoS.
- `objectclass` - The directory server will not perform schema checking on the value of a virtual object class defined by CoS.
- `nsRoleDN` - A CoS-generated `nsRoleDN` value will not be used by the server to generate roles.

Attribute subtypes not supported. The CoS mechanism will not generate attributes with subtypes, such as languages or `;binary`.

Real and virtual attribute values. The CoS mechanism never generates multivalued attributes containing “real” values defined in the entry and “virtual” values defined by the CoS template. The values of an attribute are either those stored in the entry or those generated by the CoS mechanism, as described in “Overriding Real Attribute Values”” and “Multivalued CoS Attributes” on page 197.

All templates must be local. The DNs of template entries, either in a CoS definition or in the specifier of the target entry, must refer to local entries in the directory server. Templates and the values they contain cannot be retrieved through directory chaining or referrals.

Managing CoS Using the Console

This section describes how to create and edit CoS definitions through Directory Server Console.

In addition, if your CoS values need to be secure, you should define access control instructions (ACIs) for both CoS definition and template entries, as well as for the specifier attribute in the target entries. See “Using CoS Securely,“ in Chapter 7 of the *Directory Server Deployment Planning Guide* for CoS security considerations and Chapter 6, “Managing Access Control” for procedures on creating ACIs using the console.

Creating a New CoS

In the case of pointer CoS and classic CoS, you must create the template entry before the definition entry:

1. On the top-level Directory tab of Directory Server Console, right-click the entry in the directory tree where you want to add the new template entry, and select the New>Other item from the pop-up menu.

   Alternatively, select the parent entry and choose the New>Other item from the Object menu.

2. In the New Object dialog, select `costemplate` from the list of object classes. The Generic Editor dialog opens with default values for certain attributes in the new template.

3. Edit the new template object in the following manner:

   a. Add the `LDAPsubentry` and `extensibleobject` values to the `objectclass` attribute.

b. Add the cn attribute and give it a value that will identify the template, for example, `cosTemplateForHeadquartersFax`.

c. Change the naming attribute to the new cn attribute.

   You may add any other attribute and use it as the naming attribute instead, but using cn is common practice.

d. Modify the `cosPriority` attribute by setting it to an integer value, or remove the priority attribute altogether if it is not needed. For more information, see "Cos Attribute Priority" on page 198.

e. Add the attribute and its value that you wish to be generated on target entries by the CoS mechanism.

4. Click OK in the Generic Editor dialog to create the template entry.

5. If you are going to define a pointer CoS for this template, select the new template entry in directory tree and select Edit>Copy DN from the menu.

The procedure for creating the definition entry is the same for all types of CoS:

1. On the top-level Directory tab of the Directory Server console, right-click the entry in the directory tree where you want to add the new CoS definition, and select the New>Class of Service item from the pop-up menu.

   Alternatively, select the parent entry and choose the New>Class of Service item from the Object menu.

   The custom editor for Class of Service entries is displayed.

2. Enter a name and optional description for your new Class of Service. The name will appear in the cn naming attribute for the CoS definition entry.

3. Click the Attributes tab in the left-hand list. The dialog displays the list of attributes that will be generated by the CoS mechanism on the target entries.

   Click Add to browse the list of possible attributes and add them to the list.

4. Once you have added an attribute to the list, the "Class of Service Behavior" column contains a drop-down list. Click in this cell to select the override behavior:

   - **Does not override target entry attribute -** The CoS attribute value will be generated only if there is no corresponding attribute value already stored in the same attribute of the target entry.

   - **Overrides target entry attribute -** The value of the attribute generated by the CoS will override any value for that attribute in the target entry.

- **Overrides target entry attribute and is operational -** The attribute will override any target value and be an attribute operational, so that it is not visible to client applications unless explicitly requested.

NOTE You can only make an attribute operational if it is also defined as operational in the schema.

---

5. The Merge column contains a checkbox for merge-schemes. Select this checkbox to allow this CoS attribute to merge with other CoS values for the same attribute. However, a CoS attribute will never merge with an existing value, it will either replace it or not be generated as defined by the previous column.
6. Click the Template tab in the left-hand list. Select how the template entry is identified and then fill in the corresponding fields. This will determine the type of CoS you wish to define.
   - **By its DN -** This choice will define a pointer CoS: enter the DN of a template entry in the "Template DN" field. Click Browse to select the template DN from the directory, or type Ctrl-V to paste the DN that you copied after creating the template entry.
   - **Using the value of one of the target entry's attributes -** This choice will define an indirect CoS: enter the name of the specifier attribute in the "Attribute Name" field. Be sure to select an attribute which contains DN values. Click Change to select the attribute from a list.
   - **Using both its DN and the value of one of the target entry's attributes -** This choice will define a classic CoS: enter both the base DN for a template and an attribute name. Click Browse to select the parent entry of the potential target entries, and click Change to select the attribute from a list.
7. Click OK to create the CoS definition entry.

Editing an Existing CoS

1. On the top-level Directory tab of Directory Server Console, double-click the CoS definition entry or right-click on it and select Edit With Custom Editor from the pop-up menu.

   The custom editor for Class of Service entries is displayed.
2. Edit the name and description fields as desired.

3. Click the Attributes tab in the left-hand list to add or remove virtual attributes that will be generated by the CoS mechanism.
4. Click the Template tab in the left-hand list to redefine the name of the template specifier attribute or the template entry DN. This dialog also allows you to redefine the type of your CoS definition.
5. Click OK to save your changes.

Deleting a CoS

1. On the top-level Directory tab of Directory Server Console, browse the directory tree to display the CoS definition entry.
2. Right-click the CoS entry and select Delete from the pop-up menu. A dialog box appears asking you to confirm the deletion. Click Yes.

Managing CoS From the Command Line

Because all configuration information and template data is stored as entries in the directory, you can use the LDAP command-line tools to configure and manage CoS definitions. This section shows how to create CoS definition and template entries from the command line.

In addition, if your CoS values need to be secure, you should define access control instructions (ACIs) for both CoS definition and template entries, as well as for the specifier attribute in the target entries. See “Using CoS Securely,“ in Chapter 7 of the *Directory Server Deployment Planning Guide* for CoS security considerations and Chapter 6, “Managing Access Control” for procedures to create ACIs from the command line.

Creating the CoS Definition Entry From the Command Line

All CoS definition entries have the `LDAPsubentry` object class and inherit from the `cosSuperDefinition` object class. In addition, each type of CoS inherits from specific object classes and contains the corresponding attributes. The following table lists the object classes and attributes associated with each type of CoS definition entry:

Table 5-2 Object Classes and Attributes in CoS Definition Entries

CoS Type	CoS Definition Entry

Pointer CoS	`objectclass: top`
	`objectclass: LDAPsubentry`
	`objectclass: cosSuperDefinition`
	`objectclass: cosPointerDefinition`
	`cosTemplateDN:` *DN*
	`cosAttribute:` *attributeName override merge*

Indirect CoS	`objectclass: top`
	`objectclass: LDAPsubentry`
	`objectclass: cosSuperDefinition`
	`objectclass: cosIndirectDefinition`
	`cosIndirectSpecifier:` *attributeName*
	`cosAttribute:` *attributeName override merge*

Classic CoS	`objectclass: top`
	`objectclass: LDAPsubentry`
	`objectclass: cosSuperDefinition`
	`objectclass: cosClassicDefinition`
	`cosTemplateDN:` *DN*
	`cosSpecifier:` *attributeName*
	`cosAttribute:` *attributeName override merge*

In all cases, `cosAttribute` is multi-valued, with each value defining an attribute that will be generated by the CoS mechanism.

You can use the following attributes in CoS definition entries (for more information about these attributes, refer to Chatper 10, “Attribute Reference“ in the *Directory Server Administration Reference*):

Table 5-3 CoS Definition Entry Attributes

Attribute	Purpose Within the CoS Definition Entry
`cosAttribute:` *attributeName override merge*	Defines the name of the virtual attribute for which you want to generate a value. This attribute is multivalued, each value giving the name of an attribute whose value will be generated from the template. The *override* and *merge* qualifiers specify how the CoS attribute value is computed in special cases described below this table. The *attributeName* may not contain any subtypes. Attribute names with subtypes will be ignored but other values of `cosAttribute` will be processed.

Table 5-3 CoS Definition Entry Attributes *(Continued)*

Attribute	Purpose Within the CoS Definition Entry
`cosIndirectSpecifier:` *attributeName*	Defines the name of the attribute in target entries whose value is used by indirect CoS to identify the template entry. The named attribute is called the specifier and must contain a full DN string in each target entry. This attribute is single-valued but the specifier attribute may be multivalued to designate multiple templates.
`cosSpecifier:` *attributeName*	Defines the name of the attribute in target entries whose value is used by classic CoS to identify the template entry. The named attribute is called the specifier and must contain a string that can be found in the RDN of template entries. This attribute is single-valued but the specifier attribute may be multivalued to designate multiple templates.
`cosTemplateDN:` *DN*	Provides the full DN of the template entry for a pointer CoS definition or the base DN of the template entry for classic CoS.

The `cosAttribute` attribute allows two qualifiers following the name of the CoS attribute. The *override* qualifier has one of the following values:

- `default` (or no qualifier) - Indicates that the server does not override a real attribute value stored in the entry when it has the same type as the virtual attribute.
- `override` - Indicates that the server always returns the value generated by the CoS, even when there is a value stored with the entry.
- `operational` - Indicates that the attribute will only be returned if it is explicitly requested in the search. Operational attributes do not need to pass a schema check in order to be returned. It also has the same behavior as the `override` qualifier.

  You can only make an attribute operational if it is also defined as operational in the schema. For example, if your CoS generates a value for the `description` attribute, you cannot use the `operational` qualifier because this attribute is not marked operational in the schema.

The *merge* qualifier is either absent or given with the following value:

- `merge-schemes` - Allows the virtual CoS attribute to be multivalued, either from multiple templates or multiple CoS definitions. For more information, see "Multivalued CoS Attributes" on page 197.

Overriding Real Attribute Values

You might create a pointer CoS definition entry that contains an `override` qualifier as follows:

```
dn: cn=pointerCoS,dc=example,dc=com
objectclass: top
objectclass: LDAPsubentry
objectclass: cosSuperDefinition
objectclass: cosPointerDefinition
cosTemplateDn: cn=exampleUS,cn=data
cosAttribute: postalCode override
```

This pointer CoS definition entry indicates that it is associated with the template entry `cn=exampleUS,cn=data` that generates the value of the `postalCode` attribute. The override qualifier indicates that this value will take precedence over the value of the `postalCode` attribute if it exists in a target entry.

NOTE If the CoS attribute is defined with the operational or override qualifiers, you will not be able to perform write operations on the "real" value of that attribute in any entry in the CoS scope.

Multivalued CoS Attributes

When you specify the `merge-schemes` qualifier, the generated CoS attribute may be multivalued. There are two ways for a CoS attribute to be multivalued:

- With indirect or classic CoS, the specifier attributes in target entries may be multivalued. In this case, each value determines a template and the value from each template is part of the generated value.
- There can be multiple CoS definition entries of any type containing the same attribute name in their `cosAttribute`. In this case, if all definitions contain the `merge-schemes` qualifier, the generated attribute will contain all values computed by each definition.

The two situations may occur together and define even more values. However, in all cases, duplicate values will only be returned once in generated attribute.

In the absence of the `merge-schemes` qualifier, the `cosPriority` attribute of the template entry will be used to determine a single value among all templates for the generated attribute, as described in the next section.

The `merge-schemes` qualifier never merges a “real” value defined in the target with generated values from the templates. The *merge* qualifier is independent of the *override* qualifier, all pairings are possible and the behaviors implied by each are complimentary. Also, the qualifiers may be specified in any order after the attribute name.

NOTE When there are multiple CoS definitions for the same attribute, they must all have the same *override* and *merge* qualifiers. When different pairs of qualifiers occur in CoS definitions, one of the combinations is selected arbitrarily among all definitions.

Cos Attribute Priority

If there are multiple CoS definitions or multivalued specifiers, but no `merge-schemes` qualifier Directory Server uses a priority attribute to select a single template that defines the single value of the virtual attribute.

The `cosPriority` attribute represents the global priority of a particular template among all those being considered. A priority of zero is the highest priority. Templates that contain no `cosPriority` attribute are considered the lowest priority. When two or more templates provide an attribute value but have the same (or no) priority, a value is chosen arbitrarily.

Template priorities are not taken into account when using the `merge-schemes` qualifier. When merging, all templates being considered define a value regardless of any priority they define. The `cosPriority` attribute is defined on CoS template entries as described in the following section.

NOTE The `cosPriority` attribute must not have a negative value. Also, attributes generated by indirect CoS do not support priority. Do not use `cosPriority` in template entries of an indirect CoS definition.

Creating the CoS Template Entry From the Command Line

When using pointer CoS or classic CoS, the template entry contains the `LDAPsubentry` and `cosTemplate` object classes. This entry must be created specifically for the CoS definition. Making the CoS template entry an instance of the `LDAPsubentry` object classes allows ordinary searches to be performed unhindered by the configuration entries.

The template of the indirect CoS mechanism is an arbitrary, existing entry in the directory. The target does not need to be identified ahead of time nor given the `LDAPsubentry` object class, but it must have the auxiliary `cosTemplate` object class. The indirect CoS template is accessed only when the CoS is evaluated to generate a virtual attribute and its value.

In all cases, the CoS template entry must contain the attribute and the value that is generated by the CoS on the target entries. The attribute name is specified in the `cosAttribute` attribute of the CoS definition entry.

The following example shows a template entry of the highest priority for a pointer CoS that generates the `postalCode` attribute:

```
dn: cn=ZipTemplate,ou=People,dc=example,dc=com
objectclass: top
objectclass: LDAPsubentry
objectclass: extensibleobject
objectclass: cosTemplate
postalCode: 95054
cosPriority: 0
```

The following sections provide examples of template entries along with examples of each type of CoS definition entry.

Example of a Pointer CoS

The following command creates a pointer CoS definition entry that has the `cosPointerDefinition` object class. This definition entry uses the CoS template entry given above to share a common postal code among all entries in the `ou=People,dc=example,dc=com` tree.

```
ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
dn: cn=pointerCoS,ou=People,dc=example,dc=com
objectclass: top
objectclass: LDAPsubentry
objectclass: cosSuperDefinition
objectclass: cosPointerDefinition
cosTemplateDn: cn=ZipTemplate,ou=People,dc=example,dc=com
cosAttribute: postalCode
```

The CoS template entry (`cn=ZipTemplate,ou=People,dc=example,dc=com`) supplies the value stored in its `postalCode` attribute to all entries located under the `ou=People,dc=example,dc=com` suffix. If you search for any entry that does not have a postal code in the same subtree, you will see the value of the generated attribute:

```
ldapsearch -h host -p port -D "cn=Directory Manager" -w password \
-b "ou=People,dc=example,dc=com" -s sub "(cn=*Jensen)"
dn: cn=Babs Jensen,ou=People,dc=example,dc=com
cn: Babs Jensen
...
postalCode: 95054
```

Example of an Indirect CoS

Indirect CoS names an attribute in the `cosIndirectSpecifier` attribute to locate the template specific to each target. This indirect CoS uses the `manager` attribute of the target entry to identify the CoS template entry. The template entry is the manager's user entry, and it must contain the value of the attribute to generate.

The following command creates the indirect CoS definition entry, containing the `cosIndirectDefinition` object class:

```
ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
dn: cn=generateDeptNum,ou=People,dc=example,dc=com
objectclass: top
objectclass: LDAPsubentry
objectclass: cosSuperDefinition
objectclass: cosIndirectDefinition
cosIndirectSpecifier: manager
cosAttribute: departmentNumber
```

Next, add the `cosTemplate` object class to the template entries, and make sure they define the attribute to be generated. In this example, all manager entries will be templates:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: cn=Carla Fuentes,ou=People,dc=example,dc=com
changetype: modify
add: objectclass
objectclass: cosTemplate
-
add: departmentNumber
departmentNumber: 318842
```

With this CoS, target entries (the entries under `ou=People,dc=example,dc=com`) containing the `manager` attribute will automatically have the department number of their manager. The `departmentNumber` attribute is virtual on the target entries because it does not exist in the server, but it is returned as part of the target entry. For example, if Babs Jensen's manager is defined to be Carla Fuentes, her department number will be the following:

```
ldapsearch -h host -p port -D "cn=Directory Manager" -w password \
-b "ou=People,dc=example,dc=com" -s sub "(cn=*Jensen)"
dn: cn=Babs Jensen,ou=People,dc=example,dc=com
cn: Babs Jensen
...
manager: cn=Carla Fuentes,ou=People,dc=example,dc=com
departmentNumber: 318842
```

Example of a Classic CoS

This example shows how to generate a postal address with a classic CoS. The generated value is given in a template entry that is found by a combination of the `cosTemplateDN` in the CoS definition and the value of the `cosSpecifier` attribute in the target entry. The following command creates the definition entry using the `cosClassicDefinition` object class:

```
ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
dn: cn=classicCoS,dc=example,dc=com
objectclass: top
objectclass: LDAPsubentry
objectclass: cosSuperDefinition
objectclass: cosClassicDefinition
cosTemplateDn: ou=People,dc=example,dc=com
cosSpecifier: building
cosAttribute: postalAddress
```

Continuing the same command, create the template entries that give the postal address for each building:

```
dn: cn=B07,ou=People,dc=example,dc=com
objectclass: top
objectclass: LDAPsubentry
objectclass: extensibleobject
objectclass: cosTemplate
postalAddres: 7 Old Oak Street$Anytown, CA 95054
```

With this CoS, target entries (the entries under `ou=People,dc=example,dc=com`) containing the `building` attribute will automatically have the corresponding postal address. The CoS mechanism searches for a template entry that has the specifier attribute value in its RDN. In this example, if Babs Jensen is assigned to building B07, her postal address will be generated as follows:

```
ldapsearch -h host -p port -D "cn=Directory Manager" -w password \
-b "ou=People,dc=example,dc=com" -s sub "(cn=*Jensen)"
dn: cn=Babs Jensen,ou=People,dc=example,dc=com
cn: Babs Jensen
...
building: B07
postalAddress: 7 Old Oak Street$Anytown, CA 95054
```

Creating Role-Based Attributes

You can create classic CoS schemes that generate attribute values for an entry based on the role possessed by the entry. For example, you could use role-based attributes to set the server look-through limit on an entry-by-entry basis.

To create a role-based attribute, use the `nsRole` attribute as the `cosSpecifier` in the CoS definition entry of a classic CoS. Because the `nsRole` attribute can be multivalued, you can define CoS schemes that have more than one possible template entry. To resolve the ambiguity of which template entry to use, you can include the `cosPriority` attribute in your CoS template entry.

For example, you can create a CoS that allows members of the manager role to exceed the standard mailbox quota. The manager role exists as follows:

```
dn: cn=ManagerRole,ou=People,dc=example,dc=com
objectclass: top
objectclass: LDAPsubentry
objectclass: nsRoleDefinition
objectclass: nsComplexRoleDefinition
objectclass: nsFilteredRoleDefinition
cn: ManagerRole
nsRoleFilter: (isManager=True)
Description: filtered role for managers
```

The classic CoS definition entry would be created as follows:

```
dn: cn=generateManagerQuota,ou=People,dc=example,dc=com
objectclass: top
objectclass: LDAPsubentry
objectclass: cosSuperDefinition
objectclass: cosClassicDefinition
cosTemplateDn: cn=managerCOS,dc=example,dc=com
cosSpecifier: nsRole
cosAttribute: mailboxquota override
```

The CoS template name must be a combination of the `cosTemplateDn` and the value of `nsRole`, which is the DN of the role. For example:

```
dn:cn="cn=ManagerRole,ou=People,dc=example,dc=com",ou=People,
 dc=example,dc=com
objectclass: top
objectclass: LDAPsubentry
objectclass: extensibleobject
objectclass: cosTemplate
mailboxquota: 1000000
```

The CoS template entry provides the value for the `mailboxquota` attribute. An additional qualifier of `override` tells the CoS to override any existing `mailboxquota` attributes values in the target entry. Target entries which are members of the role will have virtual attributes generated by the role and by the CoS, for example:

```
ldapsearch -h host -p port -D "cn=Directory Manager" -w password \
-b "ou=People,dc=example,dc=com" -s sub "(cn=*Fuentes)"
dn: cn=Carla Fuentes,ou=People,dc=example,dc=com
cn: Carla Fuentes
isManager: TRUE
...
nsRole: cn=ManagerRole,ou=People,dc=example,dc=com
mailboxquota: 1000000
```

NOTE The role entry and the CoS definition entry should be located in the same place in the directory tree so that they have the same target entries in their scope. The CoS target entry should also be located in the same place so that it is easy to find and maintain.

Monitoring the CoS Plug-In

Directory Server 5.2 enables you to monitor certain aspects of the CoS plug-in. CoS monitoring attributes are held under the `cn=monitor,cn=Class of Service,cn=plugins,cn=config` entry. For details of these attributes and the information they provide, see “cn=monitor,cn=Class of Service,cn=plugins, cn=config“ in Chapter 2 of the *Directory Server Administration Reference*.

Chapter 6

Managing Access Control

Controlling access to your directory contents is an integral part of creating a secure directory. This chapter describes access control instructions (ACIs) that determine what permissions are granted to users who access the directory. Directory Server includes the ability to view the effective rights of a given user for a given entry. This feature simplifies the administration of the complex and powerful access control mechanism.

While you are in the planning phase of your directory deployment, you should define an access control strategy that serves your overall security policy. Refer to "Designing Access Control" in Chapter 7 of the *Directory Server Deployment Planning Guide* for tips on planning an access control strategy.

This chapter includes the following topics:

Access Control Principles

The mechanism by which you define access is called *access control*. When the server receives a request, it uses the authentication information provided by the user in the bind operation, and the access control instructions (ACIs) defined in the server to allow or deny access to directory information. The server can allow or deny permissions such as read, write, search, or compare. The permission level granted to a user may depend on the authentication information provided.

Using access control, you can control access to the entire directory, a subtree of the directory, specific entries in the directory (including entries defining configuration tasks), a specific set of entry attributes, or specific entry attribute values. You can set permissions for a specific user, all users belonging to a specific group or role, or all users of the directory. Finally, you can define access for a specific client identified by its IP address or DNS name.

ACI Structure

Access control instructions are stored in the directory as attributes of entries. The `aci` attribute is an operational attribute; it is available for use on every entry in the directory, regardless of whether it is defined for the object class of the entry. It is used by Directory Server to evaluate what rights are granted or denied when it receives an LDAP request from a client. The `aci` attribute is returned in an `ldapsearch` operation if specifically requested.

The three main parts of an ACI statement are:

- Target - Determines the entry or attributes to which the permissions will apply.
- Permission - Defines what operations are allowed or denied.
- Bind Rule - Determines who is subject to the ACI based on their bind DN.

The permission and bind rule portions of the ACI are set as a pair, also called an Access Control Rule (ACR). The specified permission to access the target is granted or denied depending on whether the accompanying rule is evaluated to be true. For more information, see “ACI Syntax” on page 210.

ACI Placement

If an entry containing an ACI does not have any child entries, the ACI applies to that entry only. If the entry has child entries, the ACI applies to the entry itself and all entries below it. Therefore, when the server evaluates access permissions to an entry, it verifies the ACIs for every entry between the one requested and the base of its root suffix.

The `aci` attribute is multi-valued, which means that you can define several ACIs for the same entry or subtree.

You can create an ACI on an entry that does not apply directly to that entry but to some or all of the entries in the subtree below it. The advantage of this is that you can place at a high level in the directory tree a general ACI that effectively applies to entries more likely to be located lower in the tree. For example, at the level of an `organizationalUnit` entry or a `locality` entry, you could create an ACI that targets entries that include the `inetorgperson` object class.

You can use this feature to minimize the number of ACIs in the directory tree by placing general rules at high level branch points. To limit the scope of more specific rules, you should place them as close as possible to leaf entries.

NOTE ACIs placed in the root DSE entry (with the DN `""`) apply only to that entry.

ACI Evaluation

To evaluate the access rights to a particular entry, the server compiles a list of the ACIs present on the entry itself and on the parent entries back up to the base of the entry's root suffix. During evaluation, the server processes the ACIs in this order. ACIs are evaluated in all of the suffixes and subsuffixes between an entry and the base of its root suffix, but not across chained suffixes on other servers.

NOTE The Directory Manager is the only privileged user to whom access control does not apply. When a client is bound to the directory as the Directory Manager, the server does not evaluate any ACIs before performing operations.

As a result, performance of LDAP operations as Directory Manager is not comparable to the expected performance of other users. You should always test directory performance with a typical user identity.

By default, if no ACI applies to an entry, access is denied to all users except the Directory Manager. Access must be explicitly granted by an ACI for a user to access any entry in the server. The default ACIs define anonymous read access and allow users to modify their own entries, except for attributes needed for security. For more information, see "Default ACIs" on page 209.

Although the server processes the ACIs closest to the target entry first, the effect of all ACIs that apply to an entry is cumulative. Access granted by any ACI is allowed unless any ACI denies it. ACIs that deny access, no matter where they appear in the list, take precedence over ACIs that allow access to the same resource.

For example, if you deny write permission at the directory's root level, then none of the users can write to the directory regardless of the specific permissions you grant them. To grant a specific user write permissions to the directory, you have to restrict the scope of the original denial for write permission so that it does not include the user.

ACI Limitations

When creating an access control policy for your directory service, you need to be aware of the following restrictions:

- If your directory tree is distributed over several servers using the chaining feature, some restrictions apply to the keywords you can use in access control statements:

    - ACIs that depend on group entries (`groupdn` keyword) must be located on the same server as the group entry. If the group is dynamic, then all members of the group must have an entry on the server too. If the group is static, the members' entries can be located on remote servers.

    - ACIs that depend on role definitions (`roledn` keyword) must be located on the same server as the role definition entry. Every entry that is intended to have the role must also be located on the same server.

  However, you can do value matching of values stored in the target entry with values stored in the entry of the bind user (for example, using the `userattr` keyword). Access is evaluated normally even if the bind user does not have an entry on the server that holds the ACI.

  For more information on how to chain access control evaluation, see "Access Control Through Chained Suffixes" on page 136.

- Attributes generated by a CoS cannot be used in all ACI keywords. Specifically, you should not use attributes generated by CoS with the `userattr` and `userdnattr` keywords because the access control rule will not work. For more information, refer to "Using the userattr Keyword" on page 228. For more information on CoS, see Chapter 5, "Managing Identity and Roles".
- Access control rules are always evaluated on the local server. You *must not* specify the hostname or port number of the server in LDAP URLs used in ACI keywords. If you do, the LDAP URL will not be taken into account at all. For more information, see Chapter 10, "LDAP URL Reference," in the *Directory Server Administration Reference*.
- When granting proxy rights, you cannot grant a user the right to proxy as the Directory Manager, nor can you grant proxy rights to the Directory Manager.

Default ACIs

When you install Directory Server, the following default ACIs are defined on the the root suffix specified during configuration:

- All users have anonymous access to the directory for search, compare, and read operations (except for the `userpassword` attribute.)
- Bound users can modify their own entry in the directory, but not delete it. They cannot modify the `aci`, `nsroledn`, and `passwordPolicySubentry` attributes, nor any of their resource limit attributes, password policy state attributes or account lockout state attributes.
- The configuration administrator (by default `uid=admin,ou=Administrators, ou=TopologyManagement,o=NetscapeRoot`) has all rights except proxy rights.
- All members of the Configuration Administrators group have all rights except proxy rights.
- All members of the Directory Administrators group have all rights except proxy rights.
- All members of the SIE group have all rights except proxy rights. The SIE group is for administrators of this directory's server group in the Administration Server.

Whenever you create a new root suffix in the directory, its base entry has the default ACIs listed above, except for the self-modification ACI. For added security, you should add this ACI as described in "Creating a New Root Suffix Using the Console" on page 112.

The NetscapeRoot subtree for the Administration Server has its own set of default ACIs:

- All members of the Configuration Administrators group have all rights on the NetscapeRoot subtree except proxy rights. This allows them to add new members to the Configuration Administrators group
- All users have anonymous access to the NetscapeRoot subtree for search and read operations.
- The Group Expansion ACI allows members of the administrative groups to access the group definition.

The following sections explain how to modify these default settings to suit the needs of your organization.

ACI Syntax

ACIs are complex structures with many possible variations. Whether you create and modify ACIs using the console or from the command line, you should understand the syntax of an ACI in LDIF. The following sections describe the syntax of an ACI in detail.

TIP Because they are so complex, Directory Server Console does not support all ACIs for editing visually. Also, setting access control for a large number of directory entries is much faster using the command line. Therefore, understanding ACI syntax is the key to creating secure directories with effective access control.

The `aci` attribute has the following syntax:

```
aci: (target)(version 3.0;acl "name";permission bindRules;)
```

where:

- *target* specifies the entry, attributes, or set of entries and attributes for which you want to control access. The target can be a distinguished name, one or more attributes, or a single LDAP filter. The target is optional. When the target is not specified, the ACI applies to the entire entry where it is defined and all of its children.
- `version 3.0` is a required string that identifies the ACI version.

- *name* is a name for the ACI. The name can be any string that identifies the ACI. The ACI name is required and should describe the effect of the ACI.

TIP Although there are no restrictions on the name, it is good practice to use unique names for ACIs. If you use unique names, the "Get Effective Rights" control enables you to determine which ACI is in force.

- *permission* specifically states what rights you are either allowing or denying, for example read or search rights.
- *bindRules* specify the credentials and bind parameters that a user has to provide to be granted access. Bind rules can also be based on user or group membership or connection properties of the client.

You can have multiple targets and permission-bind rule pairs. This allows you to refine both the entry and attributes being targeted and efficiently set multiple access controls for a given target. For example:

```
aci: (target)...(target)(version 3.0;acl "name"; permission bindRule;
 permission bindRule; ...; permission bindRule;)
```

The following is an example of a complete LDIF ACI:

```
aci: (target="ldap:///uid=bjensen,dc=example,dc=com"
 (targetattr="*")(version 3.0; acl "example"; allow (write)
 userdn="ldap:///self";)
```

In this example, the ACI states that the user `bjensen` has rights to modify all attributes in her own directory entry.

The following sections describe the syntax of each portion of the ACI in more detail.

Defining Targets

The target identifies what the ACI applies to. When a client requests an operation on attributes in an entry, the server evaluates the target to see if the ACI must be evaluated to allow or deny the operation. If the target is not specified, the ACI applies to all attributes in the entry containing the `aci` attribute and to the entries below it.

The general syntax for a target is one of the following:

(*keyword* = "*expression*")

(*keyword* != "*expression*")

where:

- *keyword* indicates the type of target. The following types of targets are defined by the keywords in Table 6-1 on page 212:
    - A directory entry or its subtree.
    - The attributes of an entry.
    - A set of entries or attributes that match an LDAP filter.
    - An attribute value or combination of values that match an LDAP filter.
- Equal (=) indicates that the target is the object specified in the *expression*, and not equal (`!=`) indicates the target is any object not specified in the *expression*.

NOTE The "not equal" operator is not supported for the `targattrfilters` keyword.

- *expression* is dependent on the keyword and identifies the target. The quotation marks ("") around *expression* are syntactically required, although the current implementation accepts expressions like `targetattr=*`. In future versions syntax checking may become more strict, however, so you should always use quotation marks.

The following table lists each keyword and the associated expressions:

Table 6-1 LDIF Target Keywords

Keyword	Valid Expressions	Wildcard Allowed?
`target`	ldap:///*distinguished_name*	yes
`targetattr`	*attribute*	yes
`targetfilter`	*LDAP_filter*	yes
`targattrfilters`	*LDAP_operation:LDAP_filter*	yes

Targeting a Directory Entry

Use the target keyword and a DN inside an LDAP URL to target a specific directory entry and any entries below it. The targeted DN must be located in the subtree below the entry where the ACI is defined. The target expression has the following syntax:

```
(target = "ldap:///distinguished_name")
(target != "ldap:///distinguished_name")
```

The distinguished name must be in the subtree rooted at the entry where the ACI is defined. For example, the following target may be used in an ACI on `ou=People,dc=example,dc=com`:

```
(target = "ldap:///uid=bjensen,ou=People,dc=example,dc=com")
```

NOTE The DN of the entry must be a distinguished name in string representation (RFC 2253). Therefore, characters syntactically significant for a dn, such as commas, must be escaped with a single backslash (\). For example:

```
(target="ldap:///uid=cfuentes,o=Example Bolivia\, S.A.")
```

You can also use a wildcard in the DN to target any number of entries that match the LDAP URL. The following are legal examples of wildcard usage:

- `(target="ldap:///uid=*,dc=example,dc=com")`

  Matches every entry in the entire example.com tree that has the `uid` attribute in the entry’s RDN. This target will match entries at any depth in the tree, for example:

  ```
  uid=tmorris,ou=sales,dc=example,dc=com
  uid=yyorgens,ou=marketing,dc=example,dc=com
  uid=bjensen,ou=eng,ou=east,dc=example,dc=com
  ```

- `(target="ldap:///uid=*Anderson,ou=People,dc=example,dc=com")`

  Matches every entry in the `ou=People` branch with a `uid` ending in Anderson.

- `(target="ldap:///*Anderson,ou=People,dc=example,dc=com")`

  Matches every entry in the `ou=People` branch whose RDN ends with Anderson, regardless of the naming attribute.

Multiple wildcards are allowed, such as in `uid=*,ou=*,dc=example,dc=com`. This example matches every entry in the example.com tree whose distinguished name contains the `uid` and `ou` attributes.

NOTE You cannot use wildcards in the suffix part of a distinguished name. That is, if your directory uses the suffixes `c=US` and `c=GB`, then you *cannot* use the following target to reference both suffixes:

`(target="ldap:///dc=example,c=*").`

Neither can you use a target such as `uid=bjensen,o=*.com`.

Targeting Attributes

In addition to targeting directory entries, you can also target one or more attributes, or all but one or more attributes, that occur in the targeted entries. This is useful when you want to deny or allow access to partial information about an entry. For example, you could allow access to only the common name, surname, and telephone number attributes of a given entry. Or you could deny access to sensitive information such as personal data.

If no `targetattr` rule is present, no attributes can be accessed by default. To access all attributes, the rule must be `targetattr="*"`.

The targeted attributes do not need to exist on the target entry or its subtree, but the ACI will apply whenever they do. The attributes you target do not need to be defined in the schema. The absence of schema checking makes it possible to implement an access control policy before importing your data and its schema.

To target attributes, you use the `targetattr` keyword and provide the attribute names. The `targetattr` keyword uses the following syntax:

```
(targetattr = "attribute")
(targetattr != "attribute")
```

You can target multiple attributes by using the `targetattr` keyword with the following syntax:

```
(targetattr = "attribute1 || attribute2 ... || attributen")
(targetattr != "attribute1 || attribute2 ... || attributen")
```

For example, to target an entry’s common name, surname, and uid attributes, you would use the following:

```
(targetattr = "cn || sn || uid")
```

Targeted attributes include all subtypes of the named attribute. For example, `(targetattr = "locality")` will also target `locality;lang-fr`. You may also target subtypes specifically, for example `(targetattr = "locality;lang-fr-ca")`.

You can use wildcards in a `targetattr` rule, but this is discouraged as it serves no particular purpose, and may have a negative performance impact.

Targeting Both an Entry and Attributes

By default, the entry targeted by an ACI containing a `targetattr` keyword is the entry on which the ACI is placed. That is, if you put the ACI

```
aci: (targetattr = "uid")(accessControlRules;)
```

on the `ou=Marketing, dc=example,dc=com` entry, then the ACI applies to the entire Marketing subtree. However, you can also explicitly specify a target using the `target` keyword as follows:

```
aci: (target="ldap:///uid=*,ou=Marketing,dc=example,dc=com")
 (targetattr="uid") (accessControlRules;)
```

The order in which you specify the `target` and the `targetattr` keywords is irrelevant.

Targeting Entries or Attributes Using LDAP Filters

You can use LDAP filters to target a set of entries that match certain criteria. To do this, use the `targetfilter` keyword with an LDAP filter. The ACI will apply to all entries that match the filter in the subtree below the entry containing the ACI.

The syntax of the `targetfilter` keyword is:

```
(targetfilter = "LDAPfilter")
```

where *LDAPfilter* is a standard LDAP search filter. For more information on filter syntax, see "LDAP Search Filters" on page 98.

For example, suppose that all entries representing employees have a status of salaried or contractor and an attribute representing the number of hours worked, as a percentage of a full-time position. To target all the entries representing contractors or part-time employees, you could use the following filter:

```
(targetfilter = "(|(status=contractor)(fulltime<=79))")
```

NOTE The filter syntax describing matching rules for internationalized values is not supported in ACIs. For example, the following target filter is not valid:

```
(targetfilter = "(locality:fr:=<= Quebec)")
```

Target filters select whole entries as targets of the ACI. You can associate the `targetfilter` and the `targetattr` keywords to create ACIs that apply to a subset of attributes in the targeted entries.

The following LDIF example allows members of the Engineering Admins group to modify the `departmentNumber` and `manager` attributes of all entries in the Engineering business category. This example uses LDAP filtering to select all entries with `businessCategory` attributes set to `Engineering`:

```
dn: dc=example,dc=com
objectClass: top
objectClass: organization
aci: (targetattr="departmentNumber || manager")
 (targetfilter="(businessCategory=Engineering)")
 (version 3.0; acl "eng-admins-write"; allow (write)
 groupdn ="ldap:///cn=Engineering Admins, dc=example,dc=com";)
```

TIP Although using LDAP filters can be useful when you are targeting entries and attributes that are spread across the directory, the results are sometimes unpredictable because filters do not directly name the object for which you are managing access. The set of entries targeted by a filtered ACI is likely to change as attributes are added or deleted. Therefore, if you use LDAP filters in ACIs, you should verify that they target the correct entries and attributes by using the same filter in an `ldapsearch` operation.

Targeting Attribute Values Using LDAP Filters

You can use access control to target specific attribute values. This means that you can grant or deny permissions on an attribute if that attribute's value meets the criteria defined in the ACI. An ACI that grants or denies access based on an attribute's value, is called a value-based ACI.

For example, you might grant all users in your organization permission to modify the `nsRoleDN` attribute in their own entry. However, you would also want to ensure that they do not give themselves certain key roles such as "Top Level Administrator." LDAP filters are used to check that the conditions on attribute values are satisfied.

To create a value based ACI, you must use the `targattrfilters` keyword with the following syntax:

```
(targattrfilters="add=attr1:F1 && attr2:F2... && attrn:Fn,
                  del=attr1:F1 && attr2:F2 ... && attrn:Fn")
```

where:

- `add` represents the operation of creating an attribute.
- `del` represents the operation of deleting an attribute.
- *attrn* represents the target attributes.
- *Fn* represents filters that apply only to the associated attribute.

When creating an entry, if a filter applies to an attribute in the new entry, then each instance of that attribute must satisfy the filter. When deleting an entry, if a filter applies to an attribute in the entry, then each instance of that attribute must also satisfy the filter.

When modifying an entry, if the operation adds an attribute, then the add filter that applies to that attribute must be satisfied; if the operation deletes an attribute, then the delete filter that applies to that attribute must be satisfied. If individual values of an attribute already present in the entry are replaced, then both the add and delete filters must be satisfied.

For example consider the following attribute filter:

```
(targattrfilters="add=nsroleDN:(!(nsRoleDN=cn=superAdmin)) &&
telephoneNumber:(telephoneNumber=123*)")
```

This filter can be used to allow users to add any role (`nsRoleDN` attribute) to their own entry, except the `superAdmin` role. It also allows users to add a telephone number with a 123 prefix.

NOTE You cannot create value-based ACIs from Directory Server Console.

Targeting a Single Directory Entry

There is no explicit way to target a single entry. However, it can be done:

- By creating a bind rule that matches user input in the bind request with an attribute value stored in the targeted entry. For more details, see "Defining Access Based on Value Matching" on page 228.
- By using the `targetfilter` keyword.

With the `targetfilter` keyword you can specify an attribute value that appears only in the desired entry. For example, during the installation of Directory Server, the following ACI is created:

```
aci: (targetattr="*")(targetfilter=(o=NetscapeRoot))
 (version 3.0; acl "Default anonymous access";
 allow (read, search) userdn="ldap:///anyone";)
```

This ACI can apply only to the `o=NetscapeRoot` entry, because that is the only entry with an attribute `o` having the value `NetscapeRoot`.

The risk associated with these methods is that your directory tree might change in the future, and you would have to remember to modify this ACI.

Defining Targets Using Macros

You can use a macro to represent a DN in the target portion of the ACI, thereby optimizing the number of ACIs used in the directory. For more information, see "Advanced Access Control: Using Macro ACIs" on page 272.

Defining Permissions

Permissions specify the type of access you are allowing or denying. You can either allow or deny permission to perform specific operations in the directory. The various operations that can be assigned are known as *rights*.

There are two parts to setting permissions:

- Allowing or denying access
- Assigning rights

Allowing or Denying Access

You can either explicitly allow or deny access permissions to your directory tree. For more guidelines on when to allow and when to deny access, refer to "Designing Access Control," in Chapter 7 of the *Directory Server Deployment Planning Guide*.

Assigning Rights

Rights detail the specific operations a user can perform on directory data. You can allow or deny all rights, or you can assign one or more of the following rights:

Read. Indicates whether users can read directory data. This permission applies only to the search operation.

Write. Indicates whether users can modify an entry by adding, modifying, or deleting *attributes*. This permission applies to the modify and modrdn operations.

Add. Indicates whether users can create *entries*. This permission applies only to the add operation.

Delete. Indicates whether users can delete *entries.* This permission applies only to the delete operation.

Search. Indicates whether users can search for the directory data. Users must have Search and Read rights in order to view the data returned as part of a search result. This permission applies only to the search operation.

Compare. Indicates whether the users can compare data they supply with data stored in the directory. With compare rights, the directory returns a success or failure message in response to an inquiry, but the user cannot see the value of the entry or attribute. This permission applies only to the compare operation.

Selfwrite. Indicates whether users can add or delete their own DN in an attribute of the target entry. The syntax of this attribute must be "distinguished name". This right is used only for group management. Selfwrite works with proxy authorization: it grants the right to add or delete the proxy DN from the group entry (not the DN of the bound user).

Proxy. Indicates whether the specified DN can access the target with the rights of another entry. You can grant proxy access using the DN of any user in the directory except the Directory Manager DN. Moreover, you cannot grant proxy rights to the Directory Manager. An example is provided in “Proxy Authorization ACI Example” on page 262.

All. Indicates that the specified DN has all rights (read, write, search, delete, compare, and selfwrite) to the targeted entry, *excluding* proxy rights.

Rights are granted independently of one another. This means, for example, that a user who is granted add rights can create an entry but cannot delete it if delete rights have not been specifically granted. Therefore, when planning the access control policy for your directory, you must ensure that you grant rights in a way that makes sense for users. For example, it doesn’t usually make sense to grant write permission without granting read and search permissions.

Rights Required for LDAP Operations

This section describes the rights you need to grant to users depending on the type of LDAP operation you want to authorize them to perform.

Adding an entry:

- Grant add permission on the entry being added.

- Grant write permission on the value of each attribute in the entry. This right is granted by default but could be restricted using the `targattrfilters` keyword.

Deleting an entry:

- Grant delete permission on the entry to be deleted.
- Grant write permission on the value of each attribute in the entry. This right is granted by default but could be restricted using the `targattrfilters` keyword.

Modifying an attribute in an entry:

- Grant write permission on the attribute type.
- Grant write permission on the value of each attribute type. This right is granted by default but could be restricted using the `targattrfilters` keyword.

Modifying the RDN of an entry:

- Grant write permission on the entry.
- Grant write permission on the attribute type used in the new RDN.
- Grant write permission on the attribute type used in the old RDN, if you want to grant the right to delete the old RDN.
- Grant write permission on the value of attribute type used in the new RDN. This right is granted by default but could be restricted using the `targattrfilters` keyword.

Comparing the value of an attribute:

- Grant compare permission on the attribute type.

Searching for entries:

- Grant search permission on each attribute type used in the search filter.
- Grant read permission on at least one attribute type used in the entry to ensure that the entry is returned.
- Grant read permission an each attribute type to be returned with the entry.

The permissions you need to set up to allow users to search the directory are more readily understood with an example. Consider the following search:

```
ldapsearch -h host -p port -D "uid=bjensen,dc=example,dc=com" \
           -w password -b "dc=example,dc=com" \
             "(objectclass=*)" mail
```

The following ACI is used to determine whether user bjensen can be granted access for searching her own entry:

```
aci: (targetattr = "mail")(version 3.0; acl "self access to
 mail"; allow (read, search) userdn = "ldap:///self";)
```

The search result list is empty because this ACI does not allow bjensen the right to search on the objectclass attribute. If you want the search operation described above to be successful, you must modify the ACI to read as follows:

```
aci: (targetattr = "mail || objectclass")(version 3.0; acl "self
 access to mail"; allow (read, search) userdn = "ldap:///self";)
```

Permissions Syntax

In an ACI statement, the syntax for permissions is:

allow|deny (*rights*)

where *rights* is a list of 1 to 8 comma-separated keywords enclosed within parentheses. Valid keywords are **read**, **write**, **add**, **delete**, **search**, **compare**, **selfwrite, proxy**, or **all**.

In the following example, read, search, and compare access is allowed, provided the bind rule is evaluated to be true:

```
aci:  (target="ldap:///dc=example,dc=com") (version 3.0;acl
 "example"; allow (read, search, compare) bindRule;)
```

Bind Rules

Depending on the ACIs defined for the directory, for certain operations, you need to *bind* to the directory. *Binding* means logging in or authenticating yourself to the directory by providing a bind DN and password, or, if using SSL, a certificate. The credentials provided in the bind operation, and the circumstances of the bind determine whether access to the directory is allowed or denied.

Every permission set in an ACI has a corresponding bind rule that details the required credentials and bind parameters.

A simple bind rule might require that the person accessing the directory must belong to a specific group. A complex bind rule can state that a person must belong to a specific group and must log in from a machine with a specific IP address, between 8 am and 5 pm.

Bind rules define who can access the directory, when, and from where. More specifically, bind rules can specify:

- Users, groups, and roles that are granted access
- Location from which an entity must bind. Note that the location from which a user authenticates can be spoofed, and can therefore not be trusted. Do not base ACIs on this information alone.
- Time or day on which binding must occur
- Type of authentication that must be in use during binding

Additionally, bind rules can be complex constructions that combine these criteria by using Boolean operators. See "Using Boolean Bind Rules" on page 237 for more information.

The server evaluates the logical expressions used in ACIs according to a three-valued logic similar to the one used to evaluate LDAP filters, as described in RFC 2251 *Lightweight Directory Access Protocol (v3)*. In summary, this means that if any component in the expression evaluates to Undefined (for example if the evaluation of the expression aborted due to a resource limitation), then the server handles this case correctly: it does not erroneously grant access because an Undefined value occurred in a complex Boolean expression.

Bind Rule Syntax

Whether access is allowed or denied depends on whether an ACI's bind rule is evaluated to be true. Bind rules use one of the two following patterns:

keyword `= "`*expression*`";`

keyword `!= "`*expression*`";`

where equal (=) indicates that *keyword* and *expression* must match in order for the bind rule to be true, and not equal (!=) indicates that *keyword* and *expression* must not match in order for the bind rule to be true.

NOTE The `timeofday` keyword also supports the inequality expressions (<, <=, >, >=). This is the only keyword that supports these expressions.

The quotation marks ("") around *expression* and the delimiting semicolon (;) are required. The expressions you can use depend on the associated *keyword*.

The following table lists each keyword and the associated expressions. It also indicates whether wildcard characters are allowed in the expression.

Table 6-2 LDIF Bind Rule Keywords

Keyword	Valid Expressions	Wildcard Allowed?
`userdn`	ldap:///*distinguished_name* ldap:///all ldap:///anyone ldap:///self ldap:///parent ldap:///*suffix*??sub?(*filter*)	yes, in DN only
`groupdn`	[ldap:///*DN*]	no
`roledn`	[ldap:///*DN*]	no
`userattr`	*attribute#bindType* or *attribute#value*	no
`ip`	*IP_address*	yes
`dns`	*DNS_host_name*	yes
`dayofweek`	sun mon tue wed thu fri sat	no
`timeofday`	0 - 2359	no
`authmethod`	none simple ssl sasl *authentication_method*	no

The following sections further detail the bind rule syntax for each keyword.

Defining User Access - userdn Keyword

User access is defined using the `userdn` keyword. The `userdn` keyword requires one or more valid distinguished names in the following format:

```
userdn = "ldap:///dn [|| ldap:///dn]..."
userdn != "ldap:///dn [|| ldap:///dn]..."
```

where *dn* can be a DN or one of the expressions `anyone`, `all`, `self` or `parent`. These expressions refer to the following users:

- `userdn = "ldap:///anyone"` - Both anonymous and authenticated users.
- `userdn = "ldap:///all"` - Only authenticated users.
- `userdn = "ldap:///self"` - Only the same user as the target entry of the ACI.
- `userdn = "ldap:///parent"` - Only the parent entry of the ACI target.

The `userdn` keyword can also be expressed as an LDAP filter of the form:

```
userdn = ldap:///suffix??sub?(filter)
```

NOTE Characters, syntactically significant for a dn, such as commas, must be escaped with a single backslash (\).

Anonymous Access (anyone Keyword)

Granting anonymous access to the directory means that anyone can access it without providing a bind DN or password, and regardless of the circumstances of the bind. You can limit anonymous access to specific types of access (for example, access for read or access for search) or to specific subtrees or individual entries within the directory. Anonymous access using the `anyone` keyword also allows access by any authenticated user.

For example, if you want to allow anonymous read and search access to the entire example.com tree, you would create the following ACI on the `dc=example,dc=com` node:

```
aci: (version 3.0; acl "anonymous-read-search";
 allow (read, search) userdn = "ldap:///anyone";)
```

General Access (all Keyword)

You can use bind rules to indicate that a permission applies to anyone who has successfully bound to the directory. The `all` keyword therefore allows access by all authenticated users. This allows general access while preventing anonymous access.

For example, if you want to grant read access to the entire tree to all authenticated users, you would create the following ACI on the `dc=example,dc=com` node:

```
aci: (version 3.0; acl "all-read"; allow (read)
 userdn="ldap:///all";)
```

Self Access (self Keyword)

Specifies that users are granted or denied access to their own entries. In this case, access is granted or denied if the bind DN matches the DN of the targeted entry.

For example, if you want to grant all users in the example.com tree write access to their `userPassword` attribute, you would create the following ACI on the `dc=example,dc=com` node.

```
aci: (targetattr = "userPassword") (version 3.0; acl
 "modify own password"; allow (write) userdn = "ldap:///self";)
```

Parent Access (parent Keyword)

Specifies that users are granted or denied access to the entry only if their bind DN is the parent of the targeted entry. Note that you must edit ACIs manually in Server Console to use the `parent` keyword.

For example, if you want to allow users to modify any child entries of their bind DN, you would create the following ACI on the `dc=example,dc=com` node:

```
aci: (version 3.0; acl "parent access";
 allow (write) userdn="ldap:///parent";)
```

LDAP URLs

You can dynamically target users in ACIs using a URL with a filter as follows:

```
userdn = "ldap:///<suffix>??sub?(filter)"
```

For example, all users in the accounting and engineering branches of the example.com tree would be granted or denied access to the targeted resource dynamically based on the following URL:

```
userdn = "ldap:///dc=example,dc=com??sub?(|(ou=eng)(ou=acct))"
```

NOTE Do not specify a hostname or port number within the LDAP URL. LDAP URLs always apply to the local server.

For more information on LDAP URLs, see Chapter 10, “LDAP URLs Reference,” in the *Directory Server Administration Reference*.

Wildcards

You can also specify a set of users by using the wildcard character (*). For example, specifying a user DN of `uid=b*,dc=example,dc=com` indicates that only users with a bind DN beginning with the letter `b` will be allowed or denied access based on the permissions you set.

Logical OR of LDAP URLs

Specify several LDAP URLs or keyword expressions to create complex rules for user access. For example:

```
userdn = "ldap:///uid=b*,c=example.com ||
 ldap:///cn=b*,dc=example,dc=com";
```

The bind rule is evaluated to be true for users binding with either of the DN patterns.

Excluding a Specific LDAP URL

Use the not-equal (`!=`) operator to define user access that excludes specific URLs or DNs. For example:

```
userdn != "ldap:///uid=*,ou=Accounting,dc=example,dc=com";
```

The bind rule is evaluated to be true if the client is not binding as a UID-based distinguished name in the accounting subtree. This bind rule only makes sense if the targeted entry is not under the accounting branch of the directory tree.

Defining Group Access - groupdn Keyword

Members of a specific group can access a targeted resource. This is known as *group access*. Group access is defined using the `groupdn` keyword to specify that access to a targeted entry will be granted or denied if the user binds using a DN that belongs to a specific group.

The `groupdn` keyword requires the distinguished names of one or more groups in the following format:

```
groupdn="ldap:///groupDN [|| ldap:///groupDN]..."
```

The bind rule is evaluated to be true if the bind DN belongs to a group specified by any of the *groupDNs*. The following section give examples using the `groupdn` keyword.

NOTE Characters, syntactically significant for a dn, such as commas, must be escaped with a single backslash (\).

Single LDAP URL

```
groupdn = "ldap:///cn=Administrators,dc=example,dc=com";
```

The bind rule is evaluated to be true if the bind DN belongs to the Administrators group. If you wanted to grant the Administrators group permission to write to the entire directory tree, you would create the following ACI on the `dc=example,dc=com` node:

```
aci: (version 3.0; acl "Administrators-write"; allow (write)
 groupdn="ldap:///cn=Administrators,dc=example,dc=com";)
```

Logical OR of LDAP URLs

```
groupdn = "ldap:///cn=Administrators,dc=example,dc=com ||
ldap:///cn=Mail Administrators,dc=example,dc=com";
```

The bind rule is evaluated to be true if the bind DN belongs to either the Administrators or the Mail Administrators group.

Defining Role Access - roledn Keyword

Members of a specific role can access a targeted resource. This is known as *role access*. Role access is defined using the `roledn` keyword to specify that access to a targeted entry will be granted or denied if the user binds using a DN that belongs to a specific role.

The `roledn` keyword requires one or more valid distinguished names in the following format:

```
roledn = "ldap:///dn [|| ldap:///dn]... [|| ldap:///dn]"
```

The bind rule is evaluated to be true if the bind DN belongs to the specified role.

NOTE Characters, syntactically significant for a dn, such as commas, must be escaped with a single backslash (\).

The `roledn` keyword has the same syntax and is used in the same way as the `groupdn` keyword.

Defining Access Based on Value Matching

You can set bind rules to specify that an attribute value of the entry used to bind to the directory must match an attribute value of the targeted entry.

For example, you can specify that the bind DN must match the DN in the `manager` attribute of a user entry in order for the ACI to apply. In this case, only the user's manager would have access to the entry.

This example is based on DN matching. However, you can match any attribute of the entry used in the bind with the targeted entry. For example, you could create an ACI that allowed any user whose `favoriteDrink` attribute is "beer" to read all the entries of other users that have the same value for `favoriteDrink`.

Using the userattr Keyword

The `userattr` keyword can be used to specify which attribute values must match between the entry used to bind and the targeted entry.

You can specify:

- A user DN
- A group DN
- A role DN
- An LDAP filter, in an LDAP URL
- Any attribute type

The LDIF syntax of the `userattr` keyword is as follows:

```
userattr = "attrName#bindType"
```

or, if you are using an attribute type that requires a value other than a user DN, group DN, role DN, or an LDAP filter:

```
userattr = "attrName#attrValue"
```

where:

- *attrName* is the name of the attribute used for value matching
- *bindType* is one of `USERDN`, `GROUPDN`, `ROLEDN`, `LDAPURL`
- *attrValue* is any string representing an attribute value

NOTE You must not use an attribute generated by a Class of Service (CoS) definition with the `userattr` keyword. ACIs containing bind rules that depend on attribute values generated by CoS will not work.

The following sections provide examples of the `userattr` keyword with the various possible bind types.

Example with USERDN Bind Type

The following is an example of the `userattr` keyword associated with a bind based on the user DN:

```
userattr = "manager#USERDN"
```

The bind rule is evaluated to be true if the bind DN matches the value of the `manager` attribute in the targeted entry. You can use this to allow a user's manager to modify employees' attributes. This mechanism only works if the `manager` attribute in the targeted entry is expressed as a full DN.

The following example grants a manager full access to his or her employees' entries:

```
aci: (target="ldap:///dc=example,dc=com")(targetattr="*")
 (version 3.0;acl "manager-write";
 allow (all) userattr = "manager#USERDN";)
```

Example with GROUPDN Bind Type

The following is an example of the `userattr` keyword associated with a bind based on a group DN:

```
userattr = "owner#GROUPDN"
```

The bind rule is evaluated to be true if the bind DN is a member of the group specified in the `owner` attribute of the targeted entry. For example, you can use this mechanism to allow a group to manage employees' status information. You can use an attribute other than `owner`, as long as the attribute you use contains the DN of a group entry.

The group you point to can be a dynamic group, and the DN of the group can be under any suffix in the directory. However, the evaluation of this type of ACI by the server is very resource intensive.

If you are using static groups that are under the same suffix as the targeted entry, you can use the following expression:

```
userattr = "ldap:///dc=example,dc=com?owner#GROUPDN"
```

In this example, the group entry is under the `dc=example,dc=com` suffix. The server can process this type of syntax more quickly than the previous example.

Example With ROLEDN Bind Type

The following is an example of the `userattr` keyword associated with a bind based on a role DN:

```
userattr = "exampleEmployeeReportsTo#ROLEDN"
```

The bind rule is evaluated to be true if the bind DN belongs to the role specified in the `exampleEmployeeReportsTo` attribute of the targeted entry. For example, if you create a nested role for all managers in your company, you can use this mechanism to grant managers at all levels access to information about employees that are at a lower grade than themselves.

The DN of the role can be under any suffix in the directory. If, in addition, you are using filtered roles, the evaluation of this type of ACI uses a lot of resources on the server.

Example With LDAPURL Bind Type

The following is an example of the `userattr` keyword associated with a bind based on an LDAP filter:

```
userattr = "myfilter#LDAPURL"
```

The bind rule is evaluated to be true if the bind DN matches the filter specified in the *myfilter* attribute of the targeted entry. The *myfilter* attribute can be replaced by any attribute that contains an LDAP filter.

Example With Any Attribute Value

The following is an example of the `userattr` keyword associated with a bind based on any attribute value:

```
userattr = "favoriteDrink#Beer"
```

The bind rule is evaluated to be true if the bind DN and the target DN include the `favoriteDrink` attribute with a value of **`Beer`**.

Using the userattr Keyword With Inheritance

When you use the `userattr` keyword to associate the entry used to bind with the target entry, the ACI applies only to the target specified and not to the entries below it. In some circumstances, you might want to extend the application of the ACI several levels below the targeted entry. This is possible by using the parent keyword, and specifying the number of levels below the target that should inherit the ACI.

When you use the `userattr` keyword in association with the `parent` keyword, the syntax is as follows:

`userattr = "parent[`*inheritance_level*`].`*attribute#bindType*`"`

where :

- *inheritance_level* is a comma separated list that indicates how many levels below the target will inherit the ACI. You can include five levels `[0,1,2,3,4]` below the targeted entry; zero (0) indicates the targeted entry.
- *attribute* is the attribute targeted by the `userattr` or `groupattr` keyword.
- *bindType* can be either `USERDN` or `GROUPDN`. The `LDAPURL` and `ROLEDN` bind types are not supported with inheritance.

For example,

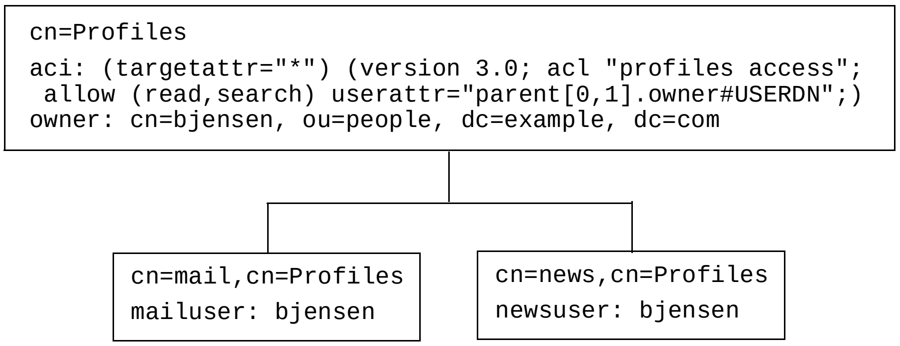
```
userattr = "parent[0,1].manager#USERDN"
```

This bind rule is evaluated to be true if the bindDN matches the manager attribute of the targeted entry. The permissions granted when the bind rule is evaluated to be true apply to the target entry *and* to all entries immediately below it.

Example With userattr Inheritance

The example in the following figure indicates that user `bjensen` is allowed to read and search the `cn=Profiles` entry as well as the first level of child entries which includes `cn=mail` and `cn=news`.

Figure 6-1 Using Inheritance With the `userattr` Keyword



```
cn=Profiles
aci: (targetattr="*") (version 3.0; acl "profiles access";
 allow (read,search) userattr="parent[0,1].owner#USERDN";)
owner: cn=bjensen, ou=people, dc=example, dc=com
```

```
cn=mail,cn=Profiles
mailuser: bjensen
```

```
cn=news,cn=Profiles
newsuser: bjensen
```

In this example, if you did not use inheritance you would have to do one of the following to achieve the same result:

- Explicitly set read and search access for user bjensen on the cn=Profiles, cn=mail, and cn=news entries in the directory.
- Add the owner attribute and the following ACI to the cn=mail,cn=Profiles and cn=news,cn=Profiles entries:

```
aci: (targetattr="*") (version 3.0; acl "profiles access"; allow
 (read,search) userattr="owner#USERDN";)
```

Granting Add Permission Using the userattr Keyword

If you use the userattr keyword in conjunction with all or add permissions, you might find that the behavior of the server is not what you expect. Typically, when a new entry is created in the directory, Directory Server evaluates access rights on the entry being created, and not on the parent entry. However, in the case of ACIs using the userattr keyword, this behavior could create a security hole, and the server's normal behavior is modified to avoid it.

Consider the following example:

```
aci: (target="ldap:///dc=example,dc=com")(targetattr="*")
 (version 3.0; acl "manager-write"; allow (all)
 userattr = "manager#USERDN";)
```

This ACI grants managers all rights on the entries of employees that report to them. However, because access rights are evaluated on the entry being created, this type of ACI would also allow any employee to create an entry in which the manager attribute is set to their own DN. For example, disgruntled employee Joe (cn=Joe,ou=eng,dc=example,dc=com), might want to create an entry in the Human Resources branch of the tree, to use (or misuse) the privileges granted to Human Resources employees.

He could do this by creating the following entry:

```
dn: cn= Trojan Horse,ou=Human Resources,dc=example,dc=com
objectclass: top
...
cn: Trojan Horse
manager: cn=Joe,ou=eng,dc=example,dc=com
```

To avoid this type of security threat, the ACI evaluation process does not grant add permission at level 0, that is, to the entry itself. You can, however, use the parent keyword to grant add rights below existing entries. You must specify the number of levels below the parent for add rights. For example, the following ACI allows child entries to be added to any entry in the dc=example,dc=com that has a manager attribute that matches the bind DN:

```
aci: (target="ldap:///dc=example,dc=com")(targetattr="*")
 (version 3.0; acl "parent-access"; allow (add)
 userattr = "parent[0,1].manager#USERDN";)
```

This ACI ensures that add permission is granted only to users whose bind DN matches the manager attribute of the parent entry.

Defining Access From a Specific IP Address

Using bind rules, you can indicate that the bind operation must originate from a specific IP address. This is often used to force all directory updates to occur from a given machine or network domain.

The LDIF syntax for setting a bind rule based on an IP address is as follows:

`ip = "`*IPaddressList*`" or ip != "`*IPaddressList*`"`

The *IPaddressList* is a list of one or more comma-separated elements from among any of the following:

- A specific IPv4 address: `123.45.6.7`
- An IPv4 address with wildcards to specify a subnetwork: `12.3.45.*`
- An IPv4 address or subnetwork with subnetwork mask: `123.45.6.*+255.255.255.115`
- An IPv6 address in any of its legal forms, as defined by RFC 2373 (`http://www.ietf.org/rfc/rfc2373.txt`). The following addresses are equivalent:
  - `12AB:0000:0000:CD30:0000:0000:0000:0000`
  - `12AB::CD30:0:0:0:0`
  - `12AB:0:0:CD30::`
- An IPv6 address with a subnet prefix length: `12AB::CD30:0:0:0:0/60`

The bind rule is evaluated to be true if the client accessing the directory is located at the named IP address. This can be useful for allowing certain kinds of directory access only from a specific subnet or machine. Note that the IP address from which a user authenticates can be spoofed, and can therefore not be trusted. Do not base ACIs on this information alone.

From the Server Console, you can define specific machines to which the ACI applies through the Access Control Editor. For more information, see "Creating ACIs Using the Console" on page 239.

Defining Access from a Specific Domain

A bind rule can specify that the bind operation must originate from a particular domain or host machine. This is often used to force all directory updates to occur from a given machine or network domain.

The LDIF syntax for setting a bind rule based on the DNS host name is as follows:

```
dns = "DNS_Hostname" or dns != "DNS_Hostname"
```

CAUTION The `dns` keyword requires that the naming service used on your machine is DNS. If the name service is not DNS, you should use the `ip` keyword instead.

The `dns` keyword requires a fully qualified DNS domain name. Granting access to a host without specifying the domain creates a potential security threat. For example, the following expression is allowed but not recommended:

```
dns = "legend.eng";
```

You should use a fully qualified name such as:

```
dns = "legend.eng.example.com";
```

The dns keyword allows wildcards. For example:

```
dns = "*.example.com";
```

The bind rule is evaluated to be true if the client accessing the directory is located in the named domain. This can be useful for allowing access only from a specific domain. Note that wildcards will not work if your system uses a naming service other than DNS. In such a case, if you want to restrict access to a particular domain, use the ip keyword, as described in "Defining Access From a Specific IP Address" on page 233.

Defining Access at a Specific Time of Day or Day of Week

You can use bind rules to specify that binding can only occur at a certain time of day or on a certain day of the week. For example, you can set a rule that will allow access only if it is between the hours of 8 am and 5 pm Monday through Friday. The time used to evaluate access rights is the time on the directory server, not the time on the client.

The LDIF syntax for setting a bind rule based on the time of day is as follows:

`timeofday` *operator* "*time*"

where *operator* can be one of the following symbols: equal to (=), not equal to (!=), greater than (>), greater than or equal to (>=), less than (<), or less than or equal to (<=). The time is expressed as four digits representing hours and minutes in the 24-hour clock (`0` to `2359`). For example:

- `timeofday = "1200";` is true if the client is accessing the directory during the minute that the system clock shows noon.
- `timeofday != "0100";` is true for access at any other time than 1 a.m.
- `timeofday > "0800";` is true for access from 8:01 a.m. through 11:59 p.m.
- `timeofday >= "0800";` is true for access from 8:00 a.m. through 11:59 p.m.
- `timeofday < "1800";` is true for access from 12:00 midnight through 5:59 p.m.

NOTE The time and date on the server are used for the evaluation of the `timeofday` and `dayofweek` bind rules, and not the time on the client.

The LDIF syntax for setting a bind rule based on the day in the week is as follows:

`dayofweek = "`*day1, day2 ...*`"`

The possible values for the dayofweek keyword are the English three-letter abbreviations for the days of the week: `sun`, `mon`, `tue`, `wed`, `thu`, `fri`, `sat`. Specify all days you wish to grant access, for example:

```
dayofweek = "Mon, Tue, Wed, Thu, Fri";
```

The bind rule is true if the directory is being accessed on one of the days listed.

Defining Access Based on Authentication Method

You can set bind rules that state that a client must bind to the directory using a specific authentication method. The authentication methods available are:

- **None -** Authentication is not required. This is the default. It represents anonymous access.

- **Simple -** The client must provide a user name and password to bind to the directory.
- **SSL -** The client must bind to the directory over a Secure Sockets Layer (SSL) or Transport Layer Security (TLS) connection.

  In the case of SSL, the connection is established to the LDAPS second port; in the case of TLS, the connection is established through a Start TLS operation.In both cases, a certificate must be provided. For information on setting up SSL, see Chapter 11, "Managing Authentication and Encryption.".
- **SASL -** The client must bind to the directory using a Simple Authentication and Security Layer (SASL) mechanism, such as DIGEST-MD5 or GSSAPI.

You cannot set up authentication-based bind rules through the Access Control Editor.

The LDIF syntax for setting a bind rule based on an authentication method is as follows:

authmethod = "*authentication_method*"

where *authentication_method* is `none`, `simple`, `ssl`, or `sasl` *sasl_mechanism*. For example:

Examples

The following are examples of the `authmethod` keyword:

- `authmethod = "none";` Authentication is not checked during bind rule evaluation.
- `authmethod = "simple";` The bind rule is evaluated to be true if the client is accessing the directory using a username and password.
- `authmethod = "ssl";` The bind rule is evaluated to be true if the client authenticates to the directory using a certificate over LDAPS. It will not be true if the client authenticates using simple authentication (bind DN and password) over LDAPS.
- `authmethod = "sasl DIGEST-MD5";` The bind rule is evaluated to be true if the client is accessing the directory using the SASL DIGEST-MD5 mechanism. The other supported SASL mechanisms are EXTERNAL (all platforms) and GSSAPI (only on Solaris systems).

Using Boolean Bind Rules

Bind rules can be complex expressions that use the Boolean expressions `AND`, `OR`, and `NOT` to set very precise access rules. You cannot use the Server Console to create Boolean bind rules. You must create an LDIF statement.

The LDIF syntax for a Boolean bind rule is as follows:

bindRule [*boolean*][*bindRule*][*boolean*][*bindRule*]...;)

For example, the following bind rule will be evaluated to be true if the bind DN is a member of either the administrator's group or the mail administrator's group, and if the client is running from within the example.com domain:

```
(groupdn = "ldap:///cn=administrators,dc=example,dc=com" or
groupdn = "ldap:///cn=mail administrators,dc=example,dc=com" and
dns = "*.example.com";)
```

The trailing semicolon (;) is a required delimiter that must appear after the final bind rule.

Boolean expressions are evaluated in the following order:

- Innermost to outermost parenthetical expressions first
- All expressions from left to right
- NOT before AND or OR operators

The Boolean `OR` and Boolean `AND` operators have no order of precedence.

Consider the following Boolean bind rules:

(*bindRule_A*) `OR` (*bindRule_B*)

(*bindRule_B*) `OR` (*bindRule_A*)

Because Boolean expressions are evaluated from left to right, in the first case, bind rule A is evaluated before bind rule B, and in the second case, bind rule B is evaluated before bind rule A.

However, the Boolean `NOT` is evaluated *before* the Boolean `OR` and Boolean `AND`. Thus, in the following example:

(*bindRule_A*) `AND NOT` (*bindRule_B*)

bind rule B is evaluated before bind rule A despite the left-to-right rule.

Creating ACIs From the Command Line

You can create access control instructions manually using LDIF statements, and add them to your directory tree using the `ldapmodify` command. Because ACI values can be very complex, it is useful to view existing values and copy them to help create new ones.

Viewing aci Attribute Values

ACIs are stored as one or more values of the `aci` attribute on an entry. The `aci` attribute is a multi-valued operational attribute that may be read and modified by directory users and that should itself be protected by ACIs. Administrative users are usually given full access to the `aci` attribute and may view its values in one of the following ways.

You can view the `aci` attribute values as any other values in the Generic Editor. In the top-level Directory tab of Directory Server Console, right-click an entry with ACIs and choose the Edit With Generic Editor menu item. However, `aci` values are usually long strings that are difficult to view and edit in this dialog.

Instead, you may then invoke the Access Control Editor by right-clicking the entry in the directory tree and choosing the Set Access Permissions menu item. Select an ACI and click Edit, then click Edit Manually to view the corresponding `aci` value. By switching between the Manual and Visual editors of the ACI, you can compare the syntax of the `aci` value with its configuration.

If your operating system allows it, you may copy the `aci` value from either the Generic Editor or the Manual Access Control Editor to paste it into your LDIF file. Administrative users can also view the aci attribute of an entry by running the following `ldapsearch` command:

```
ldapsearch -h host -p port -D "cn=Directory Manager" -w password \
           -b entryDN -s base "(objectclass=*)" aci
```

The result is LDIF text that you may copy into your new LDIF ACI definition for editing. Because the value of an ACI is a long string, the output from the `ldapsearch` operation is likely to be displayed over several lines, with the first space being a continuation marker. Take this into account when copying and pasting the LDIF output.

NOTE To view the effect of an `aci` value, in terms of the permissions that it grants or denies, see “Viewing Effective Rights” on page 263.

Creating ACIs Using the Console

Directory Server Console can be configured to show which entries in the directory have `aci` attributes. Select or deselect the View>Display>ACI Count menu item to toggle this display. Entries listed in the top-level Directory tab will then be appended with the number of ACIs which are defined in their `aci` attribute.You may then use Directory Server Console to view, create, edit, and delete access control instructions for your directory.

See "Access Control Usage Examples" on page 244 for a collection of access control rules commonly used in Directory Server security policies, along with step-by-step instructions for using Directory Server Console to create them.

The Access Control Editor does not enable you to construct some of the more complex ACIs when you are in Visual editing mode. In particular, from the Access Control Editor you cannot:

- Deny access (see "Permissions Syntax" on page 221)
- Create value-based ACIs (see "Targeting Attribute Values Using LDAP Filters" on page 216)
- Define parent access (see "Parent Access (parent Keyword)" on page 225)
- Create ACIs that contain Boolean bind rules (see "Using Boolean Bind Rules" on page 237)
- Generally, create ACIs that use the following keywords: `roledn`, `userattr`, `authmethod`

TIP In the Access Control Editor, you can click on the Edit Manually button at any time to check the LDIF representation of the changes you make through the graphical interface.

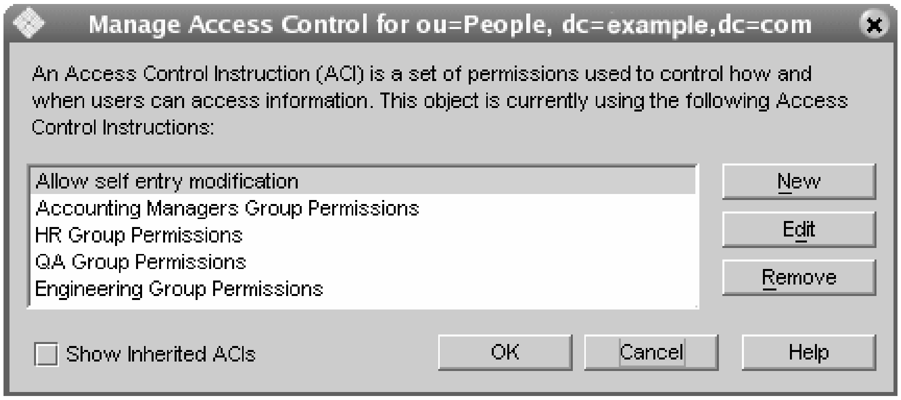
Viewing the ACIs of an Entry

1. On the top-level Directory tab of Directory Server Console, browse the directory tree to display the entry for which you wish to set access control. You must have directory administrator or directory manager privileges to edit ACIs.

2. Right-click the entry and select Set Access Permissions from the pop-up menu. Alternatively, left-click the entry to select it, and choose Set Access Permissions from the Object menu.

   The Access Control Management dialog is displayed as shown in the following figure. It lists the description of all ACIs defined on the selected entry and allows you to edit or remove them and create new ones.

Figure 6-2 The Access Control Management Dialog



Manage Access Control for ou=People, dc=example,dc=com

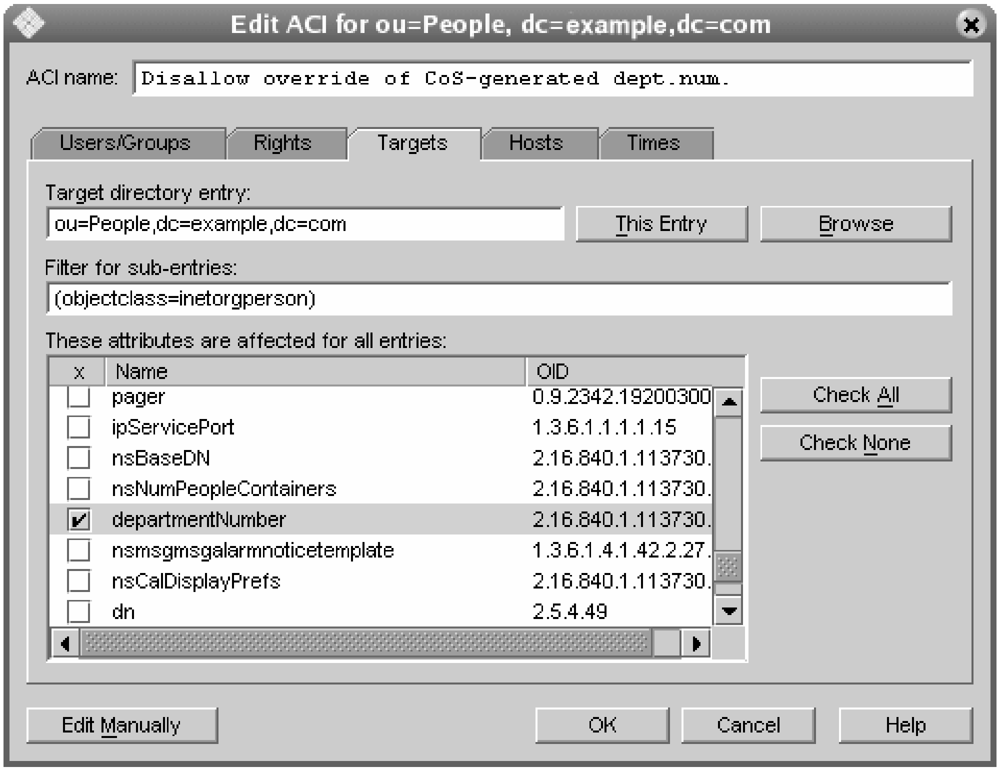
An Access Control Instruction (ACI) is a set of permissions used to control how and when users can access information. This object is currently using the following Access Control Instructions:

Allow self entry modification
Accounting Managers Group Permissions
HR Group Permissions
QA Group Permissions
Engineering Group Permissions

   Selecting the Show Inherited ACIs checkbox lists all ACIs defined by parents of the selected entry and that apply to it. Inherited ACIs cannot be edited or removed; you must manage them on the entry where they are defined.

3. Click New to define new access permissions on the selected object and its entire subtree. The ACI editor is displayed as shown in Figure 6-3.

Figure 6-3 The ACI Editor Dialog



ACI name: Disallow override of CoS-generated dept.num.

Target directory entry: ou=People,dc=example,dc=com

Filter for sub-entries: (objectclass=inetorgperson)

These attributes are affected for all entries:

x	Name	OID
☐	pager	0.9.2342.19200300
☐	ipServicePort	1.3.6.1.1.1.1.15
☐	nsBaseDN	2.16.840.1.113730.
☐	nsNumPeopleContainers	2.16.840.1.113730.
✓	departmentNumber	2.16.840.1.113730.
☐	nsmsgmsgalarmnoticetemplate	1.3.6.1.4.1.42.2.27.
☐	nsCalDisplayPrefs	2.16.840.1.113730.
☐	dn	2.5.4.49

The ACI name at the top of the dialog is the description of ACI that will appear in the Access Control Management Dialog. Giving descriptive ACI names will make it easier to manage ACIs throughout the directory, especially when viewing the inherited ACIs on a leaf entry.

The tabs of the Access Control Editor allow you to specify the users who are granted or denied access, the targets that are being accessed or restricted, and advanced parameters such as the allowed hostnames and times for the operation. For details about the individual fields in the Access Control tabs, please refer to the online help.

The tabs of the ACI editor provide a graphical display of the contents of the ACI value. Click the Edit Manually button to see the ACI value and edit it textually. In the text editor, you may define advanced ACIs that cannot be defined through the tabs. However, once you edit the ACI value, you may not be able to edit the ACI visually anymore, *even if* you do not use advanced features.

Creating a New ACI

1. Display the Access Control Editor.

   This task is explained in "Viewing the ACIs of an Entry" on page 239.

   If the view displayed is different from Figure 6-3 on page 241, click the Edit Visually button.

2. Name the ACI, by typing a name in the ACI Name text box.

   The name can be any string you want to use to uniquely identify the ACI. If you do not enter a name, the server uses **`unnamed ACI`**.

3. In the Users/Groups tab, select the users to whom you are granting access by highlighting All Users, or clicking the Add button to search the directory for the users to add.

   In the Add Users and Groups window:

   a. Select a search area from the drop-down list, enter a search string in the Search field, and click the Search button.

      The search results are displayed in the list below.

   b. Highlight the entries you want in the search result list, and click the Add button to add them to the list of entries which have access permission.

   c. Click OK to dismiss the Add Users and Groups window.

      The entries you selected are now listed on the Users/Groups tab in the ACI editor.

4. In the Access Control Editor, click the Rights tab, and use the checkboxes to select the rights to grant.

5. Click the Targets tab, then click This Entry to display the node targeted by the ACI.

   You can change the value of the target DN, but the new DN must be a direct or indirect child of the selected entry.

   If you do not want every entry in the subtree under this node to be targeted by the ACI, you must enter a filter in the Filter for Sub-entries field.

   Additionally, you can restrict the scope of the ACI to only certain attributes by selecting the attributes you want to target in the attribute list.

6. Click the Hosts tab, then the Add button to display the Add Host Filter dialog box.

   You can specify a hostname or an IP address. If you specify an IP address, you can use the wildcard character (*).

7. Click the Times tab to display the table showing at what times access is allowed.

   By default, access is allowed at all times. You can change the access times by clicking and dragging the cursor over the table. You cannot select discrete blocks of time.

8. When you have finished editing the ACI, click OK.

   The ACI Editor is dismissed and the new ACI is listed in the ACI Manager window.

NOTE At any time during the creation of the ACI, you can click the Edit Manually button to display the LDIF statement that corresponds to your input. You can modify this statement, but your changes will not necessarily be visible in the graphical interface.

Editing an ACI

To edit an ACI:

1. On the Directory tab, right-click the top entry in the subtree, and choose Set Access Permissions from the pop-up menu.

   The Access Control Manager window is displayed. It contains the list of ACIs belonging to the entry.

2. In the Access Control Manager window, highlight the ACI that you want to edit, and click Edit.

   The Access Control Editor is displayed. For details on the information you can edit using this dialog box, refer to the online help.

3. Make the changes you want under the various tabs of the Access Control Editor.

4. When you have finished editing the ACI, click OK.

   The ACI Editor is dismissed, and the modified ACI is listed in the ACI Manager.

Deleting an ACI

To delete an ACI:

1. On the Directory tab, right-click the top entry in the subtree, and choose Set Access Permissions from the pop-up menu.

   The Access Control Manager window is displayed. It contains the list of ACIs belonging to the entry.

2. In the Access Control Manager window, select the ACI that you want to delete.

3. Click Remove.

   The ACI is no longer listed in the Access Control Manager.

Access Control Usage Examples

The examples provided in this section illustrate how an imaginary ISP company, example.com, would implement its access control policy. All the examples explain how to perform a given task from the console and using an LDIF file.

Example.com's business is to offer a web hosting service and internet access. Part of Example.com's web hosting service is to host the directories of client companies. Example.com actually hosts and partially manages the directories of two medium-sized companies, Company333, and Company999. It also provides internet access to a number of individual subscribers.

These are the access control rules that example.com wants to put in place:

- Grant anonymous access for read, search, and compare to the entire example.com tree for example.com employees (see "Granting Anonymous Access" on page 245.)
- Grant write access to example.com employees for personal information for such as `homeTelephoneNumber`, `homeAddress` (see "Granting Write Access to Personal Entries" on page 247.)
- Grant example.com employees the right to add any role to their entry, except certain critical roles (see "Restricting Access to Key Roles" on page 250.)
- Grant the example.com Human Resources group all rights on the entries in the People branch (see "Granting a Group Full Access to a Suffix" on page 252.)

- Grant all example.com employees the right to create group entries under the Social Committee branch of the directory, and to delete group entries that they own (see "Granting Rights to Add and Delete Group Entries" on page 253.)
- Grant all example.com employees the right to add themselves to group entries under the Social Committee branch of the directory (see "Allowing Users to Add or Remove Themselves From a Group" on page 260.)
- Grant access to the directory administrator (role) of Company333 and Company999 on their respective branches of the directory tree, with certain conditions such as SSL authentication, time and date restrictions, and specified location (see "Granting Conditional Access to a Group or Role" on page 256.)
- Grant individual subscribers access to their own entries (see "Granting Write Access to Personal Entries" on page 247.)
- Deny individual subscribers access to the billing information in their own entries (see "Denying Access" on page 258.)
- Grant anonymous access to the world to the individual subscribers subtree, except for subscribers who have specifically requested to be unlisted. (This part of the directory could be a slave server outside of the firewall and updated once a day.) See "Granting Anonymous Access" on page 245 and "Setting a Target Using Filtering" on page 260.

Granting Anonymous Access

Most directories are run such that you can anonymously access at least one suffix for read, search, or compare. For example, you might want to set these permissions if you are running a corporate personnel directory that you want employees to be able to search, such as a phone book. This is the case at example.com internally, and is illustrated in the ACI "Anonymous example.com" example.

As an ISP, example.com also wants to advertise the contact information of all of its subscribers by creating a public phone book accessible to the world. This is illustrated in the ACI "Anonymous World" example.

ACI "Anonymous example.com"

In LDIF, to grant read, search, and compare permissions to the entire example.com tree to example.com employees, you would write the following statement:

```
aci: (targetattr !="userPassword")(version 3.0; acl "Anonymous
 example"; allow (read, search, compare)
 userdn= "ldap:///anyone" and dns="*.example.com";)
```

This example assumes that the `aci` is added to the `dc=example,dc=com entry`. Note that the `userPassword` attribute is excluded from the scope of the ACI.

From the console, you can set this permission by doing the following:

1. On the Directory tab, right click the example.com node in the left navigation tree, and choose Set Access Permissions from the pop-up menu to display the Access Control Manager.
2. Click New to display the Access Control Editor.
3. On the Users/Groups tab, in the ACI name field, type "Anonymous example.com". Check that All Users is displayed in the list of users granted access permission.
4. On the Rights tab, tick the checkboxes for read, compare, and search rights. Make sure the other checkboxes are clear.
5. On the Targets tab, click This Entry to display the `dc=example,dc=com` suffix in the target directory entry field. In the attribute table, locate the `userPassword` attribute and clear the corresponding checkbox.

   All other checkboxes should be ticked. This task is made easier if you click the Name header to organize the list of attributes alphabetically.
6. On the Hosts tab, click Add, and in the DNS host filter field, type `*.example.com`. Click OK to dismiss the dialog box.
7. Click OK in the Access Control Editor window.

   The new ACI is added to the ones listed in the Access Control Manager window.

ACI “Anonymous World”

In LDIF, to grant read and search access of the individual subscribers subtree to the world, while denying access to information on unlisted subscribers, you could write the following statement:

```
aci: (targetfilter= "(!(unlistedSubscriber=yes))")
 (targetattr="homePostalAddress || homePhone || mail")
 (version 3.0; acl "Anonymous World"; allow (read, search)
 userdn="ldap:///anyone";)
```

This example assumes that the ACI is added to the `ou=subscribers,dc=example,dc=com` entry. It also assumes that every subscriber entry has an `unlistedSubscriber` attribute which is set to yes or no. The target definition filters out the unlisted subscribers based on the value of this attribute. For details on the filter definition, refer to “Setting a Target Using Filtering” on page 260.

From the console, you can set this permission by doing the following:

1. On the Directory tab, right click the Subscribers entry under the example.com node in the left navigation tree, and choose Set Access Permissions from the pop-up menu to display the Access Control Manager.
2. Click New to display the Access Control Editor.
3. On the Users/Groups tab, in the ACI name field, type "Anonymous World". Check that All Users is displayed in the list of users granted access permission.
4. On the Rights tab, tick the checkboxes for read, and search rights. Make sure the other checkboxes are clear.
5. On the Targets tab, click This Entry to display the `dc=subscribers, dc=example,dc=com` suffix in the target directory entry field.
   a. In the filter for subentries field, type the following filter:

      (!(unlistedSubscriber=yes))

   b. In the attribute table, tick the checkboxes for the `homePhone`, `homePostalAddress`, and `mail` attributes.

      All other checkboxes should be clear. This task is made easier if you click the Check None button to clear the checkboxes for all attributes in the table, then click the Name header to organize them alphabetically, and select the appropriate ones.
6. Click OK.

   The new ACI is added to the ones listed in the Access Control Manager window.

Granting Write Access to Personal Entries

Many directory administrators want to allow internal users to change some but not all of the attributes in their own entry. The directory administrators at example.com want to allow users to change their own password, home telephone number, and home address, but nothing else. This is illustrated in the ACI “Write example.com” example.

It is also example.com’s policy to let their subscribers update their own personal information in the example.com tree provided that they establish an SSL connection to the directory. This is illustrated in the ACI “Write Subscribers” example.

ACI “Write example.com”

NOTE By setting this permission, you are also granting users the right to delete attribute values.

In LDIF, to grant example.com employees the right to update their password, home telephone number and home address, you would write the following statement:

```
aci: (targetattr="userPassword || homePhone ||
 homePostalAddress")(version 3.0; acl "Write example.com";
 allow (write) userdn="ldap:///self" and dns="*.example.com";)
```

This example assumes that the ACI is added to the `ou=People,dc=example,dc=com` entry.

From the console, you can set this permission by doing the following:

1. On the Directory tab, right-click `ou=People,dc=example,dc=com` entry the in the left navigation tree, and choose Set Access Permissions from the pop-up menu to display the Access Control Manager.
2. Click New to display the Access Control Editor.
3. On the Users/Groups tab, in the ACI name field, type "Write example.com". In the list of users granted access permission, do the following:
    a. Select and remove All Users, then click Add.

       The Add Users and Groups dialog box is displayed.
    b. Set the Search area to Special Rights, and select Self from the Search results list.
    c. Click the Add button to list Self in the list of users who are granted access permission.
    d. Click OK to dismiss the Add Users and Groups dialog box.
4. On the Rights tab, tick the checkbox for write right. Make sure the other checkboxes are clear.

5. On the Targets tab, click This Entry to enter `ou=People,dc=example,dc=com` in the target directory entry field. In the attribute table, tick the checkboxes for the `homePhone`, `homePostalAddress`, and `userPassword` attributes.

   All other checkboxes should be clear. This task is made easier if you click the Check None button to clear the checkboxes for all attributes in the table, then click the Name header to organize them alphabetically, and select the appropriate ones.

6. On the Hosts tab, click Add to display the Add Host Filter dialog box. In the DNS host filter field, type `*.example.com`. Click OK to dismiss the dialog box.

7. Click OK in the Access Control Editor window.

   The new ACI is added to the ones listed in the Access Control Manager window.

ACI "Write Subscribers"

NOTE	By setting this permission, you are also granting users the right to delete attribute values.

In LDIF, to grant example.com subscribers the right to update their password and home telephone number, you would write the following statement:

```
aci: (targetattr="userPassword || homePhone")
 (version 3.0; acl "Write Subscribers"; allow (write)
 userdn= "ldap://self" and authmethod="ssl";)
```

This example assumes that the `aci` is added to the `ou=subscribers,dc=example, dc=com` entry.

Note that example.com subscribers do not have write access to their home address, because they might delete the attribute, and example.com needs that information for billing. Therefore, the home address is business-critical information.

From the console, you can set this permission by doing the following:

1. On the Directory tab, right click the Subscribers entry under the example.com node in the left navigation tree, and choose Set Access Permissions from the pop-up menu to display the Access Control Manager.

2. Click New to display the Access Control Editor.

3. On the Users/Groups tab, in the ACI name field, type "Write Subscribers". In the list of users granted access permission, do the following:

   a. Select and remove All Users, then click Add.

      The Add Users and Groups dialog box is displayed.

   b. Set the Search area to Special Rights, and select Self from the Search results list.

   c. Click the Add button to list Self in the list of users who are granted access permission.

   d. Click OK to dismiss the Add Users and Groups dialog box.

4. On the Rights tab, tick the checkbox for write. Make sure the other checkboxes are clear.

5. On the Targets tab, click This Entry to display the `dc=subscribers, dc=example,dc=com` suffix in the target directory entry field.

   a. In the filter for subentries field, type the following filter:

      (!(unlistedSubscriber=yes))

   b. In the attribute table, tick the checkboxes for the `homePhone`, `homePostalAddress`, and `mail` attributes.

      All other checkboxes should be clear. This task is made easier if you click the Check None button to clear the checkboxes for all attributes in the table, then click the Name header to organize them alphabetically, and select the appropriate ones.

6. If you want users to authenticate using SSL, switch to manual editing by clicking the Edit Manually button and add `authmethod=ssl` to the LDIF statement so that it reads as follows:

```
(targetattr="homePostalAddress || homePhone || mail")
 (version 3.0; acl "Write Subscribers"; allow (write)
 (userdn= "ldap:///self") and authmethod="ssl";)
```

   Note that this is a continuous line, split for readability.

7. Click OK.

   The new ACI is added to the ones listed in the Access Control Manager window.

Restricting Access to Key Roles

You can use role definitions in the directory to identify functions that are critical to your business, the administration of your network and directory, or another purpose.

For example, you might create a `superAdmin` role by identifying a subset of your system administrators that are available at a particular time of day and day of the week at corporate sites worldwide. Or you might want to create a `First Aid` role that includes all members of staff on a particular site that have done first aid training. For information on creating role definitions, refer to "Assigning Roles" on page 178.

When a role gives any sort of privileged user rights over critical corporate or business functions, you should consider restricting access to that role. For example, at example.com, employees can add any role to their own entry, except the `superAdmin` role. This is illustrated in the ACI "Roles" example.

ACI "Roles"

In LDIF, to grant example.com employees the right to add any role to their own entry, except the `superAdmin` role, you would write the following statement:

```
aci: (targetattr="*") (targattrfilters="add=nsRoleDN:
 (nsRoleDN !="cn=superAdmin, dc=example, dc=com")")
 (version 3.0; acl "Roles"; allow (write)
 userdn= "ldap:///self" and dns="*.example.com";)
```

This example assumes that the ACI is added to the `ou=People,dc=example, dc=com` entry.

From the console, you can set this permission by doing the following:

1. On the Directory tab, right click the example.com node in the left navigation tree, and choose Set Access Permissions from the pop-up menu to display the Access Control Manager.
2. Click New to display the Access Control Editor.
3. On the Users/Groups tab, in the ACI name field, type "Roles". In the list of users granted access permission, do the following:
    a. Select and remove All Users, then click Add.

       The Add Users and Groups dialog box is displayed.
    b. Set the Search area in the Add Users and Groups dialog box to Special Rights, and select Self from the Search results list.
    c. Click the Add button to list Self in the list of users who are granted access permission.
    d. Click OK to dismiss the Add Users and Groups dialog box.
4. On the Rights tab, tick the checkbox for write. Make sure the other checkboxes are clear.

5. On the Hosts tab, click Add to display the Add Host Filter dialog box. In the DNS host filter field, type `*.example.com`. Click OK to dismiss the dialog box.

6. To create the value-based filter for roles, switch to manual editing by clicking the Edit Manually button. Add the following to the beginning of the LDIF statement:

   ```
   (targattrfilters="add=nsRoleDN:
    (nsRoleDN != "cn=superAdmin, dc=example,dc=com")")
   ```

   The LDIF statement should read as follows:

   ```
   (targetattr="*") (targattrfilters="add=nsRoleDN:
    (nsRoleDN != "cn=superAdmin, dc=example,dc=com")")
    (target = "ldap:///dc=example,dc=com")
    (version 3.0; acl "Roles"; allow (write)
    (userdn = "ldap:///self") and (dns="*.example.com");)
   ```

7. Click OK.

   The new ACI is added to the ones listed in the Access Control Manager window.

Granting a Group Full Access to a Suffix

Most directories have a group that is used to identify certain corporate functions. These groups can be given full access to all or part of the directory. By applying the access rights to the group, you can avoid setting the access rights for each member individually. Instead, you grant users these access rights simply by adding them to the group.

For example, when you install Directory Server using the Typical Install process, an Administrators group with full access to the directory is created by default.

At example.com, the Human Resources group is allowed full access to the `ou=People` branch of the directory so that they can update the employee directory. This is illustrated in the ACI "HR" example.

ACI "HR"

In LDIF, to grant the HR group all rights on the employee branch of the directory, you would use the following statement:

```
aci: (targetattr="*") (version 3.0; acl "HR"; allow (all)
 userdn= "ldap:///cn=HRgroup,ou=People,dc=example,dc=com";)
```

This example assumes that the ACI is added to the `ou=People,dc=example,dc=com` entry.

From the console, you can set this permission by doing the following:

1. On the Directory tab, right click the example.com-people entry under the example.com node in the left navigation tree, and choose Set Access Permissions from the pop-up menu to display the Access Control Manager.
2. Click New to display the Access Control Editor.
3. On the Users/Groups tab, in the ACI name field, type "HR". In the list of users granted access permission, do the following:
    a. Select and remove All Users, then click Add.

       The Add Users and Groups dialog box is displayed.
    b. Set the Search area to Users and Groups, and type "HRgroup" in the Search for field.

       This example assumes that you have created an HR group or role. For more information on groups and roles, see Chapter 5, “Managing Identity and Roles.”
    c. Click the Add button to list the HR group in the list of users who are granted access permission.
    d. Click OK to dismiss the Add Users and Groups dialog box.
4. On the Rights tab, click the Check All button.

   All checkboxes are ticked, except for Proxy rights.
5. Click OK.

   The new ACI is added to the ones listed in the Access Control Manager window.

Granting Rights to Add and Delete Group Entries

Some organizations want to allow employees to create entries in the tree if it can increase their efficiency, or if it can contribute to the corporate dynamics.

At example.com for example, there is an active social committee that is organized into various clubs: tennis, swimming, skiing, role-playing, etc. Any example.com employee can create a group entry representing a new club. This is illustrated in the ACI “Create Group” example. Any example.com employee can become a member of one of these groups. This is illustrated in ACI “Group Members” under “Allowing Users to Add or Remove Themselves From a Group” on page 260. Only the group owner can modify or delete a group entry. This is illustrated in the ACI “Delete Group” example.

ACI “Create Group”

In LDIF, to grant example.com employees the right to create a group entry under the `ou=Social Committee` branch, you would write the following statement:

```
aci: (target="ldap:///ou=social committee,dc=example,dc=com")
 (targetattr="*")(targattrfilters="add=objectClass:
 (|(objectClass=groupOfNames)(objectClass=top))")
 (version 3.0; acl "Create Group"; allow (read,search,add)
 userdn= "ldap:///uid=*,ou=People,dc=example,dc=com")
 and dns="*.example.com";)
```

NOTE
- This ACI does not grant write permission, which means that the entry creator cannot modify the entry.
- Because the server adds the value “top” behind the scenes, you need to specify `objectclass=top` in the `targattrfilters` keyword.

This example assumes that the ACI is added to the `ou=social committee, dc=example,dc=com` entry.

From the console, you can set this permission by doing the following:

1. On the Directory tab, right click the Social Committee entry under the example.com node in the left navigation tree, and choose Set Access Permissions from the pop-up menu to display the Access Control Manager.
2. Click New to display the Access Control Editor.
3. On the Users/Groups tab, in the ACI name field, type "Create Group". In the list of users granted access permission, do the following:
   a. Select and remove All Users, then click Add.

      The Add Users and Groups dialog box is displayed.
   b. Set the Search area to Special Rights, and select All Authenticated Users from the Search results list.
   c. Click the Add button to list All Authenticated Users in the list of users who are granted access permission.
   d. Click OK to dismiss the Add Users and Groups dialog box.
4. On the Rights tab, tick the checkbox for read, search, and add. Make sure the other checkboxes are clear.
5. On the Targets tab, click This Entry to display the `ou=social committee, dc=example,dc=com` suffix in the target directory entry field.

6. On the Hosts tab, click Add to display the Add Host Filter dialog box. In the DNS host filter field, type `*.example.com`. Click OK to dismiss the dialog box.

7. To create the value-based filter that will allow employees to add only group entries to this subtree, switch to manual editing by clicking the Edit Manually button. Add the following to the beginning of the LDIF statement:

   ```
   (targattrfilters="add=objectClass:(objectClass=groupOfNames)
    |(objectClass=top)")
   ```

   The LDIF statement should read as follows:

   ```
   (targetattr = "*")
   (targattrfilters="add=objectClass:(objectClass=groupOfNames)
    |(objectClass=top)") (target="ldap:///ou=social
    committee,dc=example,dc=com) (version 3.0; acl "Create Group";
    allow (read,search,add) (userdn= "ldap:///all") and
    (dns="*.example.com"); )
   ```

8. Click OK.

   The new ACI is added to the ones listed in the Access Control Manager window.

ACI “Delete Group”

In LDIF, to grant example.com employees the right to modify or delete a group entry which they own under the `ou=Social Committee branch`, you would write the following statement:

```
aci: (target="ou=social committee,dc=example,dc=com)
 (targetattr = "*")
 (targattrfilters="del=objectClass:(objectClass=groupOfNames)")
 (version 3.0; acl "Delete Group"; allow (write,delete)
 userattr="owner#GROUPDN";)
```

This example assumes that the `aci` is added to the `ou=social committee, dc=example,dc=com` entry.

Using the console is not an effective way of creating this ACI because you would have to use manual editing mode to create the target filter, and to check group ownership.

Granting Conditional Access to a Group or Role

In many cases, when you grant a group or role privileged access to the directory, you want to ensure that those privileges are protected from intruders trying to impersonate your privileged users. Therefore, in many cases, access control rules that grant critical access to a group or role are often associated with a number of conditions.

example.com, for example, has created a Directory Administrator role for each of its hosted companies, Company333 and Company999. It wants these companies to be able to manage their own data and implement their own access control rules while securing it against intruders. For this reason, Company333 and Company999 have full rights on their respective branches of the directory tree, provided the following conditions are fulfilled:

- Connection authenticated using a certificate over SSL,
- Access requested between 8 am and 6 pm, Monday through Thursday, and
- Access requested from a specified IP address for each company.

These conditions are illustrated in a single ACI for each company, ACI “Company333” and ACI “Company999”. Because the content of these ACIs is the same, the examples below illustrate the “Company333” ACI only.

ACI “Company333”

In LDIF, to grant Company333 full access to their own branch of the directory under the conditions stated above, you would write the following statement:

```
aci: (target="ou=Company333,ou=corporate-clients,dc=example,dc=com")
 (targetattr = "*") (version 3.0; acl "Company333"; allow (all)
 (roledn="ldap:///cn=DirectoryAdmin,ou=Company333,
 ou=corporate-clients,dc=example,dc=com") and (authmethod="ssl")
 and (dayofweek="Mon,Tues,Wed,Thu") and (timeofday >= "0800" and
 timeofday <= "1800") and (ip="255.255.123.234"); )
```

This example assumes that the ACI is added to the `ou=Company333, ou=corporate-clients,dc=example,dc=com` entry.

From the console, you can set this permission by doing the following:

1. On the Directory tab, right click the Company333 entry under the example.com node in the left navigation tree, and choose Set Access Permissions from the pop-up menu to display the Access Control Manager.
2. Click New to display the Access Control Editor.
3. On the Users/Groups tab, in the ACI name field, type "Company333". In the list of users granted access permission, do the following:

   a. Select and remove All Users, then click Add.

      The Add Users and Groups dialog box is displayed.

   b. Set the Search area to Users and Groups, and type DirectoryAdmin in the Search For field.

      This example assumes that you have created an administrators role with a `cn` of `DirectoryAdmin`.

   c. Click the Add button to list the administrators role in the list of users who are granted access permission.

   d. Click OK to dismiss the Add Users and Groups dialog box.

4. On the Rights tab, click the Check All button.

5. On the Targets tab, click This Entry to display the `ou=Company333,ou=corporate-clients,dc=example,dc=com` suffix in the target directory entry field.

6. On the Hosts tab, click Add to display the Add Host Filter dialog box. In the IP address host filter field, type `255.255.123.234`. Click OK to dismiss the dialog box.

   The IP address must be a valid IP address for the host machine that the Company333 administrators will use to connect to the example.com directory.

7. On the Times tab, select the block time corresponding to Monday through Thursday, and 8 am to 6 pm.

   A message appears below the table that specifies what time block you have selected.

8. To enforce SSL authentication from Company333 administrators, switch to manual editing by clicking the Edit Manually button. Add the following to the end of the LDIF statement:

   and (authmethod="ssl")

   The LDIF statement should be similar to:

```
aci: (targetattr = "*")(target="ou=Company333,
 ou=corporate-clients,dc=example,dc=com") (version 3.0; acl
 "Company333"; allow (all) (roledn="ldap:///cn=DirectoryAdmin,
 ou=Company333,ou=corporate-clients, dc=example,dc=com") and
 (dayofweek="Mon,Tues,Wed,Thu") and (timeofday >= "0800" and
 timeofday <= "1800") and (ip="255.255.123.234") and
 (authmethod="ssl"); )
```

9. Click OK.

   The new ACI is added to the ones listed in the Access Control Manager window.

Denying Access

If your directory holds business-critical information, you might specifically want to deny access to it.

For example, example.com wants all subscribers to be able to read billing information such as connection time or account balance under their own entries, but explicitly wants to deny write access to that information. This is illustrated in ACI "Billing Info Read" and ACI "Billing Info Deny" respectively.

ACI "Billing Info Read"

In LDIF, to grant subscribers permission to read billing information in their own entry, you would write the following statement:

```
aci: (targetattr="connectionTime || accountBalance")
 (version 3.0; acl "Billing Info Read"; allow (search,read)
 userdn="ldap:///self";)
```

This example assumes that the relevant attributes have been created in the schema, and that the ACI is added to the `ou=subscribers,dc=example,dc=com` entry.

From the console, you can set this permission by doing the following:

1. On the Directory tab, right click the subscribers entry under the example.com node in the left navigation tree, and choose Set Access Permissions from the pop-up menu to display the Access Control Manager.
2. Click New to display the Access Control Editor.
3. On the Users/Groups tab, in the ACI name field, type "Billing Info Read". In the list of users granted access permission, do the following:
   a. Select and remove All Users, then click Add.

      The Add Users and Groups dialog box is displayed.
   b. Set the Search area in the Add Users and Groups dialog box to Special Rights, and select Self from the Search results list.
   c. Click the Add button to list Self in the list of users who are granted access permission.
   d. Click OK to dismiss the Add Users and Groups dialog box.

4. On the Rights tab, tick the checkboxes for search and read rights. Make sure the other checkboxes are clear.

5. On the Targets tab, click This Entry to display the `ou=subscribers, dc=example,dc=com` suffix in the target directory entry field. In the attribute table, tick the checkboxes for the `connectionTime` and `accountBalance` attributes.

   All other checkboxes should be clear. This task is made easier if you click the Check None button to clear the checkboxes for all attributes in the table, then click the Name header to organize them alphabetically, and select the appropriate ones.

   This example assumes that you have added the `connectionTime` and `accountBalance` attributes to the schema.

6. Click OK.

   The new ACI is added to the ones listed in the Access Control Manager window.

ACI "Billing Info Deny"

In LDIF, to deny subscribers permission to modify billing information in their own entry, you would write the following statement:

```
aci: (targetattr="connectionTime || accountBalance")
 (version 3.0; acl "Billing Info Deny";
 deny (write) userdn="ldap:///self";)
```

This example assumes that the relevant attributes have been created in the schema, and that the ACI is added to the `ou=subscribers,dc=example,dc=com` entry.

From the console, you can set this permission by doing the following:

1. On the Directory tab, right click the subscribers entry under the example.com node in the left navigation tree, and choose Set Access Permissions from the pop-up menu to display the Access Control Manager.

2. Click New to display the Access Control Editor.

3. On the Users/Groups tab, in the ACI name field, type "Billing Info Deny". In the list of users granted access permission, do the following:

   a. Select and remove All Users, then click Add.

      The Add Users and Groups dialog box is displayed.

   b. Set the Search area in the Add Users and Groups dialog box to Special Rights, and select Self from the Search results list.

   c. Click the Add button to list Self in the list of users who are granted access permission.

   d. Click OK to dismiss the Add Users and Groups dialog box.

4. On the Rights tab, tick the checkbox for write. Make sure the other checkboxes are clear.

5. Click the Edit Manually button and in the LDIF statement that is displayed, change the word **`allow`** to **`deny`**.

6. On the Targets tab, click This Entry to display the `ou=subscribers, dc=example,dc=com` suffix in the target directory entry field. In the attribute table, tick the checkboxes for the `connectionTime` and `accountBalance` attributes.

   All other checkboxes should be clear. This task is made easier if you click the Check None button to clear the checkboxes for all attributes in the table, then click the Name header to organize them alphabetically, and select the appropriate ones.

   This example assumes that you have added the `connectionTime` and `accountBalance` attributes to the schema.

7. Click OK.

   The new ACI is added to the ones listed in the Access Control Manager window.

Setting a Target Using Filtering

If you want to set access controls that allow access to a number of entries that are spread across the directory, you may want to use a filter to set the target. Keep in mind that because search filters do not directly name the object for which you are managing access, it is easy to unintentionally allow or deny access to the wrong objects, especially as your directory becomes more complex. Additionally, filters can make it difficult for you to troubleshoot access control problems within your directory.

Allowing Users to Add or Remove Themselves From a Group

Many directories set ACIs that allow users to add or remove themselves from groups. This is useful, for example, for allowing users to add and remove themselves from mailing lists.

At example.com, employees can add themselves to any group entry under the `ou=social committee` subtree. This is illustrated in the ACI “Group Members” example.

ACI “Group Members”

In LDIF, to grant example.com employees the right to add or delete themselves from a group, you would write the following statement:

```
aci: (targettattr="member")(version 3.0; acl "Group Members";
 allow (selfwrite)
 (userdn= "ldap:///uid=*,ou=People,dc=example,dc=com") ;)
```

This example assumes that the ACI is added to the `ou=social committee, dc=example,dc=com` entry.

From the console, you can set this permission by doing the following:

1. On the Directory tab, right click the `People` entry under the `example.com` node in the left navigation tree, and choose Set Access Permissions from the pop-up menu to display the Access Control Manager.
2. Click New to display the Access Control Editor.
3. On the Users/Groups tab, in the ACI name field, type "Group Members". In the list of users granted access permission, do the following:
    a. Select and remove All Users, then click Add.

       The Add Users and Groups dialog box is displayed.
    b. Set the Search area in the Add Users and Groups dialog box to Special Rights, and select All Authenticated Users from the Search results list.
    c. Click the Add button to list All Authenticated Users in the list of users who are granted access permission.
    d. Click OK to dismiss the Add Users and Groups dialog box.
4. On the Rights tab, tick the checkbox for selfwrite. Make sure the other checkboxes are clear.
5. On the Targets tab, type `dc=example,dc=com` suffix in the target directory entry field. In the attribute table, tick the checkbox for the `member` attribute.

   All other checkboxes should be clear. This task is made easier if you click the Check None button to clear the checkboxes for all attributes in the table, then click the Name header to organize them alphabetically, and select the appropriate ones.
6. Click OK.

   The new ACI is added to the ones listed in the Access Control Manager window.

Defining Permissions for DNs That Contain a Comma

DNs that contain commas require special treatment within your LDIF ACI statements. In the target and bind rule portions of the ACI statement, commas must be escaped by a single backslash (\). The following example illustrates this syntax:

```
dn: o=example.com Bolivia\, S.A.
objectClass: top
objectClass: organization
aci: (target="ldap:///o=example.com Bolivia\,S.A.")
 (targetattr="*") (version 3.0; acl "aci 2"; allow (all)
 groupdn = "ldap:///cn=Directory Administrators,
 o=example.com Bolivia\, S.A.";)
```

Proxy Authorization ACI Example

The proxy authorization method is a special form of authentication: a user that binds to the directory using its own identity is granted through proxy authorization the rights of another user.

For this example, suppose:

- The client application's bind DN is `uid=MoneyWizAcctSoftware, ou=Applications,dc=example,dc=com`.
- The targeted subtree to which the client application is requesting access is `ou=Accounting,dc=example,dc=com`.
- An Accounting Administrator with access permissions to the `ou=Accounting,dc=example,dc=com` subtree exists in the directory.

In order for the client application to gain access to the Accounting subtree (using the same access permissions as the Accounting Administrator):

- The Accounting Administrator must have access permissions to the `ou=Accounting,dc=example,dc=com` subtree. For example, the following ACI grants all rights to the Accounting Administrator entry:

  ```
  aci: (target="ldap:///ou=Accounting,dc=example,dc=com")
   (targetattr="*") (version 3.0; acl "allowAll-AcctAdmin"; allow
   (all) userdn="ldap:///dn:uid=AcctAdministrator,ou=Administrators,
   dc=example,dc=com";)
  ```

- The following ACI granting proxy rights to the client application must exist in the directory:

```
aci: (target="ldap:///ou=Accounting,dc=example,dc=com")
 (targetattr="*") (version 3.0; acl "allowproxy-
 accountingsoftware"; allow (proxy) userdn=
 "ldap:///dn:uid=MoneyWizAcctSoftware,ou=Applications,
 dc=example,dc=com";)
```

With this ACI in place, the MoneyWizAcctSoftware client application can bind to the directory and send an LDAP command such as `ldapsearch` or `ldapmodify` that requires the access rights of the proxy DN.

In the above example, if the client wanted to perform an `ldapsearch` command, the command would include the following controls:

```
ldapsearch \
-D "uid=MoneyWizAcctSoftware,ou=Applications,dc=example,dc=com"\
-w password\
-y "uid=AcctAdministrator,ou=Administrators,dc=example,dc=com"\ ...
```

Note that the client binds as itself, but is granted the privileges of the proxy entry. The client does not need the password of the proxy entry.

NOTE You cannot use the Directory Manager's DN as a proxy DN. Nor can you grant proxy rights to the Directory Manager.In addition, if Directory Server receives more than one proxied authentication control in the same bind operation, an error is returned to the client application and the bind attempt is unsuccessful.

Viewing Effective Rights

When maintaining the access policy on the entries of a directory, it is useful to know the effects on security of the ACIs you define. Directory Server enables you to evaluate existing ACIs and report the effective rights that they grant for a given user on a given entry.

Directory Server responds to the "Get Effective Rights" control which may be included in a search operation. The response to this control is to return the effective rights information about the entries and attributes in the search results. This extra information includes read and write permissions for each entry and for each attribute in each entry. The permissions may be requested for the bind DN used for the search or for an arbitrary DN, allowing administrators to test the permissions of directory users.

CAUTION Viewing effective rights is itself a directory operation that should be protected and appropriately restricted. Create further ACIs for the `aclRights` and `aclRightsInfo` attributes to restrict access by directory users to this information.

Effective rights functionality relies on an LDAP control. To view the effective rights on a chained suffix, you must enable this control in the chaining policy, as described in "Configuring the Chaining Policy" on page 138. You must also ensure that the proxy identity used to bind to the remote server is also allowed to access the effective rights attributes.

Using the Get Effective Rights Control

Specify the "Get Effective Rights" control by using the `ldapsearch` command with the `-J "1.3.6.1.4.1.42.2.27.9.5.2"` option. By default, the control will return the effective rights of the bind DN entry on the entries and attributes in the search results. Use the following options to change the default behavior:

- `-c "dn:` *DN*`"` - The search results will show the effective rights of the user binding with the given *DN*. This option allows an administrator to check the effective rights of another user. The option `-c "dn:"` will show the effective rights for anonymous authentication.
- `-X "`*attributeName ...*`"` - The search results will also include the effective rights on the named attributes. Use this option to specify attributes that will not appear in the search results. For example, use this option to determine if a user has permission to add an attribute that does not currently exist in an entry.

When using either or both the `-c` and `-X` attributes, the `-J` option with the OID of the "Get Effective Rights" control is implied and does not need to be specified. If you specify a NULL value for the Effective Rights control, the rights for the current user and the rights for the attributes and entries being returned with the current `ldapsearch` operation are retrieved.

Then you must select the type of information you wish to view, either the simple rights or the more detailed logging information that explains how those rights are granted or denied. The type of information is determined by adding either `aclRights` or `aclRightsInfo`, respectively, as an attribute to return in the search results. You may request both attributes to receive all effective rights information, although the simple rights are redundant with the information in the detailed logging information.

NOTE The `aclRights` and `aclRightsInfo` attributes have the behavior of virtual operational attributes. They are not stored in the directory, and they will not be returned unless explicitly requested. These attributes are generated by Directory Server in response to the “Get Effective Rights” control.

For this reason, neither of these attributes may be used in filters or search operations of any kind.

The effective rights feature inherits other parameters that affect access control (such as time of day, authentication method, machine address and name,) from the user initiating the search operation.

The following example shows how a user may view her rights in the directory. In the results, a `1` means that permission is granted, and a `0` means that permission is denied:

```
ldapsearch -J "1.3.6.1.4.1.42.2.27.9.5.2" \
           -h rousseau.example.com -p 389 \
           -D "uid=cfuente,ou=People,dc=example,dc=com" \
           -w password -b "dc=example,dc=com" \
           "(objectclass=*)" aclRights

dn: dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0

dn: ou=Groups, dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0

dn: ou=People, dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0

dn: cn=Accounting Managers,ou=groups,dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0

dn: cn=HR Managers,ou=groups,dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0

dn: uid=bjensen,ou=People, dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0

dn: uid=cfuente, ou=People, dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:1,proxy:0
```

This result shows Carla Fuente the entries in the directory where she has at least read permission and that she can modify her own entry. The effective rights control does not bypass normal access permissions, so a user will never see the entries for which they do not have read permission. In the following example, the Directory Manager can see the entries to which Carla Fuente does not have read permission:

```
ldapsearch -h rousseau.example.com -p 389 \
           -D "cn=Directory Manager" -w password \
           -c "dn: uid=cfuente,ou=People,dc=example,dc=com" \
           -b "dc=example,dc=com" \
           "(objectclass=*)" aclRights

dn: dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0

dn: ou=Groups, dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0

dn: cn=Directory Administrators, dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:0,write:0,proxy:0

dn: ou=Special Users,dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:0,write:0,proxy:0

dn: ou=People, dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0

dn: cn=Accounting Managers,ou=groups,dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0

dn: cn=HR Managers,ou=groups,dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0

dn: uid=bjensen,ou=People, dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0

dn: uid=cfuente, ou=People, dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:1,proxy:0
```

In the output above, the directory manager can see that Carla Fuente cannot even view the Special Users nor the Directory Administrators branches of the directory tree. In the following example, the directory manager can see that Carla Fuente cannot modify the `mail` and `manager` attributes in her own entry:

```
ldapsearch -h rousseau.example.com -p 389 \
           -D "cn=Directory Manager" -w password \
           -c "dn: uid=cfuente,ou=People,dc=example,dc=com" \
           -b "dc=example,dc=com" \
           "(uid=cfuente)" aclRights "*"
```

```
version: 1
dn: uid=cfuente, ou=People, dc=example,dc=com

aclRights;attributeLevel;mail: search:1,read:1,compare:1,
 write:0,selfwrite_add:0,selfwrite_delete:0,proxy:0
mail: cfuente@example.com

aclRights;attributeLevel;uid: search:1,read:1,compare:1,
 write:1,selfwrite_add:1,selfwrite_delete:1,proxy:0
uid: cfuente

aclRights;attributeLevel;givenName: search:1,read:1,compare:1,
 write:1,selfwrite_add:1,selfwrite_delete:1,proxy:0
givenName: Carla

aclRights;attributeLevel;sn: search:1,read:1,compare:1,
 write:1,selfwrite_add:1,selfwrite_delete:1,proxy:0
sn: Fuente

aclRights;attributeLevel;cn: search:1,read:1,compare:1,
 write:1,selfwrite_add:1,selfwrite_delete:1,proxy:0
cn: Carla Fuente

aclRights;attributeLevel;userPassword: search:0,read:0,
 compare:0,write:1,selfwrite_add:1,selfwrite_delete:1,proxy:0
userPassword: {SSHA}wnbWHIq2HPiY/5ECwe6MWBGx2KMiZ8JmjF80Ow==

aclRights;attributeLevel;manager: search:1,read:1,compare:1,
 write:0,selfwrite_add:0,selfwrite_delete:0,proxy:0
manager: uid=bjensen,ou=People,dc=example,dc=com

aclRights;attributeLevel;telephoneNumber: search:1,read:1,compare:1,
 write:1,selfwrite_add:1,selfwrite_delete:1,proxy:0
telephoneNumber: (234) 555-7898

aclRights;attributeLevel;objectClass: search:1,read:1,compare:1,
 write:1,selfwrite_add:1,selfwrite_delete:1,proxy:0
objectClass: top
objectClass: person
objectClass: organizationalPerson
objectClass: inetorgperson

aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0
```

Understanding Effective Rights Results

Depending on the options specified, an effective rights request returns the following information:

- Rights Information
- Write, Selfwrite_add, and Selfwrite_delete permissions
- Logging Information

Rights Information

The effective rights information is presented according to the following subtypes:

`aclRights;entrylevel`	Presents entry level rights information
`aclRights;attributelevel`	Presents attribute level rights information
`aclRightsInfo;entrylevel`	Presents entry level logging information
`aclRightsInfo;attributelevel`	Presents attribute level logging information

The format of the `aclRights` string is: *permission:value(permission:value)**

Possible entry level permissions are `add`, `delete`, `read`, `write`, and `proxy`. Possible attribute level permissions are `read`, `search`, `compare`, `write`, `selfwrite_add`, `selfwrite_delete`, and `proxy`.

The values of these permissions can be one of:

- `0` - granted
- `1` - not granted
- `?` - in cases where the granting of rights depends on the value of the attribute you are adding, deleting, or replacing. If you see a `?`, consult the logging information to establish why the permissions will or will not be granted.
- `-` - to indicate that the attribute in question is a virtual attribute, and therefore not updatable. The only way to modify a virtual attribute is to modify the mechanism that generates it.

Write, Selfwrite_add, and Selfwrite_delete permissions

In Directory Server 5.2 only write attribute level permissions can have a value of "?". For add and delete permissions, the entries you can add and delete depend on the values of the attributes in the entry. Instead of returning a "?", the permission (`0` or `1`) is returned on the entries as they are returned with the `ldapsearch` operation.

If the value for a `write` permission is `1`, the permission is granted for both add and delete `ldapmodify` operations for all values (except the authorization dn value.) A value of `0` for a write permission means that the permission is not granted for either add or delete `ldapmodify` operations for any values (except the authorization dn value.) The permission in force for the value of the authorization dn is returned explicitly in one of the `selfwrite` permissions; that is, either `selfwrite_add` or `selfwrite_delete`.

Although `selfwrite-add` and `selfwrite-delete` attribute level permissions do not exist as such in the context of ACIs, a set of ACIs can grant a user `selfwrite` permission for *just* the add or *just* the delete part of a modify operation. For `selfwrite` permissions, the value of the attribute being modified is the authorization dn. The same distinction is not made for `write` permissions because the value of the attribute being modified for a write permission is undefined.

When the effective permission depends on a `targattrfilters` ACI, the "?" value indicates that the logging information should be consulted for more permission detail. Given the relative complexity of the interdependencies between the write, selfwrite_add, and selfwrite_delete permissions, Table 6-3 explains what the possible combinations of these three permissions mean.

Table 6-3 Effective Rights Permissions Interdependencies

write	selfwrite_ add	selfwrite_ delete	Effective Rights Explanation
0	0	0	Cannot add or delete any values of this attribute.
0	0	1	Can only delete the value of the authorization dn.
0	1	0	Can only add the value of the authorization dn.
0	1	1	Can only add or delete the value of the authorization dn.
1	0	0	Can add or delete all values except the authorization dn.
1	0	1	Can delete all values *including* the authorization dn and can add all values *excluding* the authorization dn.
1	1	0	Can add all values *including* the authorization dn and can delete all values *excluding* the authorization dn.
1	1	1	Can add or delete all values of this attribute.

Table 6-3 Effective Rights Permissions Interdependencies

write	selfwrite_ add	selfwrite_ delete	Effective Rights Explanation
?	0	0	Cannot add or delete the authorization dn value, but may be able to add or delete other values. Refer to logging information for further detail regarding the write permission.
?	0	1	Can delete but cannot add the value of the authorization dn, and may be able to add or delete other values. Refer to logging information for further detail regarding the write permission.
?	1	0	Can add but cannot delete the value of the authorization dn, and may be able to add or delete other values. Refer to logging information for further detail regarding the write permission.
?	1	1	Can add and delete the value of the authorization dn, and may be able to modify add or modify delete other values. Refer to logging information for further detail regarding the write permission.

Logging Information

The effective rights logging information enables you to understand and debug access control difficulties. The logging information contains an access control summary statement, called the `acl_summary`, that indicates why access control has been allowed or denied. The access control summary statement includes the following information:

- Whether access was allowed or denied
- The permissions granted
- The target entry of the permissions
- The name of the target attribute
- The subject of the rights being requested
- Whether or not the request was made by proxy, and if so, the proxy authentication DN
- The reason for allowing or denying access (important for debugging purposes.) Possible reasons are listed in Table 6-4:

Table 6-4 Effective Rights Logging Information Reasons and Their Explanations

Logging Information Reason	Explanation
`no reason available`	No reason available to explain why access was allowed or denied.
`no allow acis`	No allow ACIs exist, which results in denied access.
`result cached deny`	Cached information was used to determine the access denied decision.
`result cached allow`	Cached information was used to determine the access allowed decision.
`evaluated allow`	An ACI was evaluated to determine the access allowed decision. The name of the aci is included in the log information.
`evaluated deny`	An ACI was evaluated to determine the access denied decision. The name of the aci is included in the log information.
`no acis matched the resource`	No ACIs match the resource or target, which results in denied access.
`no acis matched the subject`	No ACIs match the subject requesting access control, which results in denied access.
`allow anyone aci matched anon user`	An ACI with a userdn = `"ldap:///anyone"` subject allowed access to the anonymous user.
`no matching anyone aci for anon user`	No ACI with a userdn= `"ldap:///anyone"` subject was found, and so access for the anonymous user was denied.
user root	The user is root DN and is allowed access.

NOTE Write permissions for virtual attributes are not provided, nor is any associated logging evaluation information, because virtual attributes are not updatable.

For the precise log file format see the *Directory Server Administration Reference.*

Advanced Access Control: Using Macro ACIs

In organizations that use repeating directory tree structures, it is possible to optimize the number of ACIs used in the directory by using macros. Reducing the number of ACIs in your directory tree makes it easier to manage your access control policy, and improves the efficiency of ACI memory usage.

Macros are placeholders that are used to represent a DN or a portion of a DN in an ACI. You can use a macro to represent a DN in the target portion of the ACI, in the bind rule portion, or in both. In practice, when Directory Server gets an incoming LDAP operation, the ACI macros are matched against the resource targeted by the LDAP operation to determine a matching substring, if any. If there is a match, the bind rule-side macro is expanded using the matched substring, and access to the resource is determined by evaluating that expanded bind rule.

Macro ACI Example

The benefits of macro ACIs and how they work are best explained using an example. Figure 6-4 on page 273 shows a directory tree in which using macro ACIs is an effective way of reducing the overall number of ACIs.

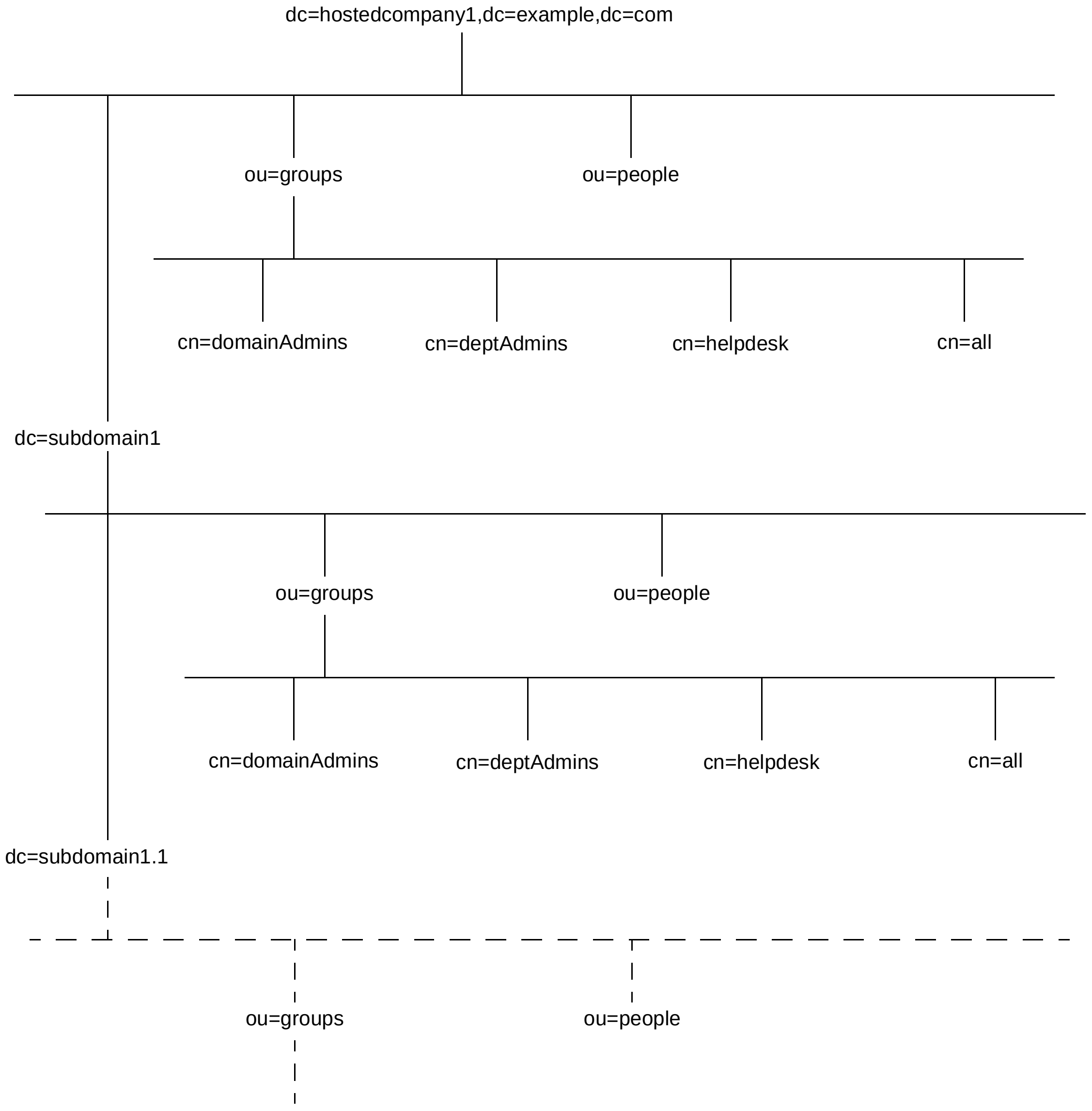
In this illustration, note the repeating pattern of subdomains with the same tree structure (`ou=groups,ou=people`). This pattern is also repeated across the tree, because the example.com directory tree stores the following suffixes `dc=hostedCompany2,dc=example,dc=com`, and `dc=hostedCompany3,dc=example,dc=com`.

The ACIs that apply in the directory tree also have a repeating pattern. For example, the following ACI is located on the `dc=hostedCompany1,dc=example,dc=com` node:

```
aci: (targetattr="*")
 (targetfilter=(objectClass=nsManagedDomain))(version 3.0;
 acl "Domain access"; allow (read,search) groupdn=
 "ldap:///cn=DomainAdmins,ou=Groups,dc=hostedCompany1,
 dc=example,dc=com";)
```

This ACI grants read and search rights to the DomainAdmins group to any entry in the `dc=hostedCompany1,dc=example,dc=com` tree.

Figure 6-4 Example Directory Tree for Macro ACIs



The following ACI is located on the `dc=hostedCompany1,dc=example,dc=com` node:

```
aci: (targetattr="*")
 (targetfilter=(objectClass=nsManagedDomain))
 (version 3.0; acl "Domain access"; allow (read,search)
 groupdn="ldap:///cn=DomainAdmins,ou=Groups,dc=hostedCompany1,
 dc=example,dc=com";)
```

The following ACI is located on the `dc=subdomain1,dc=hostedCompany1,dc=example,dc=com` node:

```
aci: (targetattr="*")
 (targetfilter=(objectClass=nsManagedDomain))
 (version 3.0; acl "Domain access"; allow (read,search)
 groupdn="ldap:///cn=DomainAdmins,ou=Groups,dc=subdomain1,
 dc=hostedCompany1,dc=example,dc=com";)
```

The following ACI is located on the `dc=hostedCompany2,dc=example,dc=com` node:

```
aci: (targetattr="*")
 (targetfilter=(objectClass=nsManagedDomain))
 (version 3.0; acl "Domain access"; allow (read,search)
 groupdn="ldap:///cn=DomainAdmins,ou=Groups,dc=hostedCompany2,
 dc=example,dc=com";)
```

The following ACI is located on the `dc=subdomain1,dc=hostedCompany2,dc=example,dc=com` node:

```
aci: (targetattr="*")
 (targetfilter=(objectClass=nsManagedDomain))
 (version 3.0; acl "Domain access"; allow (read,search)
 groupdn="ldap:///cn=DomainAdmins,ou=Groups, dc=subdomain1,
 dc=hostedCompany2,dc=example,dc=com";)
```

In the four ACIs shown above, the only difference is the DN specified in the `groupdn` keyword. By using a macro for the DN, it is possible to replace these ACIs by a single ACI at the root of the tree, on the `dc=example,dc=com` node. This ACI reads as follows:

```
aci: (target="ldap:///ou=Groups,($dn),dc=example,dc=com")
 (targetattr="*")(targetfilter=(objectClass=nsManagedDomain))
 (version 3.0; acl "Domain access"; allow (read,search) groupdn=
 "ldap:///cn=DomainAdmins,ou=Groups,[$dn],dc=example,dc=com";
)
```

Note that the target keyword which was not previously used needs to be introduced.

In the example above, the number of ACIs is reduced from four to one. However, the real benefit is a factor of how many repeating patterns you have down and across your directory tree.

Macro ACI Syntax

To simplify the discussion in this section, the ACI keywords used to provide bind credentials such as `userdn`, `roledn`, `groupdn`, and `userattr`, are collectively called the *subject* of the ACI. The subject determines to whom the ACI applies.

Macro ACIs include the following types of expressions to replace a DN or part of a DN:

- `($dn)` - For matching in the target and direct substitution in the subject.
- `[$dn]` - For substituting multiple RDNs that work in subtrees of the subject.
- `($attr.`*attributeName*`)` - For substituting the value of the *attributeName* attribute from the target entry into the subject.

Table 6-5 shows in what parts of the ACI you can use DN macros:

Table 6-5 Macros in ACI Keywords

Macro	ACI Keyword
`($dn)`	target, targetfilter, userdn, roledn, groupdn, userattr
`[$dn]`	targetfilter, userdn, roledn, groupdn, userattr
`($attr.`*attrName*`)`	userdn, roledn, groupdn, userattr

The following restrictions apply:

- When using the `($dn)` and `[$dn]` macros in a subject, you *must* define a target that contains the `($dn)` macro.
- You can combine the `($dn)` macro, but not `[$dn]`, with the `($attr.`*attrName*`)` macro in a subject.

Matching for ($dn) in the Target

The `($dn)` macro in the target of an ACI determines the substitution value by comparison to the entry targeted by the LDAP request. For example, you have an LDAP request targeted at the `cn=all,ou=groups,dc=subdomain1,dc=hostedCompany1,dc=example,dc=com` entry, and an ACI that defines the target as follows:

```
(target="ldap:///ou=Groups,($dn),dc=example,dc=com")
```

The `($dn)` macro matches with "`dc=subdomain1, dc=hostedCompany1`". This substring is then used for substitutions in the subject of the ACI.

Substituting ($dn) in the Subject

In the subject of the ACI, the `($dn)` macro is replaced by the entire substring that matches in the target. For example:

```
groupdn="ldap:///cn=DomainAdmins,ou=Groups,($dn),
 dc=example,dc=com"
```

becomes:

```
groupdn="ldap:///cn=DomainAdmins,ou=Groups,dc=subdomain1,
 dc=hostedCompany1,dc=example,dc=com"
```

Once the macro has been expanded, Directory Server evaluates the ACI following the normal process to determine whether access is granted or not.

NOTE Unlike a standard ACI, an ACI using macro substitution does not necessarily grant access to the children of the targeted entry. The reason for this is that when the DN of the children is the target, the substitution may not create a valid DN in the subject string.

Substituting [$dn] in the Subject

The substitution mechanism for `[$dn]` is slightly different than for `($dn)`. The DN of the targeted resource is examined several times, each time dropping the left-most RDN component, until a match is found.

For example, you have an LDAP request targeted at the `cn=all,ou=groups,dc=subdomain1,dc=hostedCompany1,dc=example,dc=com` subtree, and the following ACI:

```
aci: (targetattr="*")
 (target="ldap:///ou=Groups,($dn),dc=example,dc=com")
 (version 3.0; acl "Domain access"; allow (read,search)
 groupdn="ldap:///cn=DomainAdmins,ou=Groups,[$dn],
 dc=example,dc=com";)
```

The server proceeds as follows to expand this ACI:

1. `($dn)` in target matches `dc=subdomain1,dc=hostedCompany1`.
2. Replace `[$dn]` in the subject with `dc=subdomain1,dc=hostedCompany1`.

   The resulting subject is `groupdn="ldap:///cn=DomainAdmins,ou=Groups, dc=subdomain1,dc=hostedCompany1,dc=example,dc=com"`. If access is granted because the bind DN is a member of that group, the macro expansion stops, and the ACI is evaluated. If it is not a member, the process continues.
3. Replace `[$dn]` in the subject with `dc=hostedCompany1`.

   The resulting subject is `groupdn="ldap:///cn=DomainAdmins,ou=Groups, dc=hostedCompany1,dc=example,dc=com"`. Again, the bind DN is tested as a member of this group and if so, the ACI is evaluated fully. If it is not a member, macro expansion stops with the last RDN of the matched value and ACI evaluation is finished for this ACI.

The advantage of the `[$dn]` macro is that it provides a flexible way of granting access to domain-level administrators to *all* the subdomains in the directory tree. Therefore, it is useful for expressing a hierarchical relationship between domains.

For example, consider the following ACI:

```
aci: (target="ldap:///ou=*,($dn),dc=example,dc=com")
 (targetattr="*")(targetfilter=(objectClass=nsManagedDomain))
 (version 3.0; acl "Domain access"; allow (read,search) groupdn=
 "ldap:///cn=DomainAdmins,ou=Groups,[$dn],dc=example,dc=com";)
```

It grants access to the members of `cn=DomainAdmins,ou=Groups, dc=hostedCompany1,dc=example,dc=com` to all of the subdomains under `dc=hostedCompany1`, so an administrator belonging to that group could access, for example, the subtree `ou=people,dc=subdomain1.1,dc=subdomain1`.

However, at the same time, members of `cn=DomainAdmins,ou=Groups, dc=subdomain1.1`, would be denied access to the `ou=people,dc=subdomain1, dc=hostedCompany1` and `ou=people,dc=hostedCompany1` nodes.

Macro Matching for ($attr.*attrName*)

The `($attr.`*attrname*`)` macro is always used in the subject part of a DN. For example, you could define the following `roledn`:

```
roledn = "ldap:///cn=DomainAdmins,($attr.ou),dc=HostedCompany1,
 dc=example,dc=com"
```

Now, assume the server receives an LDAP operation targeted at the following entry:

```
dn: cn=Babs Jensen,ou=People,dc=HostedCompany1,dc=example,dc=com
cn: Babs Jensen
sn: Jensen
ou: Sales
...
```

In order to evaluate the `roledn` part of the ACI, the server reads the value of the `ou` attribute stored in the targeted entry, and substitutes this value in the subject to expand the macro. In the example, the `roledn` is expanded as follows:

```
roledn = "ldap:///cn=DomainAdmins,ou=Sales,dc=HostedCompany1,
 dc=example,dc=com"
```

Directory Server then evaluates the ACI according to the normal ACI evaluation algorithm.

When the attribute named in the macro is multi-valued, each value is used in turn to expand the macro, and the first one that provides a successful match is used.

Access Control and Replication

ACIs are stored as attributes of entries, therefore, if an entry containing ACIs is part of a replicated suffix, the ACIs are replicated like any other attribute.

ACIs are always evaluated on the directory server that services the incoming LDAP requests. This means that when a consumer server receives an update request, it will return a referral to the master server before evaluating whether the request can be serviced or not on the master.

Access Control and Chaining

If your directory tree is distributed over several servers using chaining, certain restrictions apply to the keywords you can use in access control statements. For more information, see "ACI Limitations" on page 208.

When an authenticated user accesses a chained suffix, the server sends the user's identity to the remote server. Access controls are always evaluated on the remote server. Every LDAP operation evaluated on the remote server uses the original identity of the client application passed via the proxied authorization control. Operations succeed on the remote server only if the user has the correct access controls on the subtree contained on the remote server. This means that you need to add the usual access controls to the remote server with a few restrictions. For more information, see "Access Control Through Chained Suffixes" on page 136.

Logging Access Control Information

To obtain information on access control in the error logs, you must set the appropriate log level.

To set the error log level from the console:

1. On the top-level Directory tab of Directory Server Console, right click the `cn=config` node, and choose Edit With Generic Editor from the pop-up menu.

   This displays the Generic Editor with the contents of the `cn=config` entry.

2. Scroll down the list of attribute value pairs to locate the `nsslapd-errorlog-level` attribute.

3. Add 128 to the value already displayed in the `nsslapd-errorlog-level` field.

   For example, if the value already displayed is 8192 (replication debugging), you should change the value to 8320. For complete information on error log levels, refer to the *Directory Server Administration Reference*.

4. Click OK to save your changes and dismiss the Generic Editor.

Compatibility with Earlier Releases

Some ACI keywords that were used in earlier releases of Directory Server have been deprecated from Directory Server 5.2. However, for reasons of backward compatibility, they are still supported. These keywords are:

- `userdnattr`
- `groupdnattr`

Therefore, if you have set up a replication agreement between a legacy supplier server and a consumer Directory Server 5.2, you should not encounter any problems in the replication of ACIs.

However, we recommend that you replace these keywords with the functionality of the `userattr` keyword, as described in "Defining Access Based on Value Matching" on page 228.

Chapter 7

Managing User Accounts and Passwords

When a user connects to Directory Server, the user is authenticated and the directory can grant access rights and resource limits to the user depending upon the identity established during authentication.

This chapter describes tasks for user account management, including configuring the password and account lockout policies for your directory, inactivating accounts or groups of users so they cannot access the directory, and limiting system resources available to users depending on their bind DNs.

Directory Server supports individual password policies. You may define any number of different password policies and apply any one of them to a given user or group of users. This makes it much easier to control how different types of users may access the directory.

This chapter contains the following sections:

Overview of Password Policies

A secure password policy minimizes the risks associated with easily-guessed passwords by enforcing the following:

- Users must change their passwords according to a schedule.
- Users must provide non-trivial passwords.
- Accounts may be locked after a number of binds with an incorrect password.

Directory Server supports both individual and global password policies. An individual password policy is defined by a subentry in the directory tree which is referenced by user entries having that policy. If a user entry does not reference an individual policy, the global password policy in `cn=PasswordPolicy,cn=config` applies to it.

Password policies apply only to the `userPassword` attribute when present in a user entry, and are enforced during authentication based on this attribute. They do not apply to other authentication schemes such as SASL GSSAPI or SSL-based authentication.

The following sections explain how to implement password policies and assign them to users and groups. For more information, see “Designing Password Policies” in Chapter 7 of the *Directory Server Deployment Planning Guide*.

Configuring the Global Password Policy

The global password policy applies to all users in the directory who do not have an individual policy defined. However, the global password policy does not apply to the Directory Manager.

Configuring the Password Policy Using the Console

To set up or modify the global password policy for your Directory Server:

1. On the top-level Configuration tab of Directory Server Console, select the Data node, then select the Passwords tab in the right-hand panel.
2. On the Passwords tab, set the following aspects of the policy:

- Specify that users must change their password the first time they log on by selecting the “User must change password after reset” checkbox.

  If you select this checkbox, only the Directory Manager is authorized to reset users’ passwords. A regular administrative user cannot force the user to update their password.

- To allow users to change their own passwords, select the “User may change password” checkbox.
- To limit how often users may change their own passwords, enter the number of days in the “Allow changes in X day(s)” text box. To allow users to change their passwords as often as they desire, select the No Limitation checkbox.
- To prevent users from using the same password over and over, select the “Keep password history” checkbox and specify the number of passwords you want the server to keep for each user in the “Remember X passwords” text box. Users will not be able to set a password that still exists in the list. To be effective, you should also limit how often users may change their password.
- If you do not want user passwords to expire, select the “Password never expires” radio button.
- Otherwise, select the “Password expires after X days” radio button to force users to periodically change their passwords, and then enter the number of days that a user password is valid.
- If you selected expiring passwords, you can specify how long before the password expires to send a warning to the user in the “Send warning X days before password expires” field.

  When the user receives a warning, the password will expire on the original date. Deselect the “Expire regardless of warning” checkbox to extend the expiration to allow a full warning period after the warning is sent. Only one warning and one extension will occur. There is no grace login if the user binds after the password has expired.

- If you want the server to check the syntax of a user password to make sure it meets the minimum requirements set by the password policy, select the “Check password syntax” checkbox. Then, specify the minimum acceptable password length in the “Password minimum length” text box.
- By default, the Directory Manager cannot reset a password that violates the password policy, for example reusing a password in the history. Select the “Allow Directory Manager to bypass Password Policy” checkbox to allow this.
- Specify what encryption method you want the server to use when storing passwords from the “Password encryption” pull-down menu.

3. Click on the Account Lockout tab and select the “Accounts may be locked out” checkbox to define the account lockout policy:

- Enter the number of login failures and the period in which they must occur to trigger a lockout.
- Select the Lockout forever radio button to make a lockout permanent until the Directory Manager resets the user password.
- Otherwise, select the Lockout duration radio button and enter the number of minutes the user account will be temporarily locked.

4. When you have finished making changes to the password policy, click Save. The new global password policy will be enforced immediately.

Configuring the Password Policy From the Command Line

The global password policy is defined by the attributes of the `cn=Password Policy,cn=config` entry. Use the `ldapmodify` utility to change the global policy in this entry.

The definition of all possible attributes in a password policy is given in “cn=Password Policy” in Chapter 4 of the *Directory Server Administration Reference*.

For example, password syntax and length checking are off by default and account lockout is disabled. Use the following command to turn on syntax checking, set the minimum length to 8, and enable a temporary five-minute lockout after 5 incorrect password attempts:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: cn=Password Policy,cn=config
changetype: modify
replace: passwordCheckSyntax
passwordCheckSyntax: on
-
replace: passwordMinLength
passwordMinLength: 8
-
replace: passwordLockout
passwordLockout: on
-
replace: passwordMaxFailure
passwordMaxFailure: 5
-
```

```
replace: passwordLockoutDuration
passwordLockoutDuration: 300
-
replace: passwordUnlock
passwordUnlock: on
```

Managing Individual Password Policies

An individual password policy is defined in a subentry with the `passwordPolicy` object class. The policy may be defined anywhere in your directory tree with a DN of the form `cn=`*policy name*`,`*subtree*. After defining the password policy using Directory Server Console or the command-line utilities, you assign the password policy by setting the `passwordPolicySubentry` attribute in the desired user entry.

In this section, we use the example of implementing a password policy for temporary employees at Example.com, whose subtree root is `dc=example,dc=com`.

Defining a Policy Using the Console

1. On the top-level Directory tab of Directory Server Console, display the entry where you wish to define the individual password policy subentry.
2. Right-click on the entry and select New>Password Policy. Alternatively, you may left-click the entry to select it and choose New>Password Policy from the Object menu.

   The custom editor for Password Policy entries is displayed.
3. In the General fields, enter a name and optional description for this policy. The name will become the value of the `cn` naming attribute for the subentry that defines the policy.
4. Click on the Password tab to set the following aspects of the policy:

- Specify that users must change their password the first time they log on by selecting the “User must change password after reset” checkbox. If you select this checkbox, only the Directory Manager is authorized to reset a user’s password. A regular administrative user cannot force the user to update their password.
- To allow users to change their own passwords, select the “User may change password” checkbox.

- To limit how often users may change their own password, enter the number of days in the “Allow changes in X day(s)” text box. To allow users to change their password as often as they like, select the No Limitation checkbox.
- To prevent users from using the same password over and over, select the “Keep password history” checkbox and specify the number of passwords to be stored for each user. Users will not be able to set a password that still exists in this list. To be effective, you should also limit how often users may change their password.
- If you do not want user passwords to expire, select the “Password never expires” radio button.
- Otherwise, select the “Password expires after X days” radio button to force users to periodically change their passwords, and then enter the number of days that a user password is valid.
- If you selected expiring passwords, you can specify how long before the password expires a warning should be sent to the user. In the “Send warning X days before password expires” text enter the number of days before password expiration a warning should be sent.

  When the user receives a warning, the password will expire on the original date. Deselect the “Expire regardless of warning” checkbox to extend the expiration to allow a full warning period after the warning is sent. Only one warning and one extension will occur. There is no grace login if the user binds after the password has expired.
- If you want the server to check the syntax of a user password to make sure it meets the minimum requirements set by the password policy, select the “Check password syntax” checkbox. Then, specify the minimum acceptable password length in the “Password minimum length” text box.
- By default, the Directory Manager cannot reset a password that violates the password policy, for example reusing a password in the history. Select the “Allow Directory Manager to bypass Password Policy” checkbox to allow this.
- Specify what encryption method you want the server to use when storing passwords from the “Password encryption” pull-down menu.

5. Click on the Lockout tab and select the “Accounts may be locked out” checkbox to define the account lockout policy:

- Enter the number of login failures and the period in which they must occur to trigger a lockout.
- Select the Lockout forever radio button to make a lockout permanent until the Directory Manager resets the user password.

- Otherwise, select the Lockout duration radio button and enter the number of minutes the user account will be temporarily locked.

6. Click OK in the custom editor to save your policy and create its subentry.

Defining a Policy From the Command Line

For this password policy, imagine you want passwords of temporary employees to expire after 100 days (8 640 000 seconds), with a warning about the expiration returned to the user upon binds starting 3 days (259 200 seconds) before the password expires. Turn on syntax checking to force minimal checks for password security, and enforce lock outs to prevent intruders from trying to crack the password through a dictionary attack. For other aspects of the policy, you apply the default values.

Define this password policy in the example.com subtree by adding the following subentry under `dc=example,dc=com`:

```
ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
dn: cn=TempPolicy,dc=example,dc=com
objectClass: top
objectClass: passwordPolicy
objectClass: LDAPsubentry
cn: TempPolicy
passwordStorageScheme: SSHA
passwordChange: on
passwordMustChange: on
passwordCheckSyntax: on
passwordExp: on
passwordMinLength: 6
passwordMaxAge: 8640000
passwordMinAge: 0
passwordWarning: 259200
passwordInHistory: 6
passwordLockout: on
passwordMaxFailure: 3
passwordUnlock: on
passwordLockoutDuration: 3600
passwordResetFailureCount: 600
```

The definition of all possible attributes in a password policy is given in “cn=Password Policy” in Chapter 4 of the *Directory Server Administration Reference*.

Assigning Password Policies

Assigning individual password policies consists of pointing to the appropriate policy subentry. Either you add the policy to a single entry as the value of `passwordPolicySubentry`, or you manage the policy with CoS and roles.You must also set access control to prevent users from modifying the password policy that applies to them.

Using the Console

The Directory Server console provides an interface for managing the password policy assigned to a user or group:

1. On the top-level Directory tab of Directory Server Console, display the user or group entry where you wish to assign or modify the individual password policy.
2. Right-click the entry and select Set Password Policy from the pop-up menu. Alternatively, you may left-click the entry to select it and then choose Set Password Policy from the Object menu.
3. The Password Policy dialog tells you which password policy applies to this entry:

- If the global policy applies, click Assign to select a password policy subentry anywhere in the directory tree.
- If an individual policy is already defined, you may replace it, remove it, or edit it. Clicking Edit Policy will invoke the custom editor for the named policy subentry.

  Assigning or replacing a password policy will invoke a directory browser dialog where you may find password policy subentries shown with a small key icon.

4. Click OK in the Password Policy dialog if you have changed the policy. The new policy will take effect immediately.

From the Command Line

To assign a password policy to a user or a group entry, add the DN of the password policy as the value of the `passwordPolicySubentry` attribute. For example, the following command will assign `cn=TempPolicy,dc=example,dc=com` to Barbara Jensen:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w  password
dn: uid=bjensen,ou=People,dc=example,dc=com
changetype: modify
add: passwordPolicySubentry
passwordPolicySubentry: cn=TempPolicy,dc=example,dc=com
```

Using Roles and CoS

When grouping users with roles, you can use CoS to point to the appropriate policy subentry. Refer to Chapter 5, “Managing Identity and Roles” for details on using Roles and CoS.

As an example, the following command will create a filtered role for temporary employees at Example.com and assign `cn=TempPolicy,dc=example,dc=com` to those having the role:

```
ldapmodify -a -h host -p port -D "cn=Directory Manager" -w  password
dn: cn=TempFilter,ou=people,dc=example,dc=com
objectclass: top
objectclass: LDAPsubentry
objectclass: nsRoleDefinition
objectclass: nsComplexRoleDefinition
objectclass: nsFilteredRoleDefinition
cn: TempFilter
nsRoleFilter: (&(objectclass=person)(status=contractor))
description: filtered role for temporary employees

dn: cn=PolTempl,dc=example,dc=com
objectclass: top
objectclass: nsContainer

dn: cn="cn=TempFilter,ou=people,dc=example,dc=com",
 cn=PolTempl,dc=example,dc=com
objectclass: top
objectclass: extensibleObject
objectclass: LDAPsubentry
objectclass: costemplate
cosPriority: 1
passwordPolicySubentry: cn=TempPolicy,dc=example,dc=com

dn: cn=PolCoS,dc=example,dc=com
objectclass: top
objectclass: LDAPsubentry
objectclass: cosSuperDefinition
```

```
objectclass: cosClassicDefinition
cosTemplateDN: cn=PolTempl,dc=example,dc=com
cosSpecifier: nsRole
cosAttribute: passwordPolicySubentry operational
```

The users who have the status of contractor now become subject to the password policy `cn=TempPolicy,dc=example,dc=com`.

Protecting the Individual Password Policy

To prevent users from modifying which password policy applies to them, you must also add an ACI such as the following to the root entry:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: dc=example,dc=com
changetype: modify
add: aci
aci: (targetattr != "passwordPolicySubentry")(version 3.0; acl
 "Allow self modification except for passwordPolicySubentry";
 allow (write) (userdn ="ldap:///self");)
```

Resetting User Passwords

The directory stores password values in the `userPassword` attribute of the user entry. Depending on the access control settings for the server, users may set the value of `userPassword` in accordance with the password policy you specify, using standard tools, such as `ldapmodify` for example.

In case permanent account lockout occurs (`accountUnlockTime`, an operational attribute for the user, is `0`, and `passwordUnlock` is `off` in the password policy), you can reset the password as Directory Manager to unlock the user account. For example, assume Example.com directory user Barbara Jensen gets permanently locked out after forgetting and guessing her password:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: uid=bjensen,ou=People,dc=example,dc=com
changetype: modify
replace: userPassword
userPassword: ChAnGeMe
```

If `passwordMustChange` is on in the password policy, Barbara will have to change her password after the next bind. Remember to tell her that you changed her password to `ChAnGeMe`, preferably through a secure channel.

Inactivating and Activating Users and Roles

You can temporarily inactivate a single user account or a set of accounts. Once inactivated, a user cannot bind to the directory. The authentication operation will fail.

The procedures in this section can be used for inactivating both users and roles in the same manner. However, when you inactivate a role, you are inactivating the members of the role and not the role entry itself. For more information about roles in general and how roles interact with access control in particular, refer to Chapter 5, "Managing Identity and Roles."

Setting User and Role Activation Using the Console

1. On the top-level Directory tab of Directory Server Console, browse the directory tree to display the user or role entry you wish to inactivate or reactivate.
2. Double-click the entry to display its custom editor, and click on the Account tab in the left-hand column.

   The right panel displays the activation status of the entry.
3. Click the button to inactivate or activate the user or role corresponding to this entry. A red box and bar through the user or role icon in the editor indicates that the entry will be inactivated.
4. Click OK to close the dialog box and save the new activation state of the entry.

   As a short cut to opening the custom editor, you may also select the entry and choose Inactivate or Activate from the Object menu.

You can view the activation state of any directory object by selecting Inactivation State from the Console View>Display menu. The icons of all inactive entries are then shown with a red bar through them. The correct activation state of user entries is shown regardless of whether they are inactivated directly or through role membership.

Setting User and Role Activation From the Command Line

To inactivate a user account or the members of a role, use the `directoryserver account-inactivate` command. To activate or reactivate a user or role, use the `directoryserver account-activate` command:

```
# /usr/sbin/directoryserver account-inactivate
# /usr/sbin/directoryserver account-activate
```

The following commands show how to use these commands to inactivate and reactivate Barbara Jensen's user account:

```
/usr/sbin/directoryserver account-inactivate -h host -p port -D "cn=Directory\
        Manager" -w password -I "uid=bjensen,ou=People,dc=example,dc=com"
```

```
/usr/sbin/directoryserver account-activate -h host -p port -D "cn=Directory\
        Manager" -w password -I "uid=bjensen,ou=People,dc=example,dc=com"
```

In both of these commands, the `-I` option specifies the DN of the user or role for which you wish to set the activation state.

For more information, see "`account-activate`" and "`account-inactivate`" in Chapter 1 of the *Directory Server Administration Reference*.

Setting Individual Resource Limits

You can control server limits for search operations using special operational attribute values on the client application binding to the directory. You can set the following search operation limits:

- The look-through limit specifies the maximum number of entries that will be examined for a search operation.
- The size limit specifies the maximum number of entries the server returns to the client application in response to a search operation.
- The time limit specifies the maximum time the server spends processing a search operation.
- The idle timeout specifies the time a client connection to the server can be idle before the server drops the connection.

NOTE The Directory Manager may use unlimited resources by default.

The resource limits you set for a specific user take precedence over the default resource limits you set in the global server configuration. You should verify that attributes which store the individual resource limits are protected from self modification by the following ACI on the suffix containing user entries:

```
(targetattr != "nsroledn || aci || nsLookThroughLimit || nsSizeLimit ||
nsTimeLimit || nsIdleTimeout || passwordPolicySubentry ||
passwordExpirationTime || passwordExpWarned || passwordRetryCount ||
retryCountResetTime || accountUnlockTime || passwordHistory ||
passwordAllowChangeTime")(version 3.0; acl "Allow self entry
modification except for nsroledn, aci, resource limit attributes,
passwordPolicySubentry and password policy state attributes"; allow
(write)userdn ="ldap:///self";)
```

Setting Resource Limits Using the Console

1. On the top-level Directory tab of Directory Server Console, browse the directory tree to display the user for which you wish to set resource limits.
2. Double-click the entry to display the custom editor, and click on the Account tab in the left-hand column. The right panel displays the current limits set on the entry.
3. Enter values in the four text fields for the resource limits described above. Entering a value of -1 indicates no limit for that resource.
4. Click OK when you are finished to save the new limits.

Setting Resource Limits From the Command Line

The following attributes can be set with the `ldapmodify` command on a user entry to limit that user's resource usage:

Attribute	Description
`nsLookThroughLimit`	Specifies how many entries examined for a search operation. Specified as a number of entries. Giving this attribute a value of -1 indicates that there is no limit.
`nsSizeLimit`	Specifies the maximum number of entries the server returns to a client application in response to a search operation. Giving this attribute a value of -1 indicates that there is no limit.
`nsTimeLimit`	Specifies the maximum time the server spends processing a search operation. Giving this attribute a value of `-1` indicates that there is no time limit.
`nsIdleTimeout`	Specifies the time a connection to the server can be idle, before the connection is dropped. The value is given in seconds. Giving this attribute a value of -1 indicate that there is no limit.

For example, you might set the size limit for an entry by performing an `ldapmodify` as follows:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: uid=bjensen,ou=People,dc=example,dc=com
changetype: modify
add: nsSizeLimit
nsSizeLimit: 500
```

The `ldapmodify` statement adds the `nsSizeLimit` attribute to Barbara Jensen's entry and gives it a search return size limit of 500 entries.

Chapter 8

Managing Replication

Replication is the mechanism by which directory contents are automatically copied from a Directory Server to one or more others. Write operations of any kind—entry additions, modifications, or even deletions—are automatically mirrored to other Directory Servers. For a complete description of replication concepts, replication scenarios, and how to plan for replication in your directory deployment, see Chapter 6, “Understanding Replication,” in the *Directory Server Deployment Planning Guide*.

Directory Server 5.2 includes the following new replication features:

- Multi-master replication (MMR) over wide area networks (WANs) enables you to create replication agreements between geographically distant masters to distribute your data more effectively.
- MMR now supports four simultaneous, fully connected masters which provides additional failover protection.
- Binary copy can make the initialization of large replicas much faster.
- Fractional replication allows you to specify the set of attributes that will be replicated to distribute your data more efficiently.
- New command-line tools help you monitor replication activity.

This chapter describes the tasks to be performed to set up the various replication scenarios, and includes the following topics:

Introduction

Configuring replication is a complex task. Before you begin, you should have a clear understanding of the way that replication will be deployed in your organization, for example, whether to use single-master, multi-master or cascading replication with hubs. The unit of replication is a suffix or a subsuffix: all the entries of that suffix are replicated together. In your intended deployment, you must identify each suffix as either a master, a hub, or a dedicated consumer for the data it contains.

A replicated suffix on a server is called a *replica*. A master is the replica that accepts both read and write operations from clients. Hubs and dedicated consumers are read-only replicas which receive updates only through the replication mechanism. A hub receives updates either from a master or another hub and forwards them to another hub or a dedicated consumer. A dedicated consumer only receives updates from either a master or a hub.

The following three diagrams show the relationship between replicas in common replication scenarios.

Figure 8-1 Single Master Replication

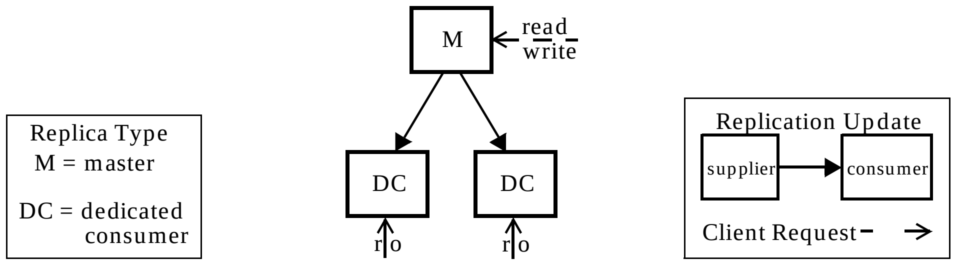


Figure 8-2 Cascading Replication With Hubs

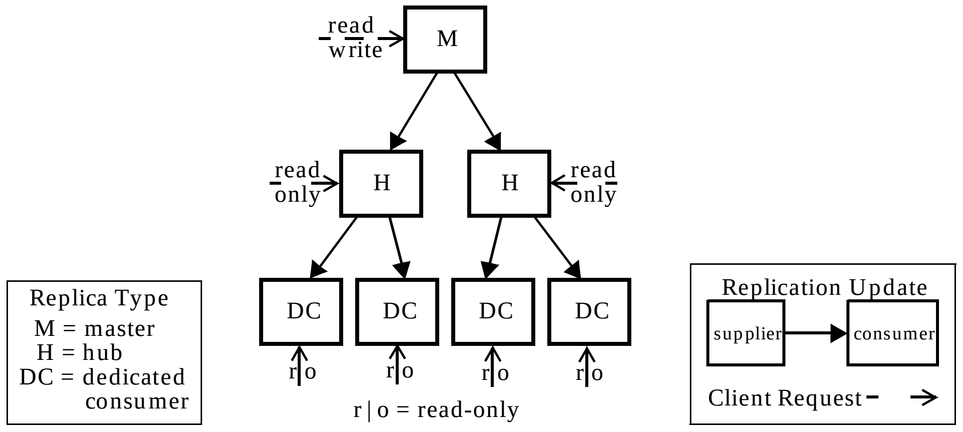
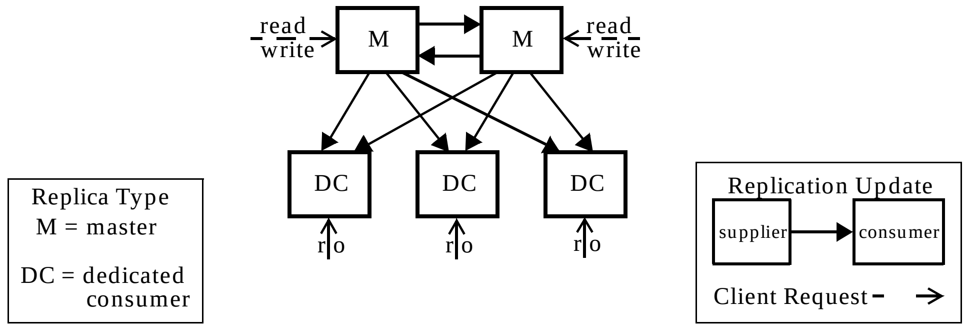


Figure 8-3 Multi-Master Replication



This document also uses the terms *supplier* and *consumer* to refer to the roles of two servers participating in a replication agreement. The supplier is the server that sends replication updates, and the consumer is the server that receives them. The diagram above demonstrates the following relationships:

- A single master is a supplier, not a consumer.
- A master in multi-master replication is both a supplier *and* a consumer of other masters.
- A hub is always a supplier and a consumer.
- A dedicated consumer is only a consumer.

Many replication settings apply to the replica in the supplier or consumer role of an agreement, regardless of its type.

Summary of Steps for Configuring Replication

The following steps assume you are replicating a single suffix. If you are replicating more than one suffix, you may configure them in parallel on each server. In other words, you may repeat each step to configure replication on multiple suffixes.

To configure any replication topology, proceed in the following order:

1. Define a replication manager entry on all servers except single masters (or use the default replication manager on all servers.)
2. On all servers containing a dedicated consumer replica:
   a. Create an empty suffix for the consumer replica.
   b. Enable the consumer replica on the suffix through the replication wizard.
   c. Optionally, configure the advanced replica settings.
3. On all servers containing a hub replica, if applicable:
   a. Create an empty suffix for the hub replica.
   b. Enable the hub replica on the suffix through the replication wizard.
   c. Optionally, configure the advanced replica settings.
4. On all servers containing a master replica:
   a. Choose or create a suffix on one of the masters that will be the master replica.

   b. Enable the master replica on the suffix through the replication wizard.
   c. Optionally, configure the advanced replica settings.
5. Configure the replication agreements on all supplier replicas, in the following order:
   a. Between masters in a multi-master set.
   b. Between masters and their dedicated consumers.
   c. Between masters and hub replicas.

   Optionally, you can configure fractional replication at this stage.
6. Configure replication agreements between the hub replicas and their consumers.
7. For multi-master replication, initialize all masters from the same master replica containing the original copy of the data. Initialize the hub and consumer replicas.

NOTE It is important to enable all replicas before you attempt to create a replication agreement. This allows you to initialize consumer replicas immediately after you create the replication agreement. Consumer initialization is always the last stage in setting up replication.

Choosing Replication Managers

A critical part of setting up replication is to choose the entry, referred to as the *replication manager*, that the suppliers will use to bind to a consumer server when sending replication updates. All servers that contain suffixes receiving updates must have at least one replication manager entry.

Directory Server has a default replication manager entry that you can use on every server. Its DN is `cn=Replication Manager,cn=replication,cn=config`.

It is recommended that you use the default replication manager for simple replication scenarios. The replication wizard automatically configures consumer replicas with this entry, thereby simplifying the deployment of replicas.

The replication wizard prompts you to set the password for the default replication manager if none is defined. To change the password at a later time:

1. On the top-level Configuration tab of Directory Server Console, select the Data node, and then select the Replication tab in the right-hand panel.
2. Type the new password in both text fields under the Replication Manager heading.
3. Click Save once the password is confirmed. The Save button will not be active if the password does not match its confirmation.

If you do not use the default replication manager, you can create any new entry to act as a replication manager. For example, you may want several replication manager entries to have a different password for every replicated suffix. Another reason to create your own replication manager is to support a different authentication model for replication, for example using certificates over SSL.

The replication manager entry must contain the attributes required by the authentication method you choose when defining the replication agreement. For example, the default replication manager is a `person` object class that allows a `userPassword` attribute for simple authentication. See "Replication Over SSL" on page 327 for details on using certificates to bind the replication manager.

The replication manager entry should not be located in a replicated suffix of the consumer server. A suitable location for defining replication managers is in `cn=replication,cn=config`.

If you create a new replication manager manually from the command line, you must specify the bind DN on the consumer by modifying the `nsDS5ReplicaBindDN` attribute of the replica configuration entry.

If you are using legacy replication, there are additional constraints on the replication manager entry. See "Configuring Directory Server 5.2 as a Consumer of Directory Server 4.x" on page 341 for more information.

CAUTION You must never bind or perform operations on the server using the DN and password of the replication manager entry. The replication manager is for use only by the replication mechanism and any other use may require reinitializing the replicas.

You must never use the Directory Manager as the replication manager.

Once you have chosen the replication manager for each consumer:

1. Write down or remember the replication manager DN that you chose or created. You will need this DN and its password later when creating the replication agreement with this consumer on its supplier.
2. If you define a password expiration policy, you must remember to exclude the replication manager, otherwise replication will fail when the password expires. To disable password expiration on the replication manager entry, create a password policy in which passwords do not expire and assign it to the replication manager entry. For more information, see "Managing Individual Password Policies" on page 285.

Configuring a Dedicated Consumer

A dedicated consumer is a read-only copy of a replicated suffix. It receives updates from servers that bind as the Replication Manager to make changes. Configuring the consumer server consists of preparing an empty suffix to hold the replica and enabling replication on that suffix using the replication wizard. Optional advanced configuration includes choosing a different replication manager, setting referrals, or setting the purge delay.

The following sections give the steps for configuring one dedicated consumer replica on its server. Repeat all procedures on each server that will contain a dedicated consumer replica of a given suffix.

Creating the Suffix for the Consumer Replica

If it does not already exist, create an empty suffix on the consumer with the same DN as the intended master replica. For instructions, refer to "Creating Suffixes" on page 111.

If the suffix exists and is not empty, its contents will be lost when the replica is initialized from the master.

Enabling a Consumer Replica

The replication wizard simplifies the task of enabling a dedicated consumer replica:

1. On the top-level Configuration tab of Directory Server Console, expand both the Data node and the node for the suffix you wish to be a consumer replica, then select the Replication node below the suffix.

   The replica status information is displayed in the right-hand panel.

2. Click the Enable replication button to begin the replication wizard.
3. The Consumer Replica radio button is selected by default. Click Next to continue.
4. If you have not already done so, you are prompted to enter and confirm a password for the default replication manager. Type the same password in each field and click Next to continue.

   If the default replication manager already had a password defined, the wizard skips this step.

5. The replication wizard displays a status message while updating the replication configuration. Click Close when it has completed.

The replication status now shows that the replica is ready to receive updates, and the icon in the left-hand pane changes to reflect this.

Advanced Consumer Configuration

By default, the wizard configures the replica to use the default replication manager. If you want to use a different replication manager entry, you must set the advanced configuration. You can also use this dialog to set referrals for modifications and the purge delay.

1. On the top-level Configuration tab of Directory Server Console, expand both the Data node and the node for the suffix you want to configure, and then select the Replication node below the suffix.
2. In the right-hand panel, click the Advanced button to display the Advanced Replica Settings dialog.

3. On the Bind DN tab, use the Add and Delete buttons to create a list of DNs that are valid replication managers. A supplier can then use any one of these DNs in its agreement with this replica. You can add a new DN by typing its name or browsing the directory.

   To configure replication using certificates over SSL, enter the DN of the certificate entry as one of the replication managers.

4. Click OK when you are done or select the Optional tab for more advanced configuration.

5. On the Optional tab of the Advanced Replica Settings dialog, the list of LDAP URLs specifies additional referrals for modification requests sent to this consumer. Use the Add or Delete buttons to create a list of LDAP URLs.

   The replication mechanism automatically configures consumers to return referrals for all known masters in the replication topology. These default referrals assume that clients will use simple authentication over a regular connection. If you want to give clients the option of binding to masters using SSL for a secure connection, add referrals of the form `ldaps://`*servername*`:`*port* that use a secure *port* number. (If the masters are configured for secure connections only, the URLs will point to the secure ports by default.)

   If you have added one or more LDAP URLs as referrals, selecting the checkbox below the list will force the consumer to send referrals exclusively for these LDAP URLs and not for the master replicas. For example, if you want clients to always be referred to the secure port on the master servers and not to the default port, create a list of LDAP URLs for these secure ports and select this checkbox. You may also use an exclusive referral if you want to designate a specific master or a Directory Server Proxy that should handle all updates.

6. Also on the Optional tab, you can change the purge delay.

   The consumer server stores internal information about updates to the replica contents, and the purge delay parameter specifies how long it must keep this information. It is related to the `MaxAge` parameter of the change log on its supplier server. The shorter of these two parameters determines the longest time that replication between the two servers may be disabled or down and still recover normally. The default value of 7 days is sufficient in most cases.

7. Click OK to save the advanced replication configuration for this replica.

Configuring a Hub

Hub replicas act as both consumers and masters to further distribute replicated data to a larger number of consumers. Hub replicas receive replication updates from their suppliers and send replication updates to their consumers. They do not accept modifications, but instead return referrals to the masters.

Configuring a hub server consists of preparing an empty suffix to hold the replica and enabling replication on that suffix using the replication wizard. Optional advanced configuration includes choosing a different replication manager, setting referrals, setting the purge delay, and setting the change log parameters.

The following sections give the steps for configuring one hub server. Repeat all procedures on each server that will contain a hub replica of a given suffix.

Creating the Suffix for the Hub Replica

If it does not already exist, create an empty suffix on the hub server with the same DN as the intended master replica. For instructions, refer to "Creating Suffixes" on page 111.

If the suffix exists and is not empty, its contents will be lost when the replica is initialized from the master.

Enabling a Hub Replica

The replication wizard simplifies the task of enabling a hub replica:

1. On the top-level Configuration tab of Directory Server Console, expand both the Data node and the node for the suffix you wish to be a hub replica, and then select the Replication node below the suffix.

   The replica status information is displayed in the right-hand panel.

2. Click the Enable replication button to begin the replication wizard.
3. Select the Hub Replica radio button and click Next to continue.
4. If you have not already done so, you will be prompted to select the change log file. The default change log file is shown in the text field. If you do not wish to use the default, type in a filename for the change log or click Browse to display a file selector.

   If the change log has already been enabled, the wizard will skip this step.

5. Click Next. If you have not already done so, you will be prompted to enter and confirm a password for the default replication manager. Type the same password in each field and then click Next to continue.

   If the default replication manager already had a password defined, the wizard will skip this step.

6. The replication wizard will display a status message while updating the replication configuration. Click Close when it has completed.

The replication status now shows that the replica is ready to receive updates, and the icon in the left-hand pane changes to reflect this.

Advanced Hub Configuration

As a supplier, a hub server requires a change log, and the wizard configures the hub replica to use the default change log settings. To modify these settings:

1. On the top-level Configuration tab of Directory Server Console, select the Data node and then the Replication tab in the right-hand panel.

2. You might need to refresh the contents of this tab by checking the Enable Changelog checkbox and clicking the Reset button. You should then see the change log file that you chose in the replication wizard.

3. You can change the name of the change log file and update the change log parameters:

   a. Max changelog records - Determines the total number of modifications to store for sending updates to consumers. By default it is unlimited. You may wish to limit the number of records to save disk space if your replica receives many large modifications.

   b. Max changelog age - Determines the time for which the hub will store updates it must send to consumers. By default it is unlimited. The max age parameter is the recommended way to limit the size of the change log.

The replication wizard also uses the default replication manager. If you have created a different replication manager entry that you wish to use, you need to set the advanced configuration. You may also use this dialog to set referrals for modifications and the purge delay.

1. On the top-level Configuration tab of Directory Server Console, expand both the Data node and the node for the suffix you wish to configure, and then select the Replication node below the suffix.

2. In the right-hand panel, click the Advanced button to display the Advanced Replica Settings dialog.
3. On the Bind DN tab, use the Add and Delete buttons to create a list of DNs that are valid replication managers. A supplier can then use any one of these DNs in its agreement with this replica. You can add a new DN by typing its name or browsing the directory.

   To configure replication using certificates over SSL, enter the DN of the certificate entry as one of the replication managers.
4. Click OK when you are done or select the Optional tab for more advanced configuration.
5. On the Optional tab of the Advanced Replica Settings dialog, the list of LDAP URLs specifies additional referrals for modification requests sent to this hub. Use the Add or Delete buttons to create a list of LDAP URLs.

   The replication mechanism automatically configures hubs to return referrals for all known masters in the replication topology. These default referrals assume that clients will use simple authentication over a regular connection. If you want to give clients the option of binding to masters using SSL for a secure connection, add referrals of the form `ldaps://`*servername*`:`*port* that use a secure *port* number.

   If you have added one or more LDAP URLs as referrals, selecting the checkbox below the list will force the server to send referrals exclusively for these LDAP URLs and not for the master replicas. For example, if you want clients to always be referred to the secure port on the master servers and not to the default port, create a list of LDAP URLs for these secure ports and select this checkbox. You may also use an exclusive referral if you want to designate a specific master or a Directory Server Proxy that should handle all updates.
6. Also on the Optional tab, you can change the purge delay.

   The hub server stores internal information about updates to the replica contents, and the purge delay parameter specifies how long it must keep this information. It is related to the MaxAge parameter of the change log on the server that supplies updates (*not* of its own change log). The shorter of these two parameters determines the longest time that replication between the two servers may be disabled or down and still recover normally. The default value of 7 days is sufficient in most cases.
7. Click OK to save the advanced replication configuration for this replica.

Configuring a Master Replica

Master replicas contain the master copy of the data and centralize all modifications before propagating updates to all other replicas. A master records all changes, checks the status of its consumers, and sends updates to them when necessary. In multi-master replication, master replicas also receive updates from other masters.

Configuring a master server consists of defining the suffix containing the master replica, enabling the master replica using the replication wizard, and configuring it for advanced replication if necessary.

The following sections give the steps for configuring one master server. Repeat all procedures on each server that will contain a master replica of a given suffix.

Defining the Suffix for the Master Replica

Choose or create a suffix on the master server that will contain the entries you wish to replicate. For instructions, refer to "Creating Suffixes" on page 111.

The suffix should contain all the initial data before you create replication agreements. This will allow you to initialize consumer replicas immediately from this data. To ensure correct multi-master configuration and initialization, only one of the masters should contain all of the initial data, and the suffix on the other masters should be empty.

Enabling a Master Replica

The replication wizard simplifies the task of enabling a master replica:

1. On the top-level Configuration tab of Directory Server Console, expand both the Data node and the node for the suffix you wish to be a master replica, and then select the Replication node below the suffix.

   The replica status information is displayed in the right-hand panel.

2. Click the Enable replication button to begin the replication wizard.
3. Select the Master Replica radio button and click Next to continue.
4. Enter a Replica ID: choose a unique integer between 1 and 65534, inclusive.

   The replica ID must be unique among all master replicas for a given suffix. Master replicas of different suffixes on the same server may use the same replica ID, as long as it is unique among each replica's other masters.

5. Click Next. If you have not already done so, you will be prompted to select the change log file. The default change log file is shown in the text field. If you do not wish to use the default, type in a filename for the change log or click Browse to display a file selector.

   If the change log has already been enabled, the wizard will skip this step.

6. Click Next. If you have not already done so, you will be prompted to enter and confirm a password for the default replication manager. The replication manager is not used in the case of single-master replication, but you must still enter a password to proceed. Type the same password in each field and then click Next to continue.

   If the default replication manager already had a password defined, the wizard will skip this step.

7. The replication wizard will display a status message while updating the replication configuration. Click Close when it has completed.

The replication status now shows the replica ID of this master, and the icon in the left-hand pane changes to show that replication is active for this suffix.

Advanced Multi-Master Configuration

By default, the wizard configures the master replica to use the default change log settings. To modify the change log settings:

1. On the top-level Configuration tab of Directory Server Console, select the Data node and then the Replication tab in the right-hand panel.

2. You might need to refresh the contents of this tab by checking the Enable Changelog checkbox and clicking the Reset button. You should then see the change log file that you chose in the replication wizard.

3. You may change the name of the change log file and update the change log parameters:

   a. Max changelog records - Determines the total number of modifications to store for sending updates to consumers. By default it is unlimited. You may wish to limit the number of records to save disk space if your replica receives many large modifications.

   b. Max changelog age - Determines the time for which the master will store updates it must send to consumers. By default it is unlimited. The max age parameter is the recommended way to limit the size of the change log.

The replication wizard also uses the default replication manager. If you have created a different replication manager entry that you wish to use, you need to set the advanced configuration. You may also use this dialog to set referrals for modifications and the purge delay. If you are configuring a single master, you may skip this procedure.

1. On the top-level Configuration tab of Directory Server Console, expand both the Data node and the node for the suffix you wish to configure, and then select the Replication node below the suffix.

2. In the right-hand panel, click the Advanced button to display the Advanced Replica Settings dialog.

3. On the Bind DN tab, use the Add and Delete buttons to create a list of DNs that are valid replication managers. A supplier can then use any one of these DNs in its agreement with this replica. You can add a new DN by typing its name or browsing the directory.

   To configure replication using certificates over SSL, enter the DN of the certificate entry as one of the replication managers.

4. Click OK when you are done or select the Optional tab for more advanced configuration.

5. On the Optional tab of the Advanced Replica Settings dialog, the list of LDAP URLs specifies additional referrals for modification requests sent to this master. A master will automatically return referrals immediately after being initialized, as described in "Convergence After Multi-Master Initialization" on page 317. Use the Add or Delete buttons to create a list LDAP URLs.

   The replication mechanism automatically configures hubs to return referrals for all known masters in the replication topology. These default referrals assume that clients will use simple authentication over a regular connection. If you want to give clients the option of binding to masters using SSL for a secure connection, add referrals of the form `ldaps://`*servername*`:`*port* that use a secure *port* number.

   If you have added one or more LDAP URLs as referrals, selecting the checkbox below the list will force the server to send referrals exclusively for these LDAP URLs and not for the master replicas. For example, if you want clients to always be referred to the secure port on the master servers and not to the default port, create a list of LDAP URLs for these secure ports and select this checkbox.

6. Also on the Optional tab, you may change the purge delay.

   The master server must store internal information about updates to the replica contents, and the purge delay parameter specifies how long it must keep this information. It is related to the MaxAge parameter of the change log on a master server that supplies updates (*not* of its own change log). The shorter of these two parameters determines the longest time that replication between the two servers may be disabled or down and still recover normally. The default value of 7 days is sufficient in most cases.

7. Click OK to save the advanced replication configuration for this replica.

Creating Replication Agreements

A replication agreement is a set of parameters on a supplier that configures and controls how updates are sent to a given consumer. The replication agreement must be created on the supplier replica that is sending updates to its consumer. You must create a replication agreement for every consumer that you wish to be updated.

Create replication agreements in the following order:

1. Between masters in a multi-master set, starting with the master containing the original copy of the suffix to replicate.
2. Between masters and dedicated consumers not replicated through hubs.
3. Between masters and hub replicas.
4. Between hub replicas and their consumers.

For example, in the multi-master replication topology with 2 masters and 3 dedicated consumers shown in Figure 8-3 on page 297, you would create eight replication agreements in the following order:

- Between one master and the other.
- Between the other master and the first one.
- Between one master and each of the 3 dedicated consumers.
- Between the other master and each of the three dedicated consumers.

To create a replication agreement:

1. On the top-level Configuration tab of Directory Server Console, expand both the Data node and the node for the supplier suffix, and then select the Replication node below the suffix.

   The replica status information is displayed in the right-hand panel.

2. Click the New button beside the list of defined replication agreements.

3. In the Replication Agreement dialog, select from the menu an existing server containing the consumer replica, or click the Other button to define one.

   When you click the Other button, enter the fully qualified name of a consumer server as well as its LDAP port number. Check the box for a secure port if using SSL on this port to enable secure connections for replication updates.

4. Enter the DN and password of the replication manager entry on the consumer server. By default, the DN is that of the default replication manager.

   If you chose a consumer with a secure port, you can click the Options button to determine the meaning of the DN field. If you connect using a password, the supplier will use simple authentication and communication over an encrypted SSL connection. If you connect using a certificate, the DN field is the DN of the entry containing the certificate and no password is required.

5. Optionally, type a description string for this agreement. The consumer server name and port number and the description string will appear in the list of replication agreements for this master replica.

6. Click OK when done. A confirmation dialog is displayed asking if you wish to test the connection parameters you have just entered.

7. Click Yes if you wish to test the connection to the given server and port number using the given replication manager and password. If the connection fails you will still have the choice of using this agreement, for example if the parameters are correct but the server is offline.

   When you have finished, the agreement appears in the list of replication agreements for this master replica.

You can edit the replication agreement later to change the DN and password of the replication manager on the consumer server:

1. Select the replication agreement from the list and click the Edit button.

2. In the Replication Agreement dialog, select the Connection tab.

3. Edit the replication manager DN or password for the consumer server.

4. Optionally, edit the description string for the agreement.

5. Click OK to save the new settings and begin using them immediately when sending updates to this consumer.

   The configuration parameters in the other tabs are described in "Enabling Fractional Replication" on page 315 and "Replication Over a WAN" on page 328.

6. After creating each replication agreement, you may optionally configure fractional replication for this suffix and then immediately initialize the replica, as described in "Initializing Replicas" on page 315.

Configuring Fractional Replication

By default, replication copies entire entries in the replicated suffix to consumer replicas. With the fractional replication feature, you can specify the subset of attributes that is replicated or excluded during replication. Fractional replication is configured in the replication agreement, allowing you to define the attribute set for each consumer replica of a master. This allows you to control which data is distributed and use replication bandwidth and consumer resources more efficiently.

For example, if you wish to reduce replication bandwidth you may choose not to replicate attributes with typically large values such as `photo`, `jpegPhoto`, and `audio`. As a result, these attributes will not be available on consumers. As another example, you may choose to replicate only the `uid` and `userpassword` attributes to a consumer server that is dedicated to performing authentication.

Considerations for Fractional Replication

Enabling or modifying the fractional set of attributes requires you to reinitialize the consumer replica. Therefore, you should determine your fractional replication needs before deployment and define your attribute set before you initialize your replicas for the first time.

You should proceed with caution when replicating a small set of attributes, given the dependency of complex features such as ACIs, roles, and CoS on certain attributes. In addition, not replicating other attributes that are mentioned in specifiers or filters of the ACI, roles, or CoS mechanisms may compromise the security of the data or result in different sets of attributes being returned in searches. Managing a list of attributes to exclude is safer, and less prone to human error, than managing a list of attributes to include.

You should turn off schema checking in the consumer server if the attribute set that you replicate does not allow all replicated entries to follow the schema. Replication of non-conforming entries will not cause errors because the replication mechanism bypasses schema checking on the consumer. However, the consumer will contain non-conforming entries and should have schema checking turned off to expose a coherent state to its clients.

Fractional replication is configured in the replication agreement of master replicas with hubs and dedicated consumers. Configuration of fractional replication between two master replicas in a multi-master replication environment is not supported. Also, if several masters have replication agreements with the same replica, all these agreements must replicate the same set of attributes.

The fractional replication functionality provided in Directory Server 5.2 is *not* backward compatible with previous versions of Directory Server. When configuring a fractional replication agreement, both the master and consumer replicas must be on Directory Server instances version 5.2.

Defining the Attribute Set

An attribute set is a list of attributes that will be replicated, exclusive of all others, when fractional replication is enabled on a replica. You may define any number of attribute sets on the master server and then associate one of them with a replication agreement.

1. On the top-level Configuration tab of Directory Server Console, select the Data node and then the Replication tab in the right-hand panel.
2. Click the Manage Replicated Attribute Sets button at the bottom of the Replication tab. You may have to scroll down to see this button.

3. Click Add to define a new attribute set or select an existing one from the list and click Edit to modify it. In the Attribute Set dialog box that is displayed, select or deselect the checkbox in the Replicate column to include or exclude the corresponding attribute from the set. A checked box next to an attribute name indicates that it will be replicated.

   By default, all attributes are selected, and it is recommended that you deselect only those attributes you specifically do not wish to replicate. If you wish to start over with your selection, the Check All button will select all attributes again. When you deselect a number of attributes, the directory server will replicate *all attributes except* the ones which are deselected. If new attributes are later defined in the schema and used in replicated entries, those new attributes will be replicated unless you edit the attribute set to deselect them.

   Clicking the Check None button will deselect all attributes and you may then select the attributes to include in your set. When you define your exact set of attributes after clicking on Check None, *only the selected attributes* will be replicated. If new attributes are later defined in the schema and used in replicated entries, those new attributes will not be replicated unless you edit the attribute set to select them.

NOTE The attributes `objectClass`, `nsUniqueId` and `nsDS50ruv`, and the RDN naming attribute are *always* replicated, regardless of whether you exclude them in the attribute set. This is because `objectClass` and the naming attribute are required for LDAP modifications and the `nsUniqueId` and `nsDS50ruv` attributes are required for replication to work correctly.

Excluding ACI attributes will have an effect on the access control in the consumer replica. Excluding the `userPassword` attribute will result in no users being able to authenticate to the consumer replica.

4. Optionally, enter or modify the description string for this attribute set. This is the text that will appear in the list of defined sets and when editing the replication agreement that will use this set. If no description is provided, the server will generate a description based on the attributes that are excluded or included.

5. Click Save when you are finished.

Enabling Fractional Replication

Fractional replication can be enabled only on existing replication agreements:

1. Create the replication agreement as described in "Creating Replication Agreements" on page 310 or select a previously defined agreement to modify.
2. Disable the replication agreement as described in "Disabling a Replication Agreement" on page 334. An agreement *must* be disabled to modify the fractional replication configuration.
3. Select the disabled agreement and click Edit. Select the Replicated Attributes tab in the Replication Agreement dialog that appears.
4. Select the "Replicate only a set of attributes" checkbox.
5. Select an existing attribute set from the drop-down list or click New to define a new attribute set as described in "Defining the Attribute Set" on page 313. You may also click Manage Replicated Attribute Sets to view and modify existing set definitions.

   Fractional replication allows only one attribute set to be associated with a replication agreement. That set should contain the exact list of attributes you wish to replicate.
6. Click OK when you have chosen an attribute set. An informational message warns you that you have configured fractional replication and that you need to reinitialize the consumer replica. Click OK to dismiss the message.
7. Click Enable to reactivate the replication agreement.
8. Depending on the attributes that are replicated, you should consider disabling schema checking on the consumer server.
9. If other masters also have replication agreements with this replica, you must repeat this procedure to enable fractional replication with the same attribute set on all of them.
10. You must now initialize the consumer replica, or reinitialize it if it was already replicated. See "Initializing Replicas"" below.

Initializing Replicas

Once you have created a replication agreement, you must initialize the consumer replica before replication will actually begin. During initialization, you physically copy data from the supplier replica to the consumer replica.

Certain error conditions or configuration changes require you to reinitialize replicas. When reinitializing, the contents of the replicated suffix are deleted on the consumer and replaced with the contents of the suffix on the master. This ensures that the replicas are in sync and replication updates may resume. Also, all of the initialization methods described here automatically rebuild the indexes of the consumer replica, so that the consumer is ready to respond optimally to client read requests.

When to Initialize

Replica initialization must be done after both replicas have been configured, and before any replication can occur. Once the data in the suffix has been entirely copied to the consumer, the supplier can begin replaying update operations to the consumer.

Under normal operations, the consumer should never have to be initialized again. However, if the data in a single master replica is restored from a backup for any reason, then you should reinitialize all of the replicas that it updates. With multi-master replication, consumers may not need to be reinitialized if they have been updated by the other masters.

You may either initialize the replica online using the console or manually using the command line. Online initialization using the console is convenient for initializing a small number of consumers. You may initialize a replica online directly from its replication agreement. However, since each replica is initialized in sequence, this method is not suited to initializing a large number of replicas. Manual initialization using the command line is a more effective method of initializing a large number of consumers simultaneously from a single LDIF file.

Finally, the binary copy feature can be used by experienced administrators to clone either master or consumer replicas. Certain restrictions on this feature make it practical and time efficient only for replicas with very large database files, for example replicas containing millions of entries.

Initializing Replicas in Multi-Master Replication

In the case of multi-master replication, you should initialize replicas in the following order:

1. Ensure that one master has the complete set of data to replicate. Use this master to initialize the replica on each of the other masters.

2. Initialize the consumer replicas from their masters (refer to "Performing Online Replica Initialization" on page 321) or from the LDIF file of any one of the masters (refer to "Exporting a Replica to LDIF" on page 322.)

Initializing Replicas in Cascading Replication

In the case of cascading replication, remember that you should always initialize replicas in the following order:

1. If you also have multi-master replication, ensure that one master has the complete set of data to replicate. Use this master to initialize the replica on each of the other masters.
2. Initialize the replicas on the first-level hub replicas from their master replicas.
3. If you have several levels of hubs, initialize each level from the previously initialized level of hubs.
4. From the last level of hub replicas, initialize the replicas on the dedicated consumers.

Convergence After Multi-Master Initialization

In the case of multi-master replication, other masters may process change operations while a given master is being initialized. Therefore, when initialization is complete, the new master must also receive new updates that were not included in the initialization data. Since initialization may take a significant amount of time, the number of pending updates may also be significant.

To allow convergence of these pending updates, newly-initialized masters are automatically set to read-only mode for client operations after initialization. (This is true only when initializing through an LDIF file from the command line or using a backup to perform a binary copy.) This behavior is new in Directory Server 5.2.

Therefore, after initialization, a master in a multi-master configuration will process replication updates and allow read operations, but it will return referrals for all write operations from clients. You may define the referrals as described in "Advanced Multi-Master Configuration" on page 308. A master will revert to read-write mode under the following conditions:

- Set the `ds5BeginReplicaAcceptUpdates` configuration attribute to `start` to explicitly allow update operations. You should verify that the new master replica has converged with the other masters before enabling updates. This may be done using either the replication configuration panel on the Directory Server console or through the command line (see the procedures below).

Manual intervention is the recommended method for enabling updates on an initialized master because it allows you to verify that the new master is fully synchronized with the other masters before allowing updates.

- If you have previously set the `ds5referralDelayAfterInit` attribute, the master replica will automatically switch to the normal read-write mode after the given delay. This attribute may be set independently for each master replica on a server.

  If you choose to set this attribute, you should determine a delay that is always sufficient to allow the master replica to converge with the other masters after initialization. This delay will depend on the size and length of expected initializations and the rate of changes occurring simultaneously on the other masters. A master that accepts update operations while still replicating changes after initialization may be the source of unexplained errors. See Chapter 8, "Error Log Message Reference," in the *Directory Server Administration Reference* if you encounter replication errors.

NOTE With master replicas sending referrals because of this new behavior, clients wanting to perform write operations may reach their configured hop limit. You may need to increase the hop limit configuration for clients so they may reach an available master. If all master replicas are initialized or reinitialized, all write operations will fail because no replica will be accepting client updates.

In any case, you should monitor initialized masters closely and set the referral attributes appropriately to maximize server response.

To Begin Accepting Updates Through the Console

Follow these steps to explicitly allow update operations after the initialization of a multi-master replica:

1. On the top-level Configuration tab of Directory Server Console, expand both the Data node and the node for the replicated suffix, and select the Replication node below the suffix.

   In the right panel, the console will display a message indicating that the replica has been initialized and is currently returning referrals for update operations. If this message indicates the automatic referral delay is enabled, you may still follow this procedure to override the delay.

2. Use the `insync` tool to ensure that the replica has converged with all other masters. Replicas are in sync if the delay between modifications on all servers is zero or if the replica has never had any changes to replicate (delay of `-1`). For more information, see "insync" in Chapter 1 of the *Directory Server Administration Reference*.
3. Click the button to the right of the message to start accepting update operations immediately.

To Begin Accepting Updates Through the Command Line

The following commands may be used in scripts that automate the process of initializing a multi-master replica by checking for convergence and explicitly allowing update operations:

1. Use the `insync` tool to ensure that the replica has converged with all other masters. Replicas are in sync if the delay between modifications on all servers is zero or if the replica has never had any changes to replicate (delay of `-1`). For more information, see "insync" in Chapter 1 of the *Directory Server Administration Reference*.
2. Modify the `ds5BeginReplicaAcceptUpdates` configuration attribute with the following command:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: cn=replica, cn=suffixName, cn=mapping tree, cn=config
changetype: modify
add: ds5BeginReplicaAcceptUpdates
ds5BeginReplicaAcceptUpdates: start
^D
```

When a replica is initialized, `ds5BeginReplicaAcceptUpdates` is automatically deleted so that update operations are again refused after the initialization.

To Set the Automatic Referral Delay

The `ds5ReferralDelayAfterInit` configuration attribute determines the number of seconds after any initialization for which a replica will return referrals. After this delay, the replica will automatically begin processing update operations from clients. This attribute is specific to each replica and should be set to a value according to the criteria described in "Convergence After Multi-Master Initialization" on page 317.

Changing the value of this attribute will dynamically affect the corresponding replica if it has been recently initialized and is still not accepting updates. You may lengthen or shorten the delay in progress by modifying this value. If the delay has already elapsed and the replica is accepting updates, setting this attribute will have no effect.

The default value of this attribute is `-1`, which means the replica will refuse update operations indefinitely. In this case, you may define a delay to automatically allow updates when the delay elapses, as measured since the initialization. Setting a delay that has already elapsed will cause the replica to begin accepting updates immediately.

1. Set the `ds5ReferralDelayAfterInit` attribute with the following command:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: cn=replica, cn=suffixName, cn=mapping tree, cn=config
changetype: modify
replace: ds5ReferralDelayAfterInit
ds5ReferralDelayAfterInit: seconds
^D
```

Initializing a Replica Using the Console

Online replica initialization using the console is the easiest way to initialize or reinitialize a consumer. However, if you are initializing a large number of entries (more than 1-2 million), this process can be time consuming, and you may find manual consumer initialization using the command line to be a more efficient approach (refer to "Initializing a Replica From the Command Line" on page 321 for more information).

When a consumer replica is being initialized using the console, all operations (including searches) on the suffix are referred to the master servers until the initialization process is completed.

Initializing a replica with fractional replication configured is transparent when using Directory Server Console. Only the selected attributes will be sent to the consumer during the initialization.

Performing Online Replica Initialization

To initialize or reinitialize a replica using the console:

1. On the top-level Configuration tab of Directory Server Console, expand both the Data node and the node for the suffix of the master replica, and then select the Replication node below the suffix.

   The replica status information is displayed in the right-hand panel.

2. In the list of defined agreements, select the replication agreement corresponding to the consumer you wish to initialize and, and click Action>Initialize remote replica.

   A confirmation message warns you that any information already stored in the replica on the consumer will be removed.

3. Click Yes in the confirmation box.

   Online consumer initialization begins immediately. The icon of the replication agreement shows a red gear to indicate the status of the initialization process.

4. Click Refresh>Refresh Now or Refresh>Continuous Refresh to follow the status of the consumer initialization.

   Any messages for the highlighted agreement will appear in the text box below the list.

For more information about monitoring replication and initialization status, see “Monitoring Replication Status” on page 347.

Initializing a Replica From the Command Line

Manual replica initialization using the command line is the fastest method of consumer initialization for deployments that are replicating large numbers of entries. Use the manual process if you find that the online process is inappropriate due to performance constraints. However, the manual consumer initialization process is more complex than the online consumer initialization process.

To manually initialize or reinitialize a replica, first export the original copy of the suffix data to an LDIF file. If you are initializing a fractional replica, then you should filter the file to keep only the replicated attributes. Then you transfer that file to all of the consumer servers and import it. In a multi-master replication deployment, you can use the LDIF file exported from the original master to initialize both the other masters and any consumers. In a cascading replication environment, you can use the same file to initialize both the hub replicas and their consumers.

In all cases, you must start with an LDIF file that has been exported from a configured master replica. You cannot use an arbitrary LDIF to initialize all replicas because it does not contain replication data. You must first import your LDIF file into a master replica, and then export it with the following procedure.

Exporting a Replica to LDIF

You can store the replica contents in an LDIF file by using the `db2ldif -r` or `db2ldif-task -r` commands. For more information, see "Exporting to LDIF From the Command Line" on page 166. You *must* use the `-r` option to export a replica with these commands.

The following example will export the entire `dc=example,dc=com` replica to a file called `example_master.ldif`:

```
# /usr/sbin/directoryserver -s example stop
# /usr/sbin/directoryserver db2ldif -r -s "dc=example,dc=com" \
  -a /var/ds5/slapd-serverID/ldif/example_master.ldif
# /usr/sbin/directoryserver -s example start
```

You can then filter the LDIF file if necessary and transfer it to the consumer hosts to initialize the consumer replicas.

Filtering an LDIF File for Fractional Replication

If you have configured fractional replication, you should filter out any unused attributes before copying the exported LDIF file to the consumer servers. Directory Server provides the `fildif` tool for this purpose. This tool filters the given LDIF file to keep only the attributes allowed by the attribute set defined in your replication agreement.

This tool will read the server's configuration to determine the attribute set definition. In order to read the configuration file, the `fildif` tool must be run as root, or as the user who owns the process and the files (specified by the `nsslapd-localuser` attribute.) For example, the following command filters the file exported from the `dc=example,dc=com` suffix in the previous example:

```
# CAMUS=/var/opt/mps/serverroot/slapd-camus
# /var/opt/mps/serverroot/shared/bin/fildif \
-i $CAMUS/ldif/example_master.ldif \
-o $CAMUS/ldif/filtered.ldif -c $CAMUS/config/dse.ldif \
-b "cn=rousseau.example.com:389, cn=replica, \
cn=\"dc=example,dc=com\", cn=mapping tree, cn=config"
```

The `-i` and `-o` options are the input and output files, respectively. The `-c` option is the configuration file that contains the replication agreement and attribute set definitions. The `dse.ldif` file is where the server stores the contents of the `cn=config` entry, including the replication agreements and attribute sets.

The `-b` option is the DN of the replication agreement where fractional replication is defined. You can find this entry by browsing the `cn=config` suffix as Directory Manager in Directory Server Console. Select the entry under the `cn=replica` entry for your suffix and use the Edit>Copy DN menu item to copy this DN to the clipboard for using when typing your command.

For the full command-line syntax for the `fildif` tool, see "fildif," in Chapter 1 of the *Directory Server Administration Reference*.

You may then use the `filtered.ldif` file produced by `fildif` to initialize the consumer in this replication agreement. Transfer the file to the consumer server and import it as described in the next section.

Importing the LDIF File to the Consumer Replica

You can import the LDIF file that contains the master replica contents to the consumer replica by using the import features in Directory Server Console, or by using either the `directoryserver ldif2db` or `directoryserver ldif2db-task` command. As with all import operations, these commands require the bind DN and password of the Directory Manager to perform the import. Both import methods are described in "Importing LDIF From the Command Line" on page 160.

The following example shows how to import an LDIF file to initialize the `dc=example,dc=com` consumer replica:

```
# /usr/sbin/directoryserver -s example stop
# /usr/sbin/directoryserver ldif2db -s "dc=example,dc=com" \
  -i example_master.ldif
# /usr/sbin/directoryserver -s example start
```

Using `ldif2db-task` does not require stopping the server beforehand. For more information, see "ldif2db-task" in Chapter 1 of the *Directory Server Administration Reference*.

Initializing a Replica Using Binary Copy

The binary copy feature clones an entire server by using the binary backup files from one server to restore the identical directory contents on another server. This advanced feature interacts with the database files of the directory server and should only be used by experienced administrators.

Binary Copy Restrictions

Because the binary copy feature moves database files from one machine to another, the mechanism is subject to the following strict limitations:

- Both machines must use the same hardware and the same operating system, including any service packs or patches.
- Both machines must have the same version of Directory Server installed, including binary format (32 bits or 64 bits), service pack and patch level.
- Both servers must have the same directory tree divided into the same suffixes. The database files for *all* suffixes *must* be copied together, individual suffixes cannot be copied.
- Each suffix must have the same indexes configured on both servers, including VLV (virtual list view) indexes. The databases for the suffixes must have the same name.
- The Directory Server to be copied must not hold the `o=NetscapeRoot` suffix, which means it cannot be a configuration directory for Administration Server.
- Each server must have the same suffixes configured as replicas, and replicas must have the same role (master, hub, or consumer) on both servers. If fractional replication is configured, it must be configured identically on all servers.
- Attribute encryption must not be used on either server.
- The attribute value uniqueness plug-in must have the same configuration on both servers if enabled, and it must be reconfigured on the new copy, as explained in the procedures below.

Under the above conditions, you may then initialize or reinitialize either a master from the binary copy of another master server or a consumer from the binary copy of another consumer server. The following two procedures describe alternate ways of performing a binary copy, one that does not require stopping the server and one that uses the minimum amount of disk space.

Binary Copy Without Stopping the Server

The following procedure is recommended for performing a binary copy because it uses the normal backup functionality to create a copy of the server's database files. Performing a normal backup ensures all database files are in a coherent state without requiring you to stop the server.

However, this procedure has certain limitations that you should take into consideration. The backup and restore operations create copies of the database files on the same machine, thereby doubling the amount of disk space required by those files on each machine. Additionally, the actual copy operation on these files may take significant time if your directory contains gigabytes of data. See "Binary Copy Using Minimum Disk Space" on page 325 if your disk space is limited or your database files are extremely large.

1. Install Directory Server on the target machine for the new replica, create a new instance of the server if necessary, and then configure it according to the "Binary Copy Restrictions" on page 324.
2. Create all replication agreements in your replication topology that involve this replica. This includes agreements from suppliers to this replica, and if it is not a dedicated consumer, from this replica to its consumers.
3. Select a fully configured and initialized replica of the same type as you wish to initialize, either master, hub, or consumer, and perform a normal backup on it according to the procedure in "Backing Up Your Server Using the Console" on page 168.
4. Copy or transfer the files from the backup directory to a directory on the target machine, for example using the `ftp` command.
5. Load the files into the target server according to the procedures in "Restoring Data from Backups" on page 169.
6. If you have initialized a new master in a multi-master replication scenario, follow the procedures in "Convergence After Multi-Master Initialization" on page 317 to ensure the new replica will begin accepting update operations from clients.

Binary Copy Using Minimum Disk Space

The following procedure uses less disk space and takes less time because it does not make backup copies of the database files. However, it requires you to stop the server being cloned to ensure the database files are in a coherent state.

CAUTION This procedure *must not* be used to reinitialize a master that has already participated in a multi-master replication scenario. It may only be used to reinitialize a consumer server or to initialize a new master server. To reinitialize an existing master replica, use online initialization, import an LDIF file, or follow the procedure for "Binary Copy Without Stopping the Server" on page 324.

1. Install Directory Server on the target machine for the new replica, create a new instance of the server if necessary, and then configure it according to the "Binary Copy Restrictions" on page 324.

2. Create all replication agreements in your replication topology that involve this replica. This includes agreements from suppliers to this replica, and if it is not a dedicated consumer, from this replica to its consumers.

3. Stop the target server that will be initialized or reinitialized, as described in "Starting and Stopping Directory Server" on page 25.

4. Select a fully configured and initialized replica of the same type that you wish to initialize, either master, hub, or consumer, and stop this server as well. If you are cloning a master replica in a multi-master configuration, you should ensure that it is fully up-to-date with all of the latest changes from the other masters before stopping it.

5. Remove all database files from the target server, including transaction logs, changelogs, and region files (__db.xxx files.) Unless the files have been relocated, database files and transaction logs are located in the *ServerRoot*`/slapd-`*serverID*`/db` directory.

6. Copy or transfer all database files including transaction logs from the source replica machine to the target machine, for example using the `ftp` command. Unless the files have been relocated, database files and transaction logs are located in the *ServerRoot*`/slapd-`*serverID*`/db` directory.

   If you are initializing a master or hub replica, you must also copy all files in the change log, located in *ServerRoot*`/slapd-`*serverID*`/changelog` by default.

7. Restart both the source and the target servers.

Enabling the Referential Integrity Plug-In

If you are using the referential integrity plug-in, you must enable it on all master servers. You do not need to enable it on hub or consumer servers. See "Using Referential Integrity with Replication" on page 90.

Replication Over SSL

You can configure Directory Servers involved in replication so that all replication operations occur over an SSL connection. To do so, complete the following steps:

1. Configure both the supplier and consumer servers to use SSL.

   Refer to Chapter 11, “Managing Authentication and Encryption” for details.

NOTE

- Replication over SSL will fail if the supplier server certificate is an SSL server-only certificate that cannot act as a client during an SSL handshake.
- Replication over SSL is currently unsupported with self-signed certificates.

2. If replication is not configured for the suffix on the consumer server, enable it as described in “Enabling a Consumer Replica” on page 302.
3. Follow the procedure in “Advanced Consumer Configuration” on page 302, to define the DN of the certificate entry on the consumer as another replication manager.
4. If replication is not configured for the suffix on the supplier server, enable it as described in “Enabling a Hub Replica” on page 304, or “Enabling a Master Replica” on page 307.
5. On the supplier server, create a new replication agreement to send updates to the consumer on the secure SSL port. Follow the procedure in “Creating Replication Agreements” on page 310, for detailed instructions. Specify a secure port on the consumer server and select the SSL option of either using a password or a certificate. Enter a DN for the SSL option that you chose, either a replication manager or a certificate.

After you finish configuring the replication agreement, the supplier will send all replication update messages to the consumer over SSL and will use certificates if you chose that option. Customer initialization will also use a secure connection if performed through the console using an agreement configure for SSL.

Replication Over a WAN

Directory Server 5.2 introduces the ability to perform all forms of replication including multi-master replication (MMR) between machines connected through a Wide Area Network (WAN). Internal improvements to the replication mechanism allow supplier servers to initialize and update consumers with reasonable delay over networks with higher latency and lower bandwidth.

NOTE Replication data transfer rates will always be less than what the available physical medium allows in terms of bandwidth. If the update volume between replicas cannot physically be made to fit into the available bandwidth, tuning will not prevent your replicas from diverging under heavy update load. Replication delay and update performance are dependent on many factors, including but not limited to: modification rate, entry size, server hardware, average latency and average bandwidth. Contact your Sun Professional Services representatives if you have questions about replication in your environment.

Internal parameters of the replication mechanism are optimized by default for WANs. However, if you experience slow replication due to the factors mentioned above, you may wish to empirically adjust the window size and group size parameters. You may also be able to schedule your replication to avoid peak network times, thus improving your overall network usage. Finally, Directory Server supports the compression of replication data to optimize bandwidth usage.

Configuring Network Parameters

The following two parameters determine how the replication mechanism groups entries to send them more efficiently over the network. They affect how suppliers and consumers exchange replication update messages and acknowledgements.

- Window Size (default value 10) - Represents the maximum number of update messages that can be sent without immediate acknowledgement from the consumer.

  It is more efficient to send many messages in quick succession instead of waiting for an acknowledgement after each one. Using the appropriate window size, you can eliminate the time replicas spend waiting for replication updates or acknowledgements to arrive.

If your consumer replica is lagging behind the supplier, increase the window size to a higher value than the default, such as 100, and check replication performance again before making further adjustments. When the replication update rate is high and the time between updates is therefore small, even replicas connected by a LAN can benefit from a higher window size.

- Group Size (default value 1) - Represents the maximum number of data modifications that can be bundled into a single update message.

  If the network connection appears to be the bottleneck for replication, increase the group size to a higher value than the default, such as 10, and check replication performance again. When increasing group size, make sure that:

  - Window size is set significantly higher than group size
  - Window size / group size is much greater than the value for `nsslapd-maxThreadsPerConn` under `cn=config` on the consumer (typically twice as large)

  When group size is set higher than 1, the supplier does not wait to fill a group before sending updates to the supplier. If the list of updates to send is larger than the group size, however, the supplier groups what it can, aiming to send groups of independent modifications that the consumer can process in parallel.

Monitor the effects of any modifications you make and adjust accordingly. Refer to "Monitoring Replication Status" on page 347 for instructions.

These two network parameters are configurable in every replication agreement. This allows you to tailor the replication performance according to the specific network conditions of each consumer.

You do not need to interrupt replication to modify the window and group size parameters:

1. Select the Configuration tab on Directory Server Console, and expand both the Data node and the node for the replicated suffix.
2. Select the Replication node below the suffix, and in the right pane, select the replication agreement you want to configure and click Edit.
3. Select the Network tab of the Replication Agreement dialog and enter new values for the window size (in the range 1 to 1000) and for the group size (in the range 1 to 100). The group size must be less than or equal to the window size.
4. Click OK to save the new values and close the Replication Agreement dialog.

   The new parameter values take effect immediately with the next replication updates sent to the corresponding consumer.

Scheduling Replication Activity

If immediate synchronization between your replicas is not critical, one way to replicate data over a WAN is to schedule updates during periods of low network usage. Updates may perform significantly faster when the network is more available, and replication messages will not add further congestion to your network when it is already under high use.

You may schedule updates on a daily or weekly basis independently for every consumer through its replication agreement:

1. On the top-level Configuration tab of Directory Server Console, expand both the Data node and the node for the replicated suffix.
2. Select the Replication node below the suffix, and in the right pane, select the replication agreement you want to configure and click Edit.
3. Select the Schedule tab of the Replication Agreement dialog and select the radio button beside the weekly schedule.
4. Define your schedule:
    a. For a weekly update, select the checkbox beside the day or days on which you wish replication to occur. You may optionally enter a time range (using 24-hour notation) if you wish to further restrict replication on those days.
    b. For a daily update, click All to replicate every day and enter a time range (using 24-hour notation) when the replication should occur.

       Note that time ranges may not straddle midnight.
5. Click OK to save the new values and close the Replication Agreement dialog.

   The new schedule will take effect immediately, causing the next replication updates for the corresponding consumer to be delayed until first allowed by the schedule.

Data Compression

To reduce the bandwidth used by replication, you may configure replication to compress the data that is sent when updating consumers. The replication mechanism uses the Zlib compression library. Both supplier and consumer must be running on a Solaris or Linux platform to enable compression.

The configuration of replication compression is only available by setting the `ds5ReplicaTransportCompressionLevel` attribute on the replication agreement entry in the master server. This attribute takes one of the following values:

`0` **-** No compression is performed. This is the behavior by default when the `ds5ReplicaTransportCompressionLevel` attribute is not defined.

`1` **-** Use the default compression level of the Zlib library.

`2` **-** Use the best size compression level of the Zlib library.

`3` **-** Use the best speed compression level of the Zlib library.

You should empirically test and select the compression level that gives you best results in your WAN environment for your expected replication usage. You should not set this parameter in a LAN (local area network) where network delay is insignificant, because the compression and decompression computations will slow down replication.

For example, to use the fastest compression when sending replication updates to the consumer on `east.example.com`, use the following `ldapmodify` command:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: cn=east.example.com:389,cn=replica,cn="suffixDN",
 cn=mapping tree,cn=config
changetype: modify
add: ds5ReplicaTransportCompressionLevel
ds5ReplicaTransportCompressionLevel: 3
^D
```

For more information on setting the compression level, see "ds5ReplicaTransportCompressionLevel" in Chapter 2 of the *Directory Server Administration Reference*.

Modifying the Replication Topology

This section contains procedures for managing an existing replication topology such as editing or removing replication agreements, promoting, demoting or disabling a replica, forcing updates to consumers, and managing the change log.

Managing Replication Agreements

From the replication panel for a master suffix, you can manage the replication agreements to change the authentication information in an agreement, interrupt replication to a specific consumer, or remove consumers from the topology.

Changing the Replication Manager

You can edit a replication agreement to change the replication manager identity used to bind to the consumer server. To avoid any interruption of the replication, you should define the new replication manager entry or certificate entry on the consumer before modifying the replication agreement. However, if replication is interrupted due to a bind failure, the replication mechanism will automatically send all the necessary updates when you correct the error, within the limits of the replication recovery settings (see "Advanced Consumer Configuration" on page 302).

To change the replication manager used to authenticate to a consumer:

1. On the top-level Configuration tab on Directory Server Console, expand both the Data node and the node for the replicated suffix, and select the Replication node below the suffix.

2. In the right panel, select the replication agreement you want to modify, and click Edit.

3. In the Replication Agreement dialog, select the Connection tab.

   The status line indicates the hostname and port number of the consumer server.

4. Modify the DN and password field to contain either the DN and password of another replication manager entry or the DN of a certificate entry on the consumer server.

5. If this replication agreement uses SSL over a secure port, you may also click the Options button to select the type of secure authentication. If you connect using a password, the supplier will use simple authentication with the given DN over an encrypted SSL connection. If you connect using a certificate, the DN field is the DN of the certificate entry and no password is required.

   You cannot switch an existing replication agreement from non-secure to secure authentication, nor vice-versa. To enable replication with a different security setting, you must create another replication agreement.

6. Click OK to save your changes.

Duplicating a Replication Agreement

Duplicating a replication agreement is a simple way to configure many consumers of a supplier replica in a large replication topology:

1. On the top-level Configuration tab on Directory Server Console, expand both the Data node and the node for the replicated suffix, and select the Replication node below the suffix.
2. From the list of replication agreements, select one that you wish to duplicate. If you wish to create a new agreement with a secure connection to the consumer, you must select an existing agreement that also uses a secure port. If you wish to create a new non-secure agreement, you must select a non-secure one.

   Verify the configuration of this agreement by clicking Edit and browsing the tabs of the Replication Agreement dialog. The configurations on these tabs are described in the following sections:

   - The Connection tab is described in "Changing the Replication Manager" on page 332.
   - The Schedule and Network tabs are described in "Replication Over a WAN" on page 328.
   - The Replicated Attributes tab is described in "Configuring Fractional Replication" on page 312.
3. With the same replication agreement still selected, click the Duplicate button.
4. Select the hostname and port number of the new consumer from the list, or click the Add Host button to use a different host and port. The list and the Add Host dialog will only allow you to select a consumer with the same type of security as the consumer agreement that is being duplicated.
5. Make sure a hostname is selected in the list and click OK to create the new replication agreement for that consumer server.
6. The new agreement duplicates all configuration information of the existing one. This implies that you must have exactly the same replication manager entry, using the same password, defined on the two servers. If you wish to modify the configuration of the new agreement, to change the replication manager DN for example, select it from the list and click Edit.

Disabling a Replication Agreement

When a replication agreement is disabled, the master stops sending updates to the designated consumer. Replication to that server is stopped, but all settings in the agreement are preserved. You may resume replication by re-enabling the agreement at a later time. See "Enabling a Replication Agreement" below for information about resuming the replication mechanism after an interruption.

To disable a replication agreement:

1. On the top-level Configuration tab on Directory Server Console, expand both the Data node and the node for the replicated suffix, and select the Replication node below the suffix.
2. In the right panel, select the replication agreement you want to disable.
3. Select Action>Disable agreement in the box below the list of agreements.
4. Click Yes to confirm that you want to disable the replication agreement.

The icon for the agreement in the list changes to show it is disabled.

Enabling a Replication Agreement

Enabling a replication agreement will resume replication with the designated consumer. However, if replication has been interrupted longer than the replication recovery settings will allow and the consumer was not updated by another supplier, you will have to reinitialize the consumer. The replication recovery settings are the maximum size and age of this supplier's change log and the purge delay of the consumer (see "Advanced Consumer Configuration" on page 302).

When the interruption is short and replication can recover, the master will update the consumer automatically when the agreement is re-enabled.

To enable a replication agreement:

1. On the top-level Configuration tab on Directory Server Console, expand both the Data node and the node for the replicated suffix, and select the Replication node below the suffix.
2. In the right panel, select the replication agreement you want to enable.
3. Click the Enable button in the box below the list of agreements.
4. Reinitialize the consumer replica if necessary.

Deleting a Replication Agreement

Deleting a replication agreement will stop the replication to the corresponding consumer and remove all configuration information about the agreement. If you wish to resume replication at a later date, disable the agreement instead, as described in "Disabling a Replication Agreement" on page 334.

To delete a replication agreement:

1. On the top-level Configuration tab on Directory Server Console, expand both the Data node and the node for the replicated suffix, and select the Replication node below the suffix.
2. In the right panel, select the replication agreement you want to delete.
3. Click the Delete button to the right of the list of agreements.
4. Click Yes to confirm that you want to delete the replication agreement.

Promoting or Demoting Replicas

Promoting or demoting a replica changes its role in the replication topology. Dedicated consumers may be promoted to hubs, and hubs may be promoted to masters. Masters may be demoted to hubs, and hubs may also be demoted to dedicated consumers. However, masters may not be demoted directly to consumers, just as consumers may not be promoted directly to masters.

The allowed promotions and demotions within the multi-master replication mechanism make the topology very flexible. A site that was formerly served by a consumer replica may grow and require a hub with several replicas to handle the load. If the load includes many modifications to the replica contents, the hub can become a master to allow faster local changes that can then be replicated to other masters at other sites.

To promote or demote a replica:

1. On the top-level Configuration tab on Directory Server Console, expand both the Data node and the node for the replicated suffix, and select the Replication node below the suffix.
2. In the right panel, select the Change>Promote-Demote Replica menu item.
3. The replication wizard will only let you select a new role that is allowed and then step through the configuration procedure for the new replica role. You should be aware of the following effects:

- ❍ When demoting a master to a hub, the replica will become read-only and be configured for sending referrals to the remaining masters. The new hub will retain all of its consumers, whether hubs or dedicated consumers.
- ❍ Demoting a single master to a hub will create a topology without a master replica. The wizard will allow you to do this under the assumption that you will define a new master. However, it is better to add a new master as a multi-master and allow it to be initialized before demoting the other one.
- ❍ When demoting a hub to a consumer, all replication agreements will be deleted. If the hub's consumers were not updated by other hubs or masters, they will no longer be updated. You should create new agreements on the remaining hubs or masters to update these consumers.
- ❍ When promoting a consumer to a hub, its change log is enabled, and you may define new agreements with consumers.
- ❍ When promoting a hub to a master, the replica will accept modification requests and you may define new agreements with other masters, hubs, or dedicated consumers.

Disabling Replicas

Disabling a replica will remove it from the replication topology. It will no longer be updated or send updates, depending on its role as a master, hub or consumer. Disabling a supplier will delete all replication agreements, and they will have to be recreated if the replica is enabled again.

To disable a replica:

1. On the top-level Configuration tab on Directory Server Console, expand both the Data node and the node for the replicated suffix, and select the Replication node below the suffix.
2. In the right panel, select the Change>Disable Replication menu item.
3. Click Yes in the confirmation dialog.
4. Optionally, reset the write permissions and referrals for this suffix. These settings are left as is when the replica is disabled, for example, a disabled consumer still sends modification requests to its former master replica.

   To modify the write permissions and referrals, select the node for this suffix on the Configuration tab and make modifications on the Settings tab in the right-hand panel. For more information, see "Setting Access Permissions and Referrals" on page 144.

Moving the Change Log

The change log is an internal record of all modifications on a given supplier replica that the server uses to replay modifications to the other replicas. The contents of the change log are managed automatically by the server and will be updated through multi-master updates even after the server is restarted.

In earlier versions of Directory Server, the change log was accessible over LDAP. Now, however, it is intended only for internal use by the server. If you have applications that need to read the change log, use the Retro Change Log Plug-in for backward compatibility. For more information, refer to "Using the Retro Change Log Plug-In" on page 344.

The only time administrators should modify the change log is when its files need to be moved to a different location, for example if the disk where it resides becomes full.

CAUTION The change log is reinitialized when you disable it or move it to a new location. In either case, you will need to reinitialize all consumers of replicas on this server.

You must move the change log using Directory Server Console and never using the operating system `rename` or `mv` commands:

1. On the top-level Configuration tab on Directory Server Console, select the Data node and choose the Replication tab in the right panel.
2. Enter a new location in the text field. This is the new path and directory name where you wish to store the change log from now on. For example, move the change log from the default location *ServerRoot*`/slapd-`*serverID*`/changelogdb` to *ServerRoot*`/slapd-`*serverID*`/newchangelog`.

   The existing change log will be deleted from the old location and a new one will be kept in the new location.
3. Click Save in the Replication tab.
4. Restart the Directory Server.
5. Reinitialize your consumers as described in "Initializing Replicas" on page 315.

Keeping Replicas in Sync

After you stop a Directory Server involved in replication for regular maintenance, when it comes back online, you need to ensure that it gets updated through replication immediately. In the case of a master in a multi-master environment, the directory information needs to be updated by another master in the multi-master set. In other cases, after a hub replica or a dedicated consumer is taken offline for maintenance, when they come back online, they need to be updated by the master replica.

This section describes the replication retry algorithm, and how to force replication updates to occur without waiting for the next retry.

NOTE The procedures described in this section can be used only when replication is already set up *and* consumers have been initialized.

Replication Retry Algorithm

When a supplier is unsuccessful in an attempt to replicate to a consumer, it retries periodically in incremental time intervals. The retry pattern is as follows: 20, 40, 80, 160, then 300 seconds. The supplier will then retry every 300 seconds (5 minutes).

Note that even if you have configured replication agreements to always keep the supplier replica and the consumer replica in sync, this is not sufficient to bring back up-to-date immediately a replica that has been offline for over five minutes.

To ensure that directory information will be synchronized immediately when a server comes back online, you can use either Directory Server Console or a customizable script.

Forcing Replication Updates from the Console

To ensure that replication updates are sent immediately when a consumer, or a master in a multi-master replication configuration, comes back online after a period of time, you can perform these steps on the supplier that holds the most recent version of the directory data:

1. On the top-level Configuration tab on Directory Server Console, expand both the Data node and the suffix node for the master replica, and select the Replication node below the suffix.

   The replica status information is displayed in the right-hand panel.

2. Select the replication agreement from the list that corresponds to the consumer you wish to update, and then click Action>Send updates now.

   This initiates replication toward the replica that holds the information that needs to be updated.

Forcing Replication Updates from the Command Line

From the consumer that requires updating, the following script will prompts its supplier to send replication updates immediately. You can copy this example and give it a meaningful name, for example, `replicate_now.sh`. You must provide actual values for the variables listed in this example.

NOTE The administrator must run this script because it cannot be configured to run automatically as soon as the server which was offline comes back online again.

```
#!/bin/sh
SUP_HOST=supplier_hostname
SUP_PORT=supplier_portnumber
SUP_MGRDN=supplier_directoryManagerDN
SUP_MGRPW=supplier_directoryManagerPassword
MY_HOST=consumer_hostname
MY_PORT=consumer_portnumber

ldapsearch -1 -h ${SUP_HOST} -p ${SUP_PORT} -D "${SUP_MGRDN}" \
           -w ${SUP_MGRPW} -b "cn=mapping tree, cn=config" \
           "(&(objectclass=nsds5replicationagreement) \
              (nsDS5ReplicaHost=${MY_HOST}) \
              (nsDS5ReplicaPort=${MY_PORT}))" \
           dn nsds5ReplicaUpdateSchedule > /tmp/$$

cat /tmp/$$ |
awk '
BEGIN { s = 0 }
/^dn: / { print $0;
  print "changetype: modify";
  print "replace: nsds5ReplicaUpdateSchedule";
  print "nsds5ReplicaUpdateSchedule: 0000-2359 0123456";
  print "-";
  print "";
  print $0;
  print "changetype: modify";
```

```
    print "replace: nsds5ReplicaUpdateSchedule";
    }
  /^nsds5ReplicaUpdateSchedule: / { s = 1; print $0; }
  /^$/ {
    if ( $s == 1 )
      { print "-" ; print ""; }
    else
      { print "nsds5ReplicaUpdateSchedule: 0000-2359 0123456";
        print "-" ; print ""; };
    s = 0; }
  ' > /tmp/ldif.$$

  echo "Ldif is in /tmp/ldif.$$"
  echo

  ldapmodify -c -h ${SUP_HOST} -p ${SUP_PORT} -D "${SUP_MGRDN}" \
             -w ${SUP_MGRPW} -f /tmp/ldif.$$
```

If you want the update operation to occur over an SSL connection, you must modify the `ldapmodify` command in the script with the appropriate parameters and values. For more information, see "Configuring LDAP Clients to Use Security" on page 411.

Replication With Earlier Releases

This section provides information on how to configure replication with earlier releases of Directory Server.

Directory Server 5.1 and 5.2 are fully compatible with regard to any replication configuration, with the following exceptions:

- Fractional replication is not possible and must not be configured between Directory Server 5.2 masters and 5.1 consumer replicas.
- Before configuring an agreement between a 5.2 supplier and a 5.1 consumer, you must set `nsslapd-schema-repl-useronly` to `on` in `cn=config`. Otherwise the schema in 5.2 will create conflicts when replicated to 5.1. With this setting, only user-defined schema elements, those stored in the file `99user.ldif`, will be replicated. See "Replicating Schema Definitions" on page 367.
- In Directory Server 5.2, the schema file 11rfc2307.ldif has been altered to conform to RFC 2307. You must update the corresponding file on your 5.1 server, as described in "Updating Directory Server 5.1 Schema" on page 343.

- A 5.2 master that has been demoted to a hub will still appear in the list of referrals on a 5.1 consumer. However, due to the internal mechanism for demotion, the port number for the demoted replica will be zero. This referral URL will not be usable, and most clients will automatically try the referrals to the other masters when they are not able to follow this one. However, you may need to increase the hop limit for referrals on clients that access these 5.1 replicas. A 5.2 consumer replica does not display nor return the unusable referral URL to a demoted master.

Directory Server 5.2 can be involved in replication scenarios with 4.x releases of Directory Server, under the following conditions:

- Directory Server 5.2 is configured as a master but replicated only as a consumer to a Directory Server 4.x supplier.
- A consumer replica cannot be a consumer to both legacy 4.x suppliers and 5.2 suppliers. However, a 5.2 server may have different replicas, where one is supplied by a legacy Directory Server, and the other is supplied by a 5.2 Directory Server.
- A Directory Server 5.2 replica that has been configured as a consumer to a legacy 4.x supplier cannot act as a hub replica for this suffix in the topology.

The main advantage of being able to use Directory Server 5.2 as a consumer of a legacy Directory Server is to ease the migration of a replicated environment. For more information on the steps to follow to migrate a replicated environment, see Chapter 4, “Replicated Server Upgrade,” in the *Directory Server Installation and Migration Guide*.

Configuring Directory Server 5.2 as a Consumer of Directory Server 4.x

If you intend to use Directory Server 5.2 as a consumer of a 4.x release of Directory Server, you must configure it as follows:

1. Enable the replica as a *master* replica, as described in “Enabling a Master Replica” on page 307. Even though the replica will be a consumer to the 4.x supplier, it must be configured as a master replica.
2. On the top-level Configuration tab on Directory Server Console, expand both the Data node and the node for the replicated suffix, and select the Replication node below the suffix.
3. In the right panel, select Change>Enable 4.x compatibility for this replica. Alternatively, select Enable 4.x compatibility from the Object menu.

4. In the Enabling 4.x Compatibility window, specify a bind DN and password that the legacy supplier server will use to bind. The bind DN and password that you specify here must be used *only* for legacy replication. You must therefore not use an existing DN, or the default replication manager used in 5.x replication.

   If you use the Replication Wizard to configure legacy replication, the bind DN and password you specify are stored correctly in the legacy replication configuration entry. If you configure legacy replication manually from the command line, you must specify the bind DN and password in the legacy replication configuration entry, using the `nsslapd-legacy-updatedn` and `nsslapd-legacy-updatepw` attributes.

   Legacy replication works only with simple authentication, not with secure authentication using certificates.

5. Click OK. This consumer replica is now ready to receive updates from a legacy supplier.

6. Make sure that the schema on the 5.2 replica server defines all attributes and object classes used by the contents that will be replicated from the 4.x master.

7. Initialize the 5.2 replica by importing an LDIF replica file created on the 4.x master. The first entry in this file contains the `copiedfrom` attribute required by the 4.x replication mechanism.

Enabling 4.x compatibility on a server configures the legacy replication plug-in that is installed by default. This plug-in processes updates from the legacy supplier and performs the updates on the contents of the replicated suffix.

NOTE As long as 4.x compatibility is enabled, this replica will return referrals for any modification requests from clients. Even though Directory Server 5.2 is configured as a master replica, it will not perform modification requests on this suffix. Instead, it will return a referral to the 4.x supplier server.

To complete the legacy replication setup, you must now configure the legacy supplier to replicate to the 5.2 Directory Server. For instructions on configuring a replication agreement on a 4.x Directory Server, refer to the documentation provided with your legacy Directory Server.

Updating Directory Server 5.1 Schema

In Directory Server 5.2, the schema file `11rfc2307.ldif` has been altered to conform to RFC 2307 (`http://www.ietf.org/rfc/rfc2307.txt`). Before you configure or enable replication between a 5.2 and 5.1 server, you must update the schema on the 5.1 server. On both versions of the server, the schema files are located in *ServerRoot*`/slapd-`*serverID*`/config/schema/`.

1. Copy the file `11rfc2307.ldif` from the 5.2 server to the 5.1 server.
   - If you have a Solaris package installation of the 5.1 server, you must also delete the outdated `10rfc2307.ldif` file.
   - If you have a zip-file installation of the 5.1 server on any other platform, you will overwrite the existing `11rfc2307.ldif` file.
2. The following schema files are affected by this change and must also be copied from the 5.2 server to overwrite the existing files on the 5.1 server:
   - `20subscriber.ldif`
   - `30ns-common.ldif`
   - `50ns-admin.ldif`
   - `50ns-certificate.ldif`
   - `50ns-directory.ldif`
   - `50ns-legacy.ldif`
   - `50ns-mail.ldif`
   - `50ns-mlm.ldif`
   - `50ns-msg.ldif`
   - `50ns-netshare.ldif`
3. Restart the 5.1 server, then proceed with the configuration of replication and initialization of replicas. There may be some schema attributes that are replicated between servers as they synchronize other schema elements, but this is the normal behavior of the replication mechanism.
4. You may need to update any applications which rely on the old version of the schema. The new `11rfc2307.ldif` file includes the following modifications:
   - The `automount` and `automountInformation` attributes were removed.
   - The list of allowed attributes of the `ipHost` object class no longer includes `o $ ou $ owne r$ seeAlso$ serialNumber` .

- The list of mandatory attributes of the `ieee802Device` object class no longer includes `cn`.
- The list of allowed attributes of the `ieee802Device` object class no longer includes `description $ l $ o $ ou$ own er$ see Also$ serialNumber`.
- The list of mandatory attributes for the `bootableDevice` object class no longer includes `cn`.
- The list of allowed attributes of the `bootableDevice` object class no longer includes `description $ l $ o $ ou$ own er$ see Also$ serialNumber`.
- The OID of the `nisMap` object class is now `1.3.6.1.1.1.2.9`.

Using the Retro Change Log Plug-In

The retro change log plug-in can be used when you want a Directory Server 5.2 master replica to maintain a 4.x style change log. This is sometimes necessary for applications such as Meta Directory that have a dependency on the Directory Server 4.x change log format, because they read information from the change log.

The retro change log plug-in does *not* allow Directory Server 5.2 to be a supplier to a legacy 4.x consumer replica. Only Directory Server 5.2 consumers of 4.x suppliers are supported, as described in "Replication With Earlier Releases" on page 340. The retro change log plug-in operates independently of the replication protocol and has no effect on the replication topology. The retro change log plug-in may be enabled on any server of a single-master deployment scenario. In general, if the requirements of any application being deployed include the retro change log, a multi-master replication topology should not be used in this deployment.

The retro change log is kept in addition to the server's 5.2 change log. The retro change log is stored in a separate database under the special suffix `cn=changelog`. The retro change log consists of a single level of entries. Each entry in the change log has the object class `changeLogEntry`, and can include the attributes listed in the following table.

Table 8-1 Attributes of a Retro Change Log Entry

Attribute	Definition
`changeNumber`	This single-valued attribute is always present. It contains an integer that uniquely identifies each change. This number is related to the order in which the change occurred. The higher the number, the later the change.
`targetDN`	This attribute contains the DN of the entry that was affected by the LDAP operation. In the case of a `modrdn` operation, the `targetDN` attribute contains the DN of the entry before it was modified or moved.
`changeTime`	This attribute specifies the time at which the change operation occurred.
`changeType`	Specifies the type of LDAP operation. This attribute can have one of the following values: `add`, `delete`, `modify`, or `modrdn`.
`changes`	For add and modify operations, contains the changes made to the entry, in LDIF format.
`newRDN`	In the case of `modrdn` operations, specifies the new RDN of the entry.
`deleteOldRdn`	In the case of `modrdn` operations, specifies whether the old RDN was deleted.
`newSuperior`	In the case of `modrdn` operations, specifies the `newSuperior` attribute of the entry.

Enabling the Retro Change Log Plug-In

The retro change log plug-in configuration information is stored in the `cn=Retro Changelog Plugin,cn=plugins,cn=config` entry in `dse.ldif`.

To enable the retro change log plug-in from Directory Server Console:

1. On the top-level Configuration tab on Directory Server Console, expand the Plugins node, and scroll down to select the Retro Changelog Plugin.
2. In the right panel, check the “Enable plug-in” checkbox and click Save. To disable the plug-in, clear this checkbox.
3. You must restart Directory Server after enabling or disabling the plug-in.

To enable the retro change log plug-in from the command line:

1. Modify the retro change log plug-in configuration entry with the following command:

   ```
   ldapmodify -h host -p port -D "cn=Directory Manager" -w password
   dn: cn=Retro Changelog Plugin,cn=plugins,cn=config
   changetype: modify
   replace: nsslapd-pluginenabled
   nsslapd-pluginenabled: on
   ^D
   ```

2. Restart the server. For information on restarting the server, refer to "Starting and Stopping Directory Server" on page 25.

Trimming the Retro Change Log

The entries in the change log can be removed automatically after a specified period of time. To configure the period of time after which entries are deleted automatically from the change log, you must set the `nsslapd-changelogmaxage` configuration attribute in the `cn=Retro Changelog Plugin, cn=plugins, cn=config` entry. This attribute can only be set from the command line, for example:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -p password
dn: cn=Retro Changelog Plugin,cn=plugins,cn=config
changetype: modify
replace: nsslapd-changelogmaxage
nsslapd-changelogmaxage: IntegerTimeunit
^D
```

where *Integer* represents a number, and *Timeunit* can be one of the following: `s` for seconds, `m` for minutes, `h` for hours, `d` for days, or `w` for weeks. There should be no space between the *Integer* and *Timeunit* variables, for example:

```
nsslapd-changelogmaxage: 2d
```

The retro change log will be trimmed at the next operation on the change log.

Accessing the Retro Change Log

The change log supports search operations. It is optimized for searches that include filters of the form:

```
(&(changeNumber>=X)(changeNumber<=Y))
```

As a general rule, you should not perform add or modify operations on the retro change log entries, although you can delete entries to trim the size of the change log. The only time you will need to perform a modify operation on the retro change log is to modify the default access control policy.

When the retro change log is created, by default, the following access control rules apply:

- Read, search, and compare rights are granted to all authenticated users (`userdn=anyone`, not to be confused with anonymous access where `userdn=all`) to the retro change log top entry `cn=changelog`.
- Write and delete access are not granted, except implicitly to the Directory Manager.

You should not grant read access to anonymous users, because the change log entries can contain modifications to sensitive information, such as passwords. You may wish to further restrict access to the retro change log contents if even authenticated users should not be allowed to view its contents.

To modify the default access control policy that applies to the retro change log, you should modify the `aci` attribute of the `cn=changelog` entry. Refer to Chapter 6, "Managing Access Control," for more information about setting `aci` attributes.

Monitoring Replication Status

You can monitor replication status using the new command-line tools and using the Directory Server console.

Command-Line Tools

There are three new command-line tools for monitoring your replication deployment:

- `repldisc` - "Discovers" and constructs a table of all known servers in a replication deployment.
- `insync` - Indicates the synchronization state between a supplier and one or more consumer replicas.
- `entrycmp` - Compares the same entry in two or more replicas.

These tools are located in the following directory:

ServerRoot`/shared/bin`

The “Tools Reference,” in Chapter 1 of the *Directory Server Administration Reference* gives the full command-line syntax and usage examples for these tools.

Replication Status Tab

To view a summary of replication status in Directory Server Console:

1. On the top-level Status tab on Directory Server Console, select the Replication node.

   The right panel displays a table that contains information about each of the replication agreements configured for this server.

2. If you wish to monitor the replication status, select the Continuous refresh checkbox. For example, you will see when a replica has finished initializing.

3. Click the Pending Change Number button if you wish to determine the last modification on the master that has not yet been replicated to the consumer. You will be warned that this operation may take a long time and asked to confirm. Determining the pending change number requires downloading the consumer’s record of updates and comparing it to the master’s change log. If these logs are very large, this operation may take significant time and server resources.

4. You can modify the layout of the table by clicking on the column headers and resizing them. You can also modify the contents of the table by clicking the View Options button and selection only those columns you wish to see. Table 8-2 describes the replication parameters you may select to display in the table for each agreement on this server.

Table 8-2 Replication Parameters on the Directory Server Console Status Tab

Table Header	Description
Suffix	Names the suffix or subsuffix that is being replicated.
Remote Replica	Contains the hostname and port of the consumer server.
Description	Contains the description string provided in this replication agreement.
State	Indicates whether the agreement is disabled, initializing the consumer, or replicating normally through incremental updates.
Summary	Contains the latest event (start or end of initialization or update) and the last message received.

Table 8-2 Replication Parameters on the Directory Server Console Status Tab *(Continued)*

Table Header	Description
Sent updates	Cumulates the total number of individual updates sent to the consumer since replication was enabled or the server was restarted.
Last update started	Indicates when the most recent replication update started.
Last update ended	Indicates when the most recent replication update ended.
Last update message	Provides the status for the most recent replication updates.
Last initialization message	Provides status on the last initialization of the consumer.
Last initialization started	Indicates when the most recent initialization of the consumer replica started.
Last initialization ended	Indicates when the most recent initialization of the consumer replica ended.

Solving Common Replication Conflicts

Multi-master replication uses a loose consistency replication model. This means that the same entries may be modified simultaneously on different servers. When updates are sent between the two servers, the conflicting changes need to be resolved. Mostly, resolution occurs automatically, based on the timestamp associated with the change on each server. The most recent change takes precedence.

However, there are some cases where change conflicts require manual intervention in order to reach a resolution. Entries that have a change conflict that cannot be resolved automatically by the replication process contain the operational attribute `nsds5ReplConflict` as a conflict marker.

Search for entries that contain this attribute periodically to find entries with conflicts. For example, you could use the following `ldapsearch` command:

```
% ldapsearch -h host -p port -D "cn=Directory Manager" -w password \
-b "dc=example,dc=com" "(nsds5ReplConflict=*)"
```

Note that the `nsds5ReplConflict` attribute is indexed by default.

Solving Naming Conflicts

Entries with identical DNs may be created on separate masters if they are created before the servers replicate the changes to each other. Upon replication, the conflict resolution mechanism will automatically rename the second entry created.

An entry with a DN naming conflict is renamed by including its unique identifier, given by the operational attribute `nsuniqueid`, in its DN. For example, if the entry `uid=bjensen,ou=People,dc=example,dc=com` is created simultaneously on two masters, both will have the following two entries after replication:

- `uid=bjensen,ou=People,dc=example,dc=com`
- `nsuniqueid=66446001-1dd211b2+uid=bjensen,dc=example,dc=com`

The second entry needs to be renamed in such a way that it has a useful DN. You can delete the conflicting entry and add it again with a non-conflicting name. However, the surest way to keep the entry as it was created is to rename it. The renaming procedure depends on whether the naming attribute is single-valued or multi-valued. Each procedure is described below.

Renaming an Entry with a Multi-Valued Naming Attribute

To rename an conflicting entry that has a multi-valued naming attribute:

1. Rename the entry while keeping the old RDN value. For example:

   ```
   ldapmodify -h host -p port -D "cn=Directory Manager" -w password
   dn: nsuniqueid=66446001-1dd211b2+uid=bjensen,dc=example,dc=com
   changetype: modrdn
   newrdn: uid=NewValue
   deleteoldrdn: 0
   ^D
   ```

   You cannot delete the old RDN value in this step because it also contains the `nsuniqueid` operational attribute which cannot be deleted.

2. Remove the old RDN value of the naming attribute and the conflict marker attribute. For example:

   ```
   ldapmodify -h host -p port -D "cn=Directory Manager" -w password
   dn: uid=NewValue,dc=example,dc=com
   changetype: modify
   delete: uid
   uid: bjensen
   -
   delete: nsds5ReplConflict
   ^D
   ```

Renaming an Entry with a Single-Valued Naming Attribute

When the naming attribute is single-valued, for example `dc` (domain component), you cannot simply rename the entry to another value of the same attribute. Instead you must give it a temporary name.

1. Rename the entry using a different naming attribute, and keep the old RDN. For example:

   ```
   ldapmodify -h host -p port -D "cn=Directory Manager" -w password
   dn: nsuniqueid=66446001-1dd211b2+dc=HR,dc=example,dc=com
   changetype: modrdn
   newrdn: o=TempName
   deleteoldrdn: 0
   ^D
   ```

   You cannot delete the old RDN value in this step because it also contains the `nsuniqueid` operational attribute which cannot be deleted.

2. Change the desired naming attribute to a unique value and remove the conflict marker attribute. For example:

   ```
   ldapmodify -h host -p port -D "cn=Directory Manager" -w password
   dn: o=TempName,dc=example,dc=com
   changetype: modify
   replace: dc
   dc: uniqueValue
   -
   delete: nsds5ReplConflict
   ^D
   ```

3. Rename the entry back to the intended naming attribute. For example:

   ```
   ldapmodify -h host -p port -D "cn=Directory Manager" -w password
   dn: o=TempName,dc=example,dc=com
   changetype: modrdn
   newrdn: dc=uniqueValue
   deleteoldrdn: 1
   ^D
   ```

By setting the value of the `deleteoldrdn` attribute to `1`, you delete the temporary attribute-value pair `o=`*TempName*. If you want to keep this attribute, you can set the value of the `deleteoldrdn` attribute to `0`.

Solving Orphan Entry Conflicts

When a delete operation is replicated, and the consumer server finds that the entry to be deleted has child entries, the conflict resolution procedure creates a *glue* entry to avoid having orphaned entries in the directory.

In the same way, when an add operation is replicated, and the consumer server cannot find the parent entry, the conflict resolution procedure creates a glue entry representing the parent so that the new entry is not an orphan entry.

Glue entries are temporary entries that include the object classes `glue` and `extensibleObject`. Glue entries can be created in several ways:

- If the conflict resolution procedure finds a deleted entry with a matching unique identifier, the glue entry is a resurrection of that entry, with the addition of the `glue` object class, and the `nsds5ReplConflict` attribute.

  In such cases, you can either modify the glue entry to remove the `glue` object class and the `nsds5ReplConflict` attribute, to keep the entry as a normal entry, or you can delete the glue entry and its child entries.

- The server creates a minimal entry with the `glue` and `extensibleObject` object classes.

  In such cases, you must modify the entry to turn it into a meaningful entry, or delete it and all of its child entries.

Solving Potential Interoperability Problems

For reasons of interoperability with applications that rely on attribute uniqueness such as a mail server, you might need to restrict access to the entries that contain the `nsds5ReplConflict` attribute. If you do not restrict access to these entries, then the applications requiring one attribute only will pick up both the original entry and the conflict resolution entry containing the `nsds5ReplConflict` and operations will fail.

To restrict access you need to modify the default ACI that grants anonymous read access, using the following command:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w  password
dn: dc=example,dc=com
changetype: modify
delete: aci
aci: (target ="ldap:///dc=example,dc=com")
 (targetattr !="userPassword"
 (version 3.0;acl "Anonymous read-search  access";
 allow (read, search, compare)(userdn = "ldap:///anyone");)
-
add: aci
aci: (target="ldap:///dc=example,dc=com")
 (targetattr!="userPassword")
 (targetfilter="(!(nsds5ReplConflict=*))")(version 3.0;acl
 "Anonymous read-search access";allow (read, search, compare)
 (userdn="ldap:///anyone");)
^D
```

The new ACI will keep entries that contain the `nsds5ReplConflict` attribute from being returned in search results.

Chapter 9

Extending the Directory Schema

Directory Server comes with a standard schema that includes hundreds of object classes and attributes. While the standard object classes and attributes should meet most of your requirements, you may need to extend your schema by creating new object classes and attributes. For an overview of the standard schema and instructions on designing schema to suit your deployment, see Chapter 3, “Directory Server Schema,“ in the *Directory Server Deployment Planning Guide*.

This chapter describes how to extend your schema in the following sections:

- Schema Checking
- Overview of Extending the Schema
- Managing Attribute Definitions
- Managing Object Class Definitions
- Replicating Schema Definitions

Schema Checking

When schema checking is on, Directory Server ensures that all import, add, and modify operations conform to the currently defined directory schema:

- The object classes and attributes of each entry conform to the schema.
- The entry contains all required attributes for all of its defined object classes.
- The entry contains only attributes that are allowed by its object classes.

NOTE When modifying an entry, Directory Server performs schema checking on the entire entry, not only on the attributes being modified. Therefore, the operation may fail if any object class or attribute in the entry does not conform to the schema. Schema checking does not verify the validity of attribute values with regard to their syntax, however.

Schema checking is turned on by default, and you should always run Directory Server with schema checking turned on. Many client applications assume that having schema checking turned on is an indication that all entries conform to the schema. However, turning on schema checking will not verify the existing contents in the directory. The only way to guarantee that all directory contents conform to the schema is to turn on schema checking before adding any entries or before reinitializing all entries.

The only case where you might want to turn schema checking off is to accelerate import operations of LDIF files known to conform to the schema. However, there is always a risk of importing entries that do not conform to the schema, and this cannot be detected.

When an entry does not conform to the schema, it may be impossible to search for this entry, and modification operations on it may fail. To make an entry comply with the schema you must do the following:

1. If your server is in a production environment, you may want to first make the entire server read-only to prevent any modifications while schema checking is turned off. See "Setting Global Read-Only Mode" on page 40.
2. Turn off schema checking as described below.
3. Retrieve the entry and manually compare it with the currently defined schema to determine why it does not comply. See "Viewing Attributes" on page 360 and "Viewing Object Classes" on page 364.
4. Modify the entry to make it comply with the schema.

   If you have many nonconforming entries, and these entries represent a pattern or new format for your data, you may consider modifying the schema instead. However, you should plan your schema ahead of your deployment to minimize changes to the schema. For more information, see Chapter 3, "Directory Server Schema,“ in the *Directory Server Deployment Planning Guide.*
5. Turn on schema checking as described below.
6. Unset the global read-only mode if you had enabled it.

Setting Schema Checking Using the Console

1. On the top-level Configuration tab of Directory Server Console, select the schema node in the configuration tree.

   The right-hand panel contains the definition of the schema.

2. The status message at the top of the panel indicates whether schema checking is currently enabled or disabled. Click the button to the right to toggle schema checking off or on:

   - The button is labeled Disable to turn off schema checking.
   - The button will be labeled Enable when you can turn on schema checking.

   The new schema checking policy is effective immediately.

Setting Schema Checking From the Command Line

You can also turn schema checking on and off by setting the `nsslapd-schemacheck` attribute of the `cn=config` entry:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: cn=config
changetype: modify
replace: nsslapd-schemacheck
nsslapd-schemacheck: on or off
^D
```

The server will enforce the new schema checking policy immediately.

Overview of Extending the Schema

When you add new attributes to your schema, you must create a new object class to contain them. Although it may seem convenient to just add the attributes you need to an existing object class that already contains most of the attributes you require, doing so compromises interoperability with LDAP clients.

Interoperability of Directory Server with existing LDAP clients relies on the standard LDAP schema. If you change the standard schema, you will also have difficulties when upgrading your server. For the same reasons, you cannot delete standard schema elements.

For more information on object classes, attributes, and the directory schema as well as guidelines for extending your schema, refer to Chapter 3, “Directory Server Schema,“ in the *Directory Server Deployment Planning Guide*. For information on standard attributes and object classes, see Chapter 9, “Object Class Reference,“ and Chapter 10, “Attribute Reference,“ in the *Directory Server Administration Reference*.

Directory Server schema is stored in attributes of the `cn=schema` entry. Like the configuration entry, this is an LDAP view of the schema that is read from files during server startup. The schema files are LDIF files located in:

ServerRoot/`slapd-`*serverID*`/config/schema`

This directory contains files for the standard schema used by Directory Server and other Sun Java System servers that rely on Directory Server. These files are described in “Schema Supported by Directory Server 5.2” in Chapter 9 of the *Directory Server Administration Reference*. The standard schema itself is described in Chapter 9, “Object Class Reference,“ and Chapter 10, “Attribute Reference,“ in the *Directory Server Administration Reference*.

Modifying the Schema Files

The schema files are read once only at startup by the server. The LDIF contents of the files are added to the in-memory LDAP view of the schema in `cn=schema`. Because the order of schema definitions is important, schema filenames are prefixed by a number and loaded in alphanumerical order. Schema files in this directory are writable only by the system user defined during installation.

To modify the schema definition in the files, you must create or modify the desired file and then restart the server. The syntax of definitions in the schema files is described in RFC 2252 (`http://www.ietf.org/rfc/rfc2252.txt`).

When defining the schema directly in an LDIF file, you must not use the value `'user defined'` for the `X-ORIGIN` field. This value is reserved for schema elements that are defined through the LDAP view of `cn=schema` and that appear in the file `99user.ldif`.

The `99user.ldif` file contains additional ACIs for the `cn=schema` entry and all schema definitions added from the command-line or using the console. The `99user.ldif` file will be overwritten when new schema definitions are added. If you wish to modify this file, you must restart the server immediately to ensure that your changes will be permanent.

You should not modify the standard schema defined in the other schema files. However, you can add new files to define new attributes and object classes. For example, to define new schema elements in many servers, you could define them in a file named `98mySchema.ldif` and copy this file to the schema directory of all servers. You must then restart all servers to load your new schema file.

Modifying the Schema From the Command Line

Because the schema is defined by the LDAP view in `cn=schema`, you may view and modify the schema online using the `ldapsearch` and `ldapmodify` utilities. However, you may modify only schema elements that have the value `'user defined'` for the `X-ORIGIN` field. The server will refuse any modification to the other definitions.

Use `ldapmodify` to add and delete individual values of the `attributeTypes` and `objectClasses` attributes. To modify one of the values, you must delete the specific value and then add it as a new value because these attributes are multivalued (see "Modifying One Value of a Multi-Valued Attribute" on page 77). You must use the syntax for defining schema elements that is described in RFC 2252 (`http://www.ietf.org/rfc/rfc2252.txt`).

Any new element definitions, and changes you make to user-defined elements are saved in the file `99user.ldif`.

Modifying schema definitions from the command line is prone to error because of the long values you must enter exactly. However, you may use this functionality in scripts that need to update your directory schema.

Modifying the Schema Using the Console

The recommended method for customizing your directory schema is to use Directory Server Console, as described in the following sections. The console lets you view the standard schema, and provides a graphical interface for defining new attributes and object classes and editing the elements you have defined.

Any new element definitions, and changes you make to user-defined elements are saved in the file `99user.ldif`.

To extend the directory schema you should proceed in the following order:

1. Create the new attributes first, as described in "Creating Attributes" on page 362.

2. Then create an object class to contain the new attributes and add the attributes to the object class. See "Creating Object Classes" on page 365 for information.

Managing Attribute Definitions

Directory Server Console provides an interface to view all attributes in your schema and to create, edit, and delete your own attribute definitions.

Viewing Attributes

To view information about all attributes that currently exist in your directory schema:

1. On the top-level Configuration tab of Directory Server Console, select the Schema node in the configuration tree, then select the Attributes tab in the right-hand panel.

   This tab contains tables that list all the standard (read-only) and user-defined attributes in the schema. Holding the mouse over a line of a table will display the description string for the corresponding attribute.

   The following tables describe the fields of the attribute tables.

Table 9-1 Columns of Tables in the Attributes Tab

Column Heading	Description
Name	The name, sometimes called the type, of the attribute.
OID	The object identifier of the attribute. An OID is a string, usually of dotted decimal numbers, that uniquely identifies the schema object. For more information about OIDs, or to request a prefix for your enterprise, send mail to the IANA (Internet Assigned Number Authority) at `iana@iana.org` or visit the IANA website at `http://www.iana.org/`.
Syntax	The syntax describes the allowed format of values for this attribute the possible syntaxes are listed in Table 9-2 o n page361
Multivalued	The checkbox in this column designates whether or not the attribute is multivalued. A multivalued attribute may appear any number of times in an entry, but a single valued attribute may only appear once.

Table 9-2 Attribute Syntax Definitions

Syntax Name	**Definition**
Binary (formerly `bin`)	Indicates that values for this attribute are treated as binary data.
Boolean	Indicates that this attribute has one of only two values: `True` or `False`.
Country String	Indicates that values for this attribute are limited to a two-letter country code specified by ISO 3166, for example FR.
DN (formerly `dn`)	Indicates that values for this attribute are DNs (distinguished names).
DirectoryString (formerly `cis`)	Indicates that values for this attribute may contain any UTF-8 encoded character and are not treated as case-sensitive.
GeneralizedTime	Indicates that values for this attribute are encoded as printable strings. The time zone must be specified. It is strongly recommended to use GMT.
IA5String (formerly `ces`)	Indicates that values for this attribute may contain only a subset of the ASCII characters and are treated as case-sensitive.
Integer (formerly `int`)	Indicates that valid values for this attribute are numbers.
OctetString	Same behavior as binary.
Postal Address	Indicates that values for this attribute are encoded as *dstring*`[$` *dstring*`]*` where each *dstring* component is encoded as a value with DirectoryString syntax. Backslashes and dollar characters within *dstring* must be quoted, so that they will not be mistaken for line delimiters. Many servers limit the postal address to 6 lines of up to thirty characters. For example: `1234 Main St.$Anytown, CA 12345$USA`
TelephoneNumber (formerly `tel`)	Indicates that values for this attribute are in the form of telephone numbers. It is recommended to use telephone numbers in international form.
URI	Indicates that the values for this attribute contain a URL, with an optional prefix such as `http://`, `https://`, `ftp://`, `ldap://`, or `ldaps://`. The URI values have the same behavior as IA5String (see RFC 2396, `http://www.ietf.org/rfc/rfc2396.txt`).

Creating Attributes

To add your own definition of an attribute to the schema:

1. On the top-level Configuration tab of Directory Server Console, select the Schema node in the configuration tree, then select the Attributes tab in the right-hand panel.

2. Click Create to display the Create Attribute dialog.

3. Enter the following information in the text fields to define your new attribute. Only the attribute name and syntax are required:

   - Attribute Name - Enter a unique name for the attribute, also called its attribute type. Attribute names must begin with a letter and only contain ASCII letters, digits, and hyphens.

NOTE The attribute name may contain upper-case letters, but no LDAP client should rely on them. Attribute names must be handled in a case-insensitive manner according to section 4.1.4 of RFC 2251 (`http://www.ietf.org/rfc/rfc2251.txt`).

   - Attribute OID (optional) - Enter an object identifier for your attribute. OIDs are described in Table 9-1 on page 360. If you do not specify an OID, Directory Server automatically uses *attributeName*`-oid`. Note that for strict LDAP v3 compliance, you must provide a valid, numeric OID.

   - Attribute aliases (optional) - Enter alternate names for your attribute in a comma-separated list.

   - Attribute description (optional) - Enter a short descriptive text to explain the attribute's purpose.

   - Syntax - Select a syntax from the drop-down list that describes the data to be held by the attribute. Available syntaxes are described in Table 9-2 on page 361.

   - Multi-valued - By default, attributes are multi-valued. Deselect this checkbox if your attribute must have only one value per entry.

4. Click OK in the Create Attribute dialog to define your new attribute. It will appear in the table of user-defined attributes.

   Before defining values for this attribute in directory entries, you must create or edit an object class that requires or allows it, as described in "Managing Object Class Definitions" on page 364.

Editing Attributes

You can edit only the user-defined attributes using the console. Before modifying the name, syntax, or multi-valued definition of an attribute, you must ensure that no entry in the directory currently uses this attribute, otherwise clients will be unable to access that entry.

To modify the schema definition of an attribute:

1. On the top-level Configuration tab of Directory Server Console, select the Schema node in the configuration tree, then select the Attributes tab in the right-hand panel.
2. Select the attribute that you want to edit in the table of User Defined Attributes and click Edit.
3. Modify the fields of the Edit Attribute dialog to redefine your attribute.

   If the OID string is based on the attribute's name, you should change the OID whenever you change the name. OIDs are described in Table 9-1 on page 360. Available syntaxes are described in Table 9-2 on page 361.
4. When you have finished editing the attribute, click OK to save your changes.

Deleting Attributes

You can delete only the user-defined attributes using the console. Before deleting an attribute definition, you must ensure that no entry in directory currently uses this attribute, otherwise clients will be unable to access that entry.

To delete the schema definition of an attribute:

1. On the top-level Configuration tab of Directory Server Console, select the Schema node in the configuration tree, then select the Attributes tab in the right-hand panel.
2. In the table of user-defined attributes, select the attribute and click Delete.
3. Confirm the delete when prompted.

   The server will delete the attribute definition immediately. You cannot undo this action.

Managing Object Class Definitions

Directory Server Console also provides an interface to view all object classes in your schema and to create, edit, and delete your own object class definitions.

Viewing Object Classes

To view information about all currently defined object classes:

1. On the top-level Configuration tab of Directory Server Console, select the Schema node in the configuration tree, then select the Object Classes tab in the right-hand panel.

   This tab contains lists of all the standard (read-only) and user-defined object classes in the schema.

2. Select the object class that you want to view from either list.

   The other fields in the tab display the following information about the selected object class:

Table 9-3 Fields of the Object Classes Tab

Field	Description
Required Attributes	Contains a list of attributes that must be present in entries that use this object class. This list includes inherited attributes.
Allowed Attributes	Contains a list of attributes that may be present in entries that use this object class. This list includes inherited attributes.
Parent	The parent identifies the object class from which an object class inherits its attributes and structure. Object classes automatically inherit the required and allowed attributes from their parent object class.
OID	The object identifier of the object class. An OID is a string, usually of dotted decimal numbers, that uniquely identifies the schema object. For more information about OIDs, or to request a prefix for your enterprise, send mail to the IANA (Internet Assigned Number Authority) at `iana@iana.org` or visit the IANA website at `http://www.iana.org/`.

Creating Object Classes

If you are creating several object classes that inherit from one another, you must create the parent object classes first. If your new object class will use custom attributes, you must also define those first.

NOTE The console only allows you to create structural object classes. These object classes must inherit from a parent. To define auxiliary and abstract object classes, you must use the command-line utilities.

To add your own definition of an object class to the schema:

1. On the top-level Configuration tab of Directory Server Console, select the Schema node in the configuration tree, then select the Object Classes tab in the right-hand panel.
2. Click Create to display the Create Object Class dialog.
3. Enter the following information in the text fields to define your new object class:
   - Name - Enter a unique name for the object class.
   - Parent - Select an existing object class to be the parent. By default, `top` is selected and must be used if your object class does not inherit from any other. The required and allowed attributes inherited from the parent and its parents are shown in the corresponding lists.

     Typically, if you want to add new attributes for user entries, the parent would be the `inetOrgPerson` object class. If you want to add new attributes for corporate entries, the parent is usually `organization` or `organizationalUnit`. If you want to add new attributes for group entries, the parent is usually `groupOfNames` or `groupOfUniqueNames`.
   - OID (Optional) - Enter an object identifier for your object class. OIDs are described in Table 9-3 on page 364. If you do not specify an OID, Directory Server automatically uses *objectClassName*`-oid`. Note that for strict LDAP v3 compliance, you must provide a valid, numeric OID.
4. Define the attributes that entries using your new object class will contain:
   - To define attributes that *must* be present, select one or more of them in the Available Attributes list and then click the Add button to the left of the Required Attributes box.

- To define attribute that *may* be present, select one or more of them in the Available Attributes list and then click the Add button to the left of the Allowed Attributes box.
- To remove an attribute that you previously added, highlight the attribute in either list and then click the corresponding Remove button. You cannot remove allowed or required attributes that are inherited from the parent object class.

5. Click OK in the Create Object Class dialog to define your new object class. It will appear in the table of user-defined object classes, and you may now define entries with this object class.

Editing Object Classes

You can edit only the user-defined object classes using the console. Before modifying the definition of an object class, you must ensure that no entry in the directory currently uses it, otherwise clients will be unable to access that entry.

To modify the schema definition of an object class:

1. On the top-level Configuration tab of Directory Server Console, select the Schema node in the configuration tree, then select the Object Class tab in the right-hand panel.
2. Select the object class that you want to edit in the list of User Defined Object Classes and click Edit.
3. Modify the fields of the Edit Object Class dialog to redefine your object class.

   You cannot rename the object class nor change its OID. To modify these, delete the object class and create a new one.

   - Parent - Select an existing object class to be the parent. The required and allowed attributes inherited from the parent and its parents are shown in the corresponding lists.
   - To define attributes that *must* be present, select one or more of them in the Available Attributes list and then click the Add button to the left of the Required Attributes box.
   - To define attribute that *may* be present, select one or more of them in the Available Attributes list and then click the Add button to the left of the Allowed Attributes box.

- To remove an attribute that you previously added, highlight the attribute in either list and then click the corresponding Remove button. You cannot remove allowed or required attributes that are inherited from the parent object class.

4. When you have finished editing the object class, click OK to save your changes.

Deleting Object Classes

You can delete only the user-defined object classes using the console. Before deleting an object class definition, you must ensure that no entry in the directory currently uses this object class, otherwise clients will be unable to access that entry.

To delete the schema definition of an object class:

1. On the top-level Configuration tab of Directory Server Console, select the Schema node in the configuration tree, then select the Object Class tab in the right-hand panel.
2. In the list of user-defined object classes, select the object class name and click Delete.
3. Confirm the delete when prompted.

   The server will delete the object class definition immediately. You cannot undo this action.

Replicating Schema Definitions

Whenever you configure the replication of one or more suffixes between two servers, the schema is automatically replicated as well. This ensures that all replicas have a complete, identical schema that defines all object classes and attributes that may be replicated to the consumers. Therefore, master servers also contain the master schema.

To enforce the schema on all replicas, you must enable schema checking on all masters. Because the schema is checked on the master where the LDAP operation is performed, it does not need to be checked when updating the consumer. To improve performance, the replication mechanism bypasses schema checking on consumer replicas.

NOTE You should not turn off schema checking on hubs and dedicated consumers. Schema checking has no performance impact on a consumer, and it should be left on to indicate that the replica contents conform to its schema.

Master servers replicate the schema automatically to their consumers during consumer initialization and anytime the schema is modified through the console or through the command-line tools. By default, the entire schema is replicated and any additional schema elements that do not yet exist on the consumer will be created there and stored in the `99user.ldif` file.

For example, assume a master server contains schema definitions in the `98mySchema.ldif` file when it is started, and you then define replication agreements to other servers, either masters, hubs, or dedicated consumers. When you subsequently initialize the replicas from this master, the replicated schemas will contain the definitions from `98mySchema.ldif`, but they will be stored in `99user.ldif` on the replica servers.

After the schema has been replicated during consumer initialization, modifying the schema in `cn=schema` on the master will also replicate the entire schema to the consumer. Therefore, any modifications to the master schema through the command-line utilities or through the console will be replicated to the consumers. These modifications will be stored in `99user.ldif` on the master, and by the same mechanism as above, they will also be stored in `99user.ldif` on the consumers.

Modifying Replicated Schema Files

The replication mechanism cannot detect any changes you make directly to the LDIF files that contain the schema. Therefore, if you update your schema as described in "Modifying the Schema Files" on page 358, your changes will not be replicated to consumers even after restarting the master.

Directory Server 5.2 provides the following script to "push" the changes in a schema file to consumers:

```
# ServerRoot/slapd-serverID/schema_push.pl
```

Use the following procedure to modify the schema files on a master server:

1. Add a new schema file or modify an existing one in the schema directory:

   ServerRoot`/slapd-`*serverID*`/config/schema`

   Schema files in this directory are writable only by the system user defined during installation. For more information, see "Modifying the Schema Files" on page 358.

2. Run the `schema_push.pl` script, as described above. This script does not actually "push" the schema to replicas, instead it writes a special attribute into the schema files so that they will be replicated as soon as they are loaded.

3. Restart the server. The server will load all schema files and the replication mechanism will replicate the new schema to its consumers.

Limiting Schema Replication

By default, whenever the replication mechanism replicates the schema, it sends the entire schema to its consumers. There are two situations where this is not desirable:

- Modifications to `cn=schema` using the console or from the command-line are limited to the user-defined schema elements, all of the standard schema is unchanged. If you modify the schema often, sending the large set of unchanged schema elements every time has a performance impact. You may improve replication and server performance by replicating only the user-defined schema elements.

- When a master on Directory Server 5.2 replicates to a consumer on Directory Server 5.1, the schema for the configuration attributes of these versions differ and create conflicts. In this case, you *must* replicate only the user-defined schema elements, as described below.

Use the following command to limit schema replication so that only the user-defined schema is replicated:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: cn=config
changetype: modify
replace: nsslapd-schema-repl-useronly
nsslapd-schema-repl-useronly: on
^D
```

The default value of `off` will cause the entire schema to be replicated when necessary.

Chapter 10

Indexing Directory Data

Like a book index, Directory Server indexes speed up searches by associating search strings with references to the directory contents. Indexes are tables of attribute values that are stored in separate database files. Indexes are created and managed independently for each suffix in the directory. Once you create an index in the suffix configuration, the server maintains the index automatically.

For an introduction to indexing, its costs and benefits, an explanation of the `nsslapd-allidsthreshold` attribute, and how to improve Directory Server performance, see Chapter 4, "Tuning Indexing," in the *Directory Server Performance Tuning Guide*.

This chapter contains the following sections:

Overview of Indexing

Indexes are stored for each suffix in files in the corresponding database directory. Each index file contains all of the indexes defined in the suffix for a given attribute. For example, all indexes maintained for the common name (`cn`) attribute are stored in the *databaseName*_`cn.db3` file.

Index files are created when you initialize a suffix or use the commands described in this chapter. During client search operations and internal operations, the server accesses the indexes to find entries in the directory faster. During modify operations, the directory updates the directory contents and maintains the index by updating the index files.

Directory Server supports the following types of indexes:

- Presence index (`pres`) - Contains a list of the entries that contain the particular attribute, regardless of its value.
- Equality index (`eq`) - Enables you to search efficiently for entries containing a specific attribute value.
- Approximate index (`approx`) - Provides efficient “sounds-like” searches using the ~= filter operator. For example, the approximate index is useful for searching partial names or misspelled names. Directory Server uses a variation of the metaphone phonetic algorithm to perform searches on an approximate index.

NOTE The metaphone phonetic algorithm in Directory Server supports only US-ASCII letters. Therefore, use approximate indexing only with English values.

- Substring index (`sub`) - Provides efficient searches of attribute value substrings, such as `cn=*john` or `cn=john*`. This is a costly index to maintain because of the many possible substrings for every value.

  Directory Server indexes substrings such that searches for a minimum of *two*-character substrings may be found in the index. A search for `(sn=*ab)` can therefore be accelerated using an index, for example, but a search for `(sn=*a)` cannot. Directory Server offers further optimization allowing initial substring searches of only one character *before* the wildcard. Thus a search for `(sn=a*)`, but not `(sn=*a)`, can also be accelerated when a substring index is available. For more information on substring indexes, see “Substring Indexes” in the *Directory Server Performance Tuning Guide*.
- Matching rule index - Speeds up searches in international directories by associating the OID of a localized matching rule (also called collation order) with the attributes to be indexed.
- Browsing index - Improves the response time of searches performed with the virtual list view (VLV) control. You may create a browsing index on any branchpoint in the directory tree to improve display performance of a very populated subtree, for example `ou=People,dc=example,dc=com`.

System Indexes

System indexes are indexes that cannot be deleted or modified. They are required for Directory Server to function properly and efficiently. The following table lists the system indexes created automatically in every suffix:

Table 10-1 System Indexes in Every Suffix

Attribute	Eq	Pres	Purpose
aci		X	Allows the directory server to quickly obtain the access control information maintained in the directory.
ancestorid	X		Contains a list of ancestors for every entry.
entrydn	X		Speeds up entry retrieval based on DN searches.
id2entry	X		Contains the actual database of directory entries. All other database files can be recreated from this one.
nsUniqueId	X		Used to search for specific entries.
nscpEntryDN	X		Used internally in Directory Server for replication.
nsds5ReplConflict	X	X	Used to help find replication conflicts.
numsubordinates		X	Used by Directory Server Console to enhance display performance on the Directory tab.
objectClass	X		Used to help accelerate subtree searches in the directory.
parentID	X		Enhances directory performance during one-level searches.

Default Indexes

When you create a new suffix in your directory, the server configures a set of default indexes in the corresponding database directory. The default indexes can be modified depending on your indexing needs, although you should ensure that no server plug-ins or other servers in your enterprise depend on an indexed attribute before you unconfigure its index.

To modify the set of default indexes that will be used when new suffixes are created, see "Modifying the Set of Default Indexes" on page 383.

The following tables lists the preconfigured default indexes in Directory Server:

Table 10-2 Default Indexes in Every New Suffix

Attribute	Eq	Pres	Sub	Purpose
`cn`	X	X	X	Improves the performance of the most common types of user directory searches.
`givenName`	X	X	X	Improves the performance of the most common types of user directory searches.
`mail`	X	X	X	Improves the performance of the most common types of user directory searches.
`mailAlternateAddress`	X			Used by Sun Java System Messaging Server.
`mailHost`	X			Used by Sun Java System Messaging Server.
`member`	X			Improves Sun Java System server performance. This index is also used by the referential integrity plug-in. See “Maintaining Referential Integrity” on page 88 for more information.
`nsCalXItemId`	X	X	X	Used by Sun Java System Calendar Server.
`nsLIProfileName`	X			Used by roaming feature of Sun Java System Messaging Server.
`nsRoleDN`	X			Improves the performance of role-based operations.
`nswcalCALID`	X			Used by Sun Java System Calendar Server.
`owner`	X			Improves Sun Java System server performance. This index is also used by the referential integrity plug-in. See “Maintaining Referential Integrity” on page 88 for more information.
`pipstatus`	X			Used by Sun Java System Servers.
`pipuid`		X		Used by Sun Java System Servers.
`seeAlso`	X			Improves Sun Java System server performance. This index is also used by the referential integrity plug-in. See “Maintaining Referential Integrity” on page 88 for more information.
`sn`	X	X	X	Improves the performance of the most common types of user directory searches.
`telephoneNumber`	X	X	X	Improves the performance of the most common types of user directory searches.
`uid`	X			Improves Sun Java System server performance.

Table 10-2 Default Indexes in Every New Suffix *(Continued)*

Attribute	Eq	Pres	Sub	Purpose
`uniquemember`	X			Improves Sun Java System server performance. This index is also used by the referential integrity plug-in. See "Maintaining Referential Integrity" on page 88 for more information.

Attribute Name Quick Reference Table

The following table lists all attributes which have a primary or real name as well as an alias. When creating indexes be sure to use the primary name.

Table 10-3 Primary Attribute Name and Their Alias

Primary Attribute Name	Attribute Alias
`authorCn`	`documentAuthorCommonName`
`authorSn`	`documentAuthorSurname`
`c`	`countryName`
`cn`	`commonName`
`co`	`friendlyCountryName`
`dc`	`domainComponent`
`dn`	`distinguishedName`
`drink`	`favoriteDrink`
`facsimileTelephoneNumber`	`fax`
`l`	`localityName`
`labeledUri`	`labeledUrl`
`mail`	`rfc822mailbox`
`mobile`	`mobileTelephoneNumber`
`o`	`organizationName`
`ou`	`organizationalUnitName`
`pager`	`pagerTelephoneNumber`
`sn`	`surname`
`st`	`stateOrProvinceName`

Table 10-3 Primary Attribute Name and Their Alias

Primary Attribute Name	Attribute Alias
`street`	`streetAddress`
`ttl`	`timeToLive`
`uid`	`userId`

Managing Indexes

This section describes how to create and remove presence, equality, approximate, substring and international indexes for specific attributes using Directory Server Console and the command line. See "Managing Browsing Indexes" on page 384 for the separate procedures required for virtual list view (VLV) operations.

NOTE Because indexes are specific to each suffix, you need to remember to create your new indexes in *every* suffix configuration.

When you create new suffixes using the console, you have the option of cloning the index configuration of an existing suffix.

Before you create new indexes, balance the benefits of maintaining indexes against the costs. Keep in mind that:

- Approximate indexes should not be used for attributes commonly containing numbers, such as telephone numbers, because they are not efficient.
- Substring indexes do not work for binary attributes.
- Equality indexes should not be used for large values such as attributes intended to contain binary data, for example `jpegPhoto`.
- Maintaining indexes requires more resources, therefore only attributes that are commonly searched should be indexed. Entry creation will require more CPU time because the server must examine all indexed attributes and generate new entries for each one contained in the new entry.
- The size of each index file is proportional to directory contents.
- Attributes that are not indexed can still be specified in search requests, although the search performance will not be comparable to that of indexed searches, depending on the type of search.

Managing Indexes Using the Console

If you plan to modify or add indexes on many attributes, you should first make the suffix read-only and then export its contents to LDIF. It will then be faster to reindex the suffix by reinitializing it from the LDIF file.

1. On the top-level Configuration tab of Directory Server Console, expand the Data node and select the suffix you want to index. Then select the Indexes tab in the right-hand panel.

   The table of System Indexes cannot be modified. Add, modify or remove indexes on attributes in the table of Additional Indexes.

2. To add an index on an attribute that is not yet indexed, click on the Add Attribute button. In the dialog that is displayed, select one or more attributes to index, and click OK.

   The new attributes appear in the table of Additional Indexes.

3. To modify the indexes of an attribute, select or deselect the checkboxes for each type of index you wish to maintain for that attribute in the table of Additional Indexes.

4. If you want to create an index for an attribute containing values in a language other than English, enter the OID of the collation order you want to use in the Matching Rules field.

   You can index the attribute using multiple languages by listing multiple OIDs separated by commas (but no whitespace). For the list of supported locales and the OID of their associated collation order, see Chapter 5, “Directory Internationalization Reference,” in the *Directory Server Administration Reference*.

5. To remove all indexes for an attribute, select its row in the table and click the Delete attribute button.

6. Click Save to save the new index configuration.

   If you removed all indexes of an attribute, the server will remove the index files for that attribute and the configuration is finished. If you modified the indexes of an attribute or added a new one, proceed with the following step.

7. A warning dialog informs you that you must update the database files to begin using the new index. You may either reindex the suffix or reinitialize it.

- ❍ If you added or modified only one or two indexes, or if your suffix must not be unavailable, you should reindex the suffix. Click on the Reindex Suffix button to display the reindexing dialog. By default, the attributes that you modified or added to the index configuration are selected. Click OK to begin reindexing these attributes. Reindexing many attributes for directories with millions of entries may take several hours, but the suffix will always be online during the reindexing.
- ❍ If you added or modified indexes on several attributes, and you have a recent LDIF file exported from this suffix, click on the Initialize suffix button. In the Initialize suffix dialog enter or browse the path and name of the LDIF file and click OK. The server will reinitialize the suffix from the LDIF file an create all indexes according to the new configuration. Depending on the size of the directory, reinitializing the suffix is usually faster than reindexing two or more attribute, but the suffix is unavailable during the initialization.
- ❍ If you do not reindex or reinitialize the suffix, all data will still be available but the new index will not be created and will not improve directory access performance.

If you reindex or reinitialize the suffix, the new index is immediately active for any new data that you add and any existing data in your directory. You do not have to restart your server.

Managing Indexes From the Command Line

Creating or modifying indexes from the command line involves two steps:

- Using the `ldapmodify` command-line utility to add or modify an index configuration entry. Indexes are configured separately in each suffix, and index configuration entries are stored with the corresponding database configuration.
- Running the `directoryserver db2index-task` command to generate the new set of indexes to be maintained by the server.

CAUTION You must not delete system indexes as deleting them can significantly affect Directory Server performance. System indexes are located in the following entries:

```
cn=index,cn=databaseName,cn=ldbm database,cn=plugins,cn=config
```

```
cn=default indexes,cn=config,cn=ldbm database,
 cn=plugins,cn=config
```

Take care when deleting default indexes, because they can also affect how Directory Server works.

Creating an Index Configuration Entry

To create an index for an attribute that is not already indexed, you must create a new entry for that attribute in the configuration of the corresponding database.

Index configuration entries have the following DN:

```
cn=attributeName,cn=index,cn=databaseName,cn=ldbm database,
 cn=plugins,cn=config
```

where *databaseName* is the name of the database corresponding to the suffix in which you wish to create the index. For example, the following command will create presence, equality, substring, and "sounds-like" indexes for values of the `sn` (surname) attribute in French:

```
ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
dn: cn=sn,cn=index,cn=databaseName,cn=ldbm database,
 cn=plugins,cn=config
objectClass: top
objectClass: nsIndex
cn: sn
nsSystemIndex: false
nsIndexType: pres
nsIndexType: eq
nsIndexType: sub
nsIndexType: approx
nsMatchingRule: 1.3.6.1.4.1.42.2.27.9.4.76.1
^D
```

Index configuration entries have the `nsIndex` object class, and the `nsSystemIndex` attribute must be present and its value must be `false`. You cannot create a new system index. Only the existing system indexes defined internally by Directory Server will be maintained.

The values of the `nsIndexType` attribute list the indexes that will be maintained for the given attribute. Use any of the values shown above to define the corresponding index.

You may also use the single value `none` to explicitly disable indexes for the attribute, for example in order to temporarily disable indexing of the attribute. If you do not include the `nsIndexType` attribute in your index configuration entry, all indexes will be maintained by default.

The optional `nsMatchingRule` attribute contains the OID of a language collation order for internationalized indexes. For the list of supported locales and the OID of their associated collation order, see Chapter 5, "Directory Internationalization Reference," in the *Directory Server Administration Reference*.

For more information about index configuration attributes, see "Default Index Attributes" in Chapter 2 of the *Directory Server Administration Reference*.

NOTE You should always use the attribute's primary name (not the attribute's alias) when creating indexes. The primary name of the attribute is the first name listed for the attribute in the schema, for example `uid` for the `userid` attribute. See Table 10-3 on page 375 for a list of all primary and alias attribute names.

Modifying an Index Configuration Entry

To configure the indexes that have already been defined on an attribute, modify the corresponding index entry. For example, the following command on the previously defined `sn` index configuration will remove the "sounds-like" index and change the language to Canadian French:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: cn=sn,cn=index,cn=databaseName,cn=ldbm database,
 cn=plugins,cn=config
changetype: modify
delete: nsIndexType
nsIndexType: approx
-
replace: nsMatchingRule
nsMatchingRule: 1.3.6.1.4.1.42.2.27.9.4.78.1
^D
```

Running db2index-task

Once you have created an indexing entry, added additional index types to an existing indexing entry, or modified its collation order, run the `directoryserver db2index-task` command to generate the new indexes. This command reads the contents of the suffix and reindexes the given attribute according to its configuration entry.

While this command is running, the contents of the suffix remain available through the server, but searches will not be indexed until the command has completed. Reindexing is a resource-intensive task that may impact the performance of other operations on the server. Depending on the size of the directory, reinitializing the suffix is usually faster than reindexing two or more attributes, but a suffix is unavailable during the initialization. For more information, see "Reinitializing a Suffix" on page 383.

The following example regenerates the *sn* index in the suffix corresponding to the *databaseName*.

```
# /usr/sbin/directoryserver db2index-task
  -D "cn=Directory Manager" -w password -n databaseName -t sn
```

For more information, see "db2index-task," in Chapter 1 of the *Directory Server Administration Reference*.

Deleting all Indexes for an Attribute

If you wish to remove all indexes configured for an attribute, you may remove its configuration entry and database file. For example, the following command will unconfigure all indexes for the `sn` attribute in the database named *databaseName*.

```
ldapdelete -h host -p port -D "cn=Directory Manager" -w password \
"cn=sn,cn=index,cn=databaseName,cn=ldbm database,cn=plugins, \
 cn=config"
```

Once you have deleted this entry, the indexes for the `sn` attribute will no longer be maintained in the suffix corresponding to the *databaseName* database. To save disk space you may also delete the corresponding index file because it will no longer be used by the server. In this example, you could delete the following file:

```
ServerRoot/slapd-serverID/db/databaseName/databaseName_sn.db3
```

Reindexing a Suffix

If your index files become corrupt, you will need to reindex the suffix to recreate the index files in the corresponding database directory. There are two ways to reindex a suffix using Directory Server Console, either reindexing or reinitialization.

Reindexing a Suffix

When you reindex a suffix, the server examines all of the entries it contains and rebuilds the index files. During reindexing, the contents of the suffix are available for read and write operations. However, the server must scan the entire suffix for every attribute that is reindexed. This may take up to several hours for suffixes with millions of entries, depending on the indexes you configure. Also, during reindexing, indexes are not available and server performance is impacted.

To reindex a suffix using the console:

1. On the top-level Configuration tab of Directory Server Console, expand the Data node to display the suffix you want to reindex.
2. Right-click the suffix configuration node and select Reindex from the pop-up menu. Alternatively, left-click the node to select it and then choose Reindex from the Object menu.

   The Reindex Suffix dialog is displayed with a list of all attributes that are indexed in the chosen suffix.
3. Select the checkbox beside each attribute you wish to reindex. Use the Check All and Check None buttons to help you make your selection. Because all indexes for a given attribute are stored in the same database file, you must reindex all of them together.
4. Click OK. The console displays a confirmation message about possible unexpected search results and performance impact during the reindexing.
5. Click Yes to begin reindexing.

   The console displays a dialog with any messages about the reindexing. Close the dialog when done.

To reindex a suffix from the command line, follow the instructions in "Running db2index-task" on page 381 and specify all attributes for which you wish to rebuild an index file.

Reinitializing a Suffix

When you reinitialize a suffix, its contents are replaced and new index files are created as the new contents are imported. Reinitializing a suffix is usually faster than reindexing more than one attribute because all attributes are indexed in one pass as the entries are loaded. However, the suffix is unavailable while it is being reinitialized.

All of the following steps may be performed using Directory Server Console or from the command line:

1. Set the suffix to read-only as described in "Setting Access Permissions and Referrals" on page 121. You must make the suffix unwritable first so that no modifications are made after you export the contents.
2. Export the entire suffix to an LDIF file as described in "Exporting a Single Suffix to LDIF Using the Console" on page 166.
3. Import the same LDIF file to reinitialize the suffix, as described in "Initializing a Suffix" on page 161.

   During the initialization, the suffix will be unavailable. When the initialization is done, all configured indexes will be ready to use.
4. Make the suffix writable again, as described in "Setting Access Permissions and Referrals" on page 121.

Modifying the Set of Default Indexes

The set of default indexes that is used when creating a new suffix is defined under the following entry:

```
cn=default indexes,cn=config,cn=ldbm database,cn=plugins,cn=config
```

Whenever you create a suffix using the console or from the command line, the default index definition entries will be copied as-is to become the initial index configuration of the corresponding database.

The set of default indexes may only be configured using the command-line utilities. The default index entries have exactly the same syntax as index configuration entries described in "Managing Indexes From the Command Line" on page 378. For example, use the following `ldapmodify` command to add a default index configuration entry:

```
ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
dn: cn=drink,cn=default indexes,cn=config,cn=ldbm database,
 cn=plugins,cn=config
objectClass: top
objectClass: nsIndex
cn: drink
nsSystemIndex: false
nsIndexType: eq
nsIndexType: sub
nsMatchingRule: 1.3.6.1.4.1.42.2.27.9.4.76.1
^D
```

After this entry has been added, any new suffix will have values of the `drink` attribute indexed for equality and substring searches in French.

To modify or delete the default index entries, use the `ldapmodify` or `ldapdelete` commands to edit the set of indexes in `cn=default indexes,cn=config,cn=ldbm database,cn=plugins,cn=config`.

Managing Browsing Indexes

Browsing indexes are special indexes used only for search operations that request server-side sorting or virtual list view (VLV) results. Using browsing indexes can improve the performance of searches that request server-side sorting of a large number of results. Depending on your directory configuration, the server may refuse to perform searches that request sorting when no browsing index is defined. This prevents large sorting operations from overloading server resources.

Browsing indexes apply to an entry that is the base of your searches, and you must create a separate index for every search filter you use in sorted requests. For example, if your client applications often request a sorted list of all users, you would create a browsing index on `ou=People` for the filter string used by your clients.

As with other indexes, there is a performance cost during update operations needed to maintain a browsing index. You should carefully plan and test the deployment of browsing indexes.

Browsing Indexes for the Console

Directory Server Console often performs searches of the entire directory to refresh the contents of it panels. If you have configured the console to sort the entries in the directory tree as described in "Directory Tree View Options" on page 36, you should create browsing indexes for the console.

The browsing indexes for the console are specific to the searches performed by the console. They are also created using the console. To create a browsing index for the console:

1. On the top-level Directory tab of Directory Server Console, browse the directory tree to display the parent of a large subtree that needs to be sorted, for example `ou=People,dc=example,dc=com` containing thousands of user entries.

2. Right-click the parent entry and select Create Browsing Index from the pop-up menu. Alternatively, left-click the entry to select it, and choose Create Browsing Index from the Object menu.

   The Create Browsing Index dialog box shows you the status of the index creation. The console creates the browsing index configuration entries shown below and then generates the contents of the index file.

3. Click Close to close the Create Browsing Index dialog box.

   The new index is immediately active for any console refresh operations and it will be maintained for any new data that you add to your directory. You do not have to restart your server.

The browsing index configuration for the console consists of the following entries. The `vlvSearch` entry defines the base, scope and filter of the search that will be indexed. The `vlvSort` attribute of the `vlvIndex` entry shows the attributes supported for sorting in the order in which they are sorted:

```
dn: cn=MCC entryDN,cn=databaseName,cn=ldbm database,
 cn=plugins,cn=config
objectClass: top
objectClass: vlvSearch
cn: MCC entryDN
vlvBase: "entryDN"
vlvScope: 1
vlvFilter: (|(objectclass=*)(objectclass=ldapsubentry))

dn: cn=by MCC entryDN, cn=MCC entryDN,cn=databaseName,
 cn=ldbm database,cn=plugins,cn=config
```

```
objectClass: top
objectClass: vlvIndex
cn: by MCC entryDN
vlvSort: cn givenname o ou sn uid
```

To delete a browsing index for Directory Server Console:

1. On the top-level Directory tab of Directory Server Console, browse the directory tree to display an entry where you have created a browsing index.
2. Right-click the entry and select Delete Browsing Index from the pop-up menu. Alternatively, left-click the entry to select it, and choose Delete Browsing Index from the Object menu. This menu item will only be active if the chosen entry has a Browsing Index for the console.
3. A Delete Browsing Index dialog box appears asking you to confirm that you want to delete the index. Click Yes to delete the browsing index.

Browsing Indexes for Client Searches

Customized browsing indexes for sorting client search results must be defined manually. Creating a browsing index, or virtual list view (VLV) index from the command line involves two steps:

- Add new browsing index entries or edit existing browsing index entries using the `ldapmodify` utility or the Directory tab of Directory Server Console.
- Run the `directoryserver vlvindex` command to generate the new set of browsing indexes to be maintained by the server.

Specifying the Browsing Index Entries

A browsing index is specific to a given search on a given base entry and its subtree. The browsing index configuration is defined in the database configuration of the suffix containing the entry.

NOTE	You cannot create browsing indexes in chained suffixes, only in local suffixes and subsuffixes.

Two entries are used to configure a browsing index. The first uses the `vlvSearch` object class and specifies the base, scope, and filter of the search operation whose results will be indexed. The second is a child of the first and uses the `vlvIndex` object class to specify the attributes to sort, and order in which to sort them.

The following example uses the `ldapmodify` utility to create the two browsing index configuration entries:

```
ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
dn: cn=Browsing ou=People, cn=databaseName,
 cn=ldbm database,cn=plugins,cn=config
objectClass: top
objectClass: vlvSearch
cn: Browsing ou=People
vlvbase: ou=People,dc=example,dc=com
vlvscope: 1
vlvfilter: (objectclass=inetOrgPerson)

dn: cn=Sort rev employeenumber, cn=Browsing ou=People,
 cn=databaseName,cn=ldbm database,cn=plugins,cn=config
objectClass: top
objectClass: vlvIndex
cn: Sort rev employeenumber
vlvSort: -employeenumber
^D
```

The `vlvscope` is either `0` for the base entry alone, `1` for the immediate children of the base, or `2` for the entire subtree rooted at the base. The `vlvfilter` is the same LDAP filter that will be used in the client search operations. Because all browsing index entries are located in the same place, you should use descriptive `cn` values to name your browsing indexes.

Each `vlvSearch` entry must have at least one `vlvIndex` entry. The `vlvSort` attribute is a list of attribute names that defines the attribute to sort on and the sorting order. The dash (-) in front of an attribute name indicates reverse ordering. You may define more than one index for a search by defining several `vlvIndex` entries. With the previous example, you could add the following entry:

```
ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
dn: cn=Sort sn givenname uid, cn=Browsing ou=People,
 cn=databaseName,cn=ldbm database,cn=plugins,cn=config
objectClass: top
objectClass: vlvIndex
cn: Sort sn givenname uid
vlvSort: sn givenname uid
^D
```

To modify a browsing index configuration, edit the corresponding `vlvSearch` or `vlvIndex` entry. To remove a browsing index so it is no longer maintained by the server, remove the individual `vlvIndex` entries, or if there is only one, remove both the `vlvSearch` entry and the `vlvIndex` entry. When you remove a `vlvIndex` entry, you may also remove the corresponding database file, for example:

```
ServerRoot/slapd-serverID/db/dbName/dbName_vlv#Sortsngivennameuid.db3
```

Running the vlvindex Command

Once you have created the browsing index entries or modified existing ones, you must run the `directoryserver vlvindex` command to generate the new set of browsing indexes. This command will scan the directory contents and create a database file for the browsing index.

To generate browsing indexes, use the following command:

```
# /usr/sbin/directoryserver vlvindex
```

The following example generates the browsing indexes defined in the previous section:

```
# /usr/sbin/directoryserver vlvindex -n databaseName -T "Browsing ou=People"
```

Table 10-4 Description of vlvindex Options Used in the Example

Option	Description
`-n`	Specifies the name of the database containing the entries to be indexed.
`-T`	Specifies the value of the naming attribute of the `vlvSearch` entry of the corresponding browsing index. All indexes corresponding to the `vlvIndex` entries of the given `vlvSearch` entry will be generated.

For more information, see “vlvindex,“ in Chapter 1 of the *Directory Server Administration Reference*.

Chapter 11

Managing Authentication and Encryption

Directory Server supports several mechanisms to provide secure and trusted communications over the network. LDAPS is the standard LDAP protocol that runs on top of the Secure Sockets Layer (SSL) to encrypt data and optionally use certificates for authentication.

Directory Server also supports the Start Transport Layer Security (Start TLS) extended operation to enable TLS on an LDAP connection that was originally not encrypted.

Directory Server now also supports the Generic Security Services API (GSSAPI) over the Simple Authentication and Security Layer (SASL). This allows you to use the Kerberos Version 5 security protocol on the Solaris Operating System. An identity mapping mechanism then associates the Kerberos principal with an identity in the directory.

For additional security information, refer to the NSS website at:

`http://www.mozilla.org/projects/security/pki/nss/`

This chapter contains the following sections:

Introduction to SSL in Directory Server

The Secure Sockets Layer (SSL) provides encrypted communications and optional authentication between a Directory Server and its clients. SSL may be enabled for both the LDAP and DSML-over-HTTP protocols to provide security for any connection to the server. In addition, the replication and chaining suffix mechanisms may be configured to use SSL for secure communications between servers.

Using SSL with simple authentication (bind DN and password) will encrypt all data sent to and from the server to guarantee confidentiality and data integrity. Optionally, clients may use a certificate to authenticate to Directory Server or a third-party security mechanism through the Simple Authentication and Security Layer (SASL). Certificate-based authentication uses public-key cryptography to prevent forgery and impersonation of either client or server.

Directory Server is capable of simultaneous SSL and non-SSL communications on separate ports. For security reasons, you may also restrict all communications to the secure port. Client authentication is also configurable and may be either required or simply allowed to determine the level of security you enforce.

Enabling SSL also enables support for the Start TLS extended operation that provides security on a regular LDAP connection. Clients may bind to the non-SSL port and then use the Transport Layer Security protocol to initiate an SSL connection. The Start TLS operation allows more flexibility for clients and may help simplify port allocation.

The encryption mechanisms provided by SSL are also used for attribute encryption. Enabling SSL will allow you to configure attribute encryption on your suffixes to protect data while it is stored in the directory. For more information, see “Encrypting Attribute Values” on page 83.

For additional security, access control to directory contents may be configured according to the client’s use of SSL and certificates. You may define access control instructions (ACIs) which require a specific authentication method, and will thus ensure that data can only be transmitted over a secure channel. For more information, see “Bind Rules” on page 221.

For a complete description of SSL, internet security, and certificates, including how to configure SSL in your Administration Server as well, see Chapter 10, “Using SSL and TLS with Sun Java System Servers” in the *Administration Server Administration Guide*.

Summary of Steps for Enabling SSL

Each of the following steps are covered in the subsequent sections of this chapter:

1. Obtain and install a certificate for your Directory Server, and configure Directory Server to trust the certification authority's certificate. This procedure includes:
    a. Creating a certificate database if necessary.
    b. Generating and sending a certificate request from your server to your Certificate Authority who will provide your server certificate.
    c. Installing your new certificate in the server.
    d. Trusting your Certificate Authority and all certificates it issues.
2. Activate and configure SSL in your directory, including the secure ports for LDAP and DSML operations. You may also configure Directory Server Console to access the server using SSL.
3. Optionally, configure the server for one or more of the following client authentication mechanisms:
    a. The default certificate-based authentication.
    b. The DIGEST_MD5 authentication mechanism over SASL.
    c. The GSSAPI authentication over SASL that allows use of the Kerberos V5 security mechanism.
4. Configure your clients to use SSL when communicating with Directory Server, including any of the optional authentication mechanisms you wish to use.

Some of the steps above may also be performed with the `certutil` tool to manage certificates through the command line. This tool is provided in the `SUNWtlsu` package.

Obtaining and Installing Server Certificates

This section describes the process of creating a certificate database, obtaining and installing a certificate for use with Directory Server, and configuring Directory Server to trust the Certificate Authority's (CA) certificate.

Creating a Certificate Database

The first time you configure SSL on your server, you must set the password for your security device. If you are not using an external hardware security device, the internal security device is a certificate and key database stored in the following files:

```
ServerRoot/alias/slapd-serverID-cert8.db
ServerRoot/alias/slapd-serverID-key3.db
```

If your *serverID* contains upper-case letters, you must use the command-line procedure below to create your certificate database.

Using the Console

When using the console, the server will create the certificate database files automatically the first time you invoke the certificate manager dialog:

1. On the top-level Tasks tab of Directory Server Console, click the Manage Certificates button. Alternatively, with the Tasks tab showing, select the Manage Certificates item from the Console>Security menu.
2. The server will automatically create a certificate and key database, and you will be asked to set its password for the security device. This password protects the private keys of the certificates stored in your server. Enter the password twice to confirm it, then click OK.

Using the Command Line

When creating the certificate database files from the command line, you must use the path and file name prefixes shown in the following procedure so that the server can find them.

1. On the server host machine, create a certificate database with the following command:

   ```
   certutil -N -d ServerRoot/alias -P slapd-LCserverID
   ```

   where *LCserverID* is your server name in all lower-case letters.

   The tool will prompt you for a password to protect the keys of the certificates.

Generating a Certificate Request

Use one of the following procedures to generate a PKCS #10 certificate request in PEM format. PEM is the Privacy Enhanced Mail format specified by RFCs 1421 through 1424 (`http://www.ietf.org/rfc/rfc1421.txt`) and used to represent a base64-encoded certificate request in US-ASCII characters. The content of the request will look similar to the following example:

```
-----BEGIN NEW CERTIFICATE REQUEST-----
MIIBrjCCARcCAQAwbjELMAkGA1UBhMCVXMxEzARBgNVBAgTCkNBElGT1JOSUExLD
AqBgVBAoTI25ldHNjYXBlIGNvb11bmljYXRpb25zIGNvcnBvcmF0aWuMRwwGgYDV
QQDExNtZWxsb24umV0c2NhcGUuY29tMIGfMA0GCSqGSIb3DQEBAUAA4GNADCBiQK
BgCwAbskGh6SKYOgHy+UCSLnm3ok3X3u83Us7u0EfgSLR0f+K41eNqqWRftGR83e
mqPLDOf0ZLTLjVGJaHJn4l1gG+JDf/n/zMyahxtV7+T8GOFFigFfuxJaxMjr2j7I
vELlxQ4IfZgwqCm4qQecv3G+N9YdbjveMVXW0v4XwIDAQABAAwDQYJKoZIhvcNAQ
EEBQADgYEAZyZAm8UmP9PQYwNy4Pmypk79t2nvzKbwKVb97G+MT/gw1pLRsuBoKi
nMfLgKp1Q38K5Py2VGW1E47/rhm3yVQrIiwV+Z8Lcc=
-----END NEW CERTIFICATE REQUEST-----
```

Using the Console

1. On the top-level Tasks tab of Directory Server Console, click the Manage Certificates button. Alternatively, with the Tasks tab showing, select the Manage Certificates item from the Console>Security menu.

   The Manage Certificates dialog is displayed.

2. Select the Server Certs tab, and click the Request button.

   The Certificate Request Wizard is displayed.

3. If you have installed a plug-in allowing the server to communicate directly with the CA, you may select it now. Otherwise, you must request a certificate manually by transmitting the generated request via email or a website. Click Next to continue.

4. Enter the Requestor Information in the blank text fields:

   Server Name. Enter the fully qualified hostname of the Directory Server as it is used in DNS lookups, for example, `east.example.com`.

   Organization. Enter the legal name of your company or institution. Most CAs require you to verify this information with legal documents such as a copy of a business license.

   Organizational Unit. (Optional). Enter a descriptive name for your division or business unit within your company.

Locality. (Optional). Enter your company's city name.

State or Province. Enter the full name of your company's state or province, with no abbreviations.

Country. Select the two-character abbreviation for your country's name in ISO format. The country code for the United States is US. Chapter 5, "Directory Internationalization Reference" in the *Directory Server Administration Reference* contains a list of ISO Country Codes.

Click Next to continue.

5. Enter the password of your security device, then click Next. This is the password set in "Creating a Certificate Database" on page 392.
6. Select Copy to Clipboard or Save to File to save the certificate request information that you must send to the Certificate Authority.
7. Click Done to dismiss the Certificate Request Wizard.

Using the Command Line

1. Create a request for a server certificate with the following command:

```
certutil -R \
-s "cn=serverName,ou=division,o=company,l=city,st=state,c=country" \
-a -d ServerRoot/alias -P slapd-serverID-
```

   The `-s` option specifies the DN of the requested server certificate. Certificate Authorities usually require all of the attributes shown in this example in order to completely identify the server. See Step 4 above for a description of each attribute.

2. The `certutil` tool will prompt you for the password to the server's key database. This is the password set in "Creating a Certificate Database" on page 392. The tool will then generate a PKCS #10 certificate request in the PEM encoded text format.

Installing the Server Certificate

Transmit the request from the previous section to your Certificate Authority, according to its procedures. For example, you may be asked to send the certificate request in an email, or you may be able to enter the request through the CA's website.

Once you have sent your request, you must wait for the CA to respond with your certificate. Response time for your request varies. For example, if your CA is internal to your company, it may only take a day or two to respond to your request. If your selected CA is external to your company, it could take several weeks to respond to your request.

When the CA sends a response, be sure to save the information in a text file. The PKCS #11 certificate in PEM format will look similar to the following example.

```
-----BEGIN CERTIFICATE-----
MIICjCCAZugAwIBAgICCEEwDQYJKoZIhKqvcNAQFBQAwfDELMAkGA1UEBhMCVVMx
IzAhBgNVBAoGlBhbG9a2FWaWxsZGwSBXaWRnZXRzLCBJbmMuMR0wGwYDVQQLExRX
aWRnZXQgTW3FrZXJzICdSJyBVczEpMCcGAx1UEAxgVGVzdCBUXN0IFRlc3QgVGVz
dCBUZXN0IFlc3QgQ0EswHhcNOTgwMzEyMDIzMzUWhcNOTgwMzI2MDIzMpzU3WjBP
MQswCYDDVQQGEwJVUzEoMCYGA1UEChMfTmV0c2NhcGUgRGlyZN0b3J5VIFB1Ymxp
Y2F0aW9uczEWMB4QGA1UEAxMNZHVgh49dq2tLNvbjTBaMA0GCSqGSIb3DQEBAQUA
A0kAMEYkCQCksMR/aLGdfp4m0OiGgijG5KgOsyRNvwGYW7kfW+8mmijDtZaRjYNj
jcgpF3VnlbxbclX9LVjjNLC5737XZdAgEDozYwpNDARBglghkgBhvhCEAQEEBAMC
APAwHkwYDVR0jBBgwFAU67URjwCaGqZHUpSpdLxlzwJKiMwDQYJKoZIhQvcNAQEF
BQADgYEAJ+BfVem3vBOPBveNdLGfjlb9hucgmaMcQa9FA/db8qimKT/ue9UGOJqL
bwbMKBBopsDn56p2yV3PLIsBgrcuSoBCuFFnxBnqSiTS7YiYgCWqWaUA0ExJFmD6
6hBLseqkSWulk+hXHN7L/NrViO+7zNtKcaZLlFPf7d7j2MgX4Bo=
-----END CERTIFICATE-----
```

You should also back up the certificate data in a safe location. If your system ever loses the certificate data, you can reinstall the certificate using your backup file.

Once you have your server certificate, you are ready to install it in your server's certificate database.

Using the Console

1. On the top-level Tasks tab of Directory Server Console, click the Manage Certificates button. Alternatively, with the Tasks tab showing, select the Manage Certificates item from the Console>Security menu.

   The Manage Certificates window is displayed.

2. Select the Server Certs tab, and click Install.

   The Certificate Install Wizard is displayed.

3. Choose one of the following options for the certificate location:

   In this file. Enter the absolute path to the certificate in this field.

In the following encoded text block. Copy the text from the Certificate Authority or from the text file you created and paste it in this field. For example:

Click Next to continue.

4. Verify that the certificate information displayed is correct, then click Next.
5. Specify a name for the certificate, then click Next. This is the name that will appear in the table of certificates.
6. Verify the certificate by providing the password that protects the private key. This password is the same as the one you provided in Step 2 of "Creating a Certificate Database" on page 392. Click Done when you are finished.

   Your new certificate appears in the list on the Server Certs tab. Your server is now ready for SSL activation.

Using the Command Line

1. Install the new server certificate in your certificate database with the following command:

   ```
   certutil -A -n "certificateName" -t "u,," -a -i certFile \
            -d ServerRoot/alias -P slapd-serverID-
   ```

   where *certificateName* is a name you give to identify your certificate, and *certFile* is the text file containing the PKCS #11 certificate in PEM format. The `-t "u,,"` option indicates that this is a server certificate for SSL communications.

2. Optionally, you may also use the following `certutil` command to verify your installed certificates:

   ```
   certutil -L -d ServerRoot/alias -P slapd-serverID-
   ```

   The certificates listed with a trust attribute of `u,,` are the server certificates.

Trusting the Certificate Authority

Configuring your Directory Server to trust the Certificate Authority consists of obtaining its certificate and installing it into your server's certificate database. This process differs depending on the certificate authority you use. Some commercial CAs provide a website that allows you to automatically download the certificate, and others will email it to you upon request.

Using the Console

Once you have the CA certificate, you can use the Certificate Install Wizard to configure Directory Server to trust the Certificate Authority.

1. On the top-level Tasks tab of Directory Server Console, click the Manage Certificates button. Alternatively, with the Tasks tab showing, select the Manage Certificates item from the Console>Security menu.

   The Manage Certificates window is displayed.

2. Select the CA Certs tab, and click Install.

   The Certificate Install Wizard is displayed.

3. If you saved the CA's certificate to a file, enter the path in the field provided. If you received the CA's certificate via email, copy and paste the certificate including the headers into the text field provided. Click Next.

4. Verify that the certificate information displayed is correct for your Certificate Authority, then click Next.

5. Specify a name for the certificate, then click Next.

6. Select the purpose of trusting this CA. You may select either or both:

   Accepting connections from clients (Client Authentication). Select this checkbox if your LDAP clients perform certificate-based client authentication by presenting certificates issued by this CA.

   Accepting connections to other servers (Server Authentication). Select this checkbox if your server will play a replication supplier or chaining multiplexor role over SSL with another server that has a certificate issued by this CA.

7. Click Done to dismiss the wizard.

Using the Command Line

1. You may also use the following command to install a trusted CA certificate:

   ```
   certutil -A -n "CAcertificateName" -t "trust,," -a -i certFile \
           -d ServerRoot/alias -P slapd-serverID-
   ```

   where *CAcertificateName* is a name you give to identify the trusted CA, *certFile* is the text file containing the PKCS #11 certificate of the CA in PEM encoded text format, and the *trust* is one of the following codes:

   - `T` - This CA is trusted to issue client certificates. Use this code if your LDAP clients perform certificate-based client authentication by presenting certificates issued by this CA.

- `C` - This CA is trusted to issue server certificates. Use this code if your server will play a replication supplier or chaining multiplexor role over SSL with another server that has a certificate issued by this CA.
- `CT` - This CA is trusted to issue both client and server certificates. Use this code if both cases above apply to this CA.

2. Optionally, you may also use the following `certutil` command to verify your installed certificates:

   ```
   certutil -L -d ServerRoot/alias -P slapd-serverID
   ```

   The certificates listed with a trust attribute of `u,,` are the server certificates and those with `CT,,` are trusted CA certificates.

Activating SSL

Once you have installed your server certificate and trusted the CA's certificate, you are ready to activate SSL. Most of the time, you want your server to run with SSL enabled. If you temporarily disable SSL, make sure you re-enable it before processing operations that require confidentiality, authentication, or data integrity.

Before you can activate SSL, you must create a certificate database, obtain and install a server certificate and trust the CA's certificate as described in "Obtaining and Installing Server Certificates" on page 391.

Then, the following procedure will activate SSL communications and enable encryption mechanisms in the directory server:

1. On the top-level Configuration tab of Directory Server Console, select the root node with the server name, and then select the Encryption tab in the right-hand panel.

   The tab displays the current server encryption settings.

2. Indicate that you want encryption enabled by selecting the "Enable SSL for this Server" checkbox.
3. Check the "Use this Cipher Family" checkbox.
4. Select the certificate that you want to use from the drop-down menu.
5. Click Cipher Settings and select the ciphers you want to use in the Cipher Preference dialog. For more information about specific ciphers, see "Choosing Encryption Ciphers" on page 400.

6. Set your preferences for client authentication:

   Do not allow client authentication. With this option, the server will ignore the client's certificate and will refuse authentication based on it.

   Allow client authentication. This is the default setting. With this option, authentication is performed on the client's request. For more information about certificate-based authentication, see "Configuring Client Authentication" on page 402.

NOTE If you are using certificate-based authentication with replication, then you must configure the consumer server to either allow or require client authentication.

   Require client authentication. With this option, the client connection will be refused if the client does not respond to the server's request for authentication.

NOTE If Server Console connects to Directory Server over SSL, selecting "Require client authentication" disables communication because the Server Console does not have a certificate to use for client authentication. To modify this attribute from the command line, see "Allowing Client Authentication" on page 402.

7. Optionally, select Use SSL in Server Console if you want the Console to use SSL when communicating with Directory Server.

8. Click Save when done.

9. Optionally, set the secure port you want the server to use for SSL communications in both LDAP and DSML-over-HTTP protocols. See "Changing Directory Server Port Numbers" on page 39 for information.

   All connections to the secure port must use SSL. Regardless of whether you configure the secure port, once SSL is activated, clients may use the Start TLS operation to perform SSL encryption over the non-secure port.

10. Restart Directory Server.

    See "Starting the Server with SSL Enabled" on page 26 for more information.

Choosing Encryption Ciphers

A *cipher* is the algorithm used to encrypt and decrypt data. Generally speaking, the more bits a cipher uses during encryption, the *stronger* or more secure it is. Ciphers for SSL are also identified by the type of message authentication used. Message authentication is another algorithm which computes a checksum that guarantees data integrity. For a more complete discussion of cipher algorithms and their strengths, see "Ciphers Used With SSL" in Appendix B of the *Administration Server Administration Guide*.

When a client initiates an SSL connection with a server, the client and server must agree on a cipher to use to encrypt information. In any two-way encryption process, both parties must use the same cipher, normally the strongest one supported by both parties.

Directory Server provides the following ciphers for SSL 3.0 and TLS:

Table 11-1 Ciphers Provided with Directory Server

Cipher Name	Description
None	No encryption, only MD5 message authentication (rsa_null_md5).
RC4 (128 bits)	RC4 cipher with 128-bit encryption and MD5 message authentication (rsa_rc4_128_md5).
RC4 (Export)	RC4 cipher with 40-bit encryption and MD5 message authentication (rsa_rc4_40_md5).
RC2 (Export)	RC2 cipher with 40-bit encryption and MD5 message authentication (rsa_rc2_40_md5).
DES or DES (Export)	DES with 56-bit encryption and SHA message authentication (rsa_des_sha).
DES (FIPS)	FIPS DES with 56-bit encryption and SHA message authentication. This cipher meets the FIPS 140-1 U.S. government standard for implementations of cryptographic modules (rsa_fips_des_sha).
Triple-DES	Triple DES with 168-bit encryption and SHA message authentication (rsa_3des_sha).
Triple-DES (FIPS)	FIPS Triple DES with 168-bit encryption and SHA message authentication. This cipher meets the FIPS 140-1 U.S. government standard for implementations of cryptographic modules (rsa_fips_3des_sha).
Fortezza	Fortezza cipher with 80-bit encryption and SHA message authentication.
RC4 (Fortezza)	Fortezza RC4 cipher with 128-bit encryption and SHA message authentication.

Table 11-1 Ciphers Provided with Directory Server *(Continued)*

Cipher Name	Description
None (Fortezza)	No encryption, only Fortezza SHA message authentication.

In order to continue using Server Console with SSL, you must select at least one of the following ciphers:

- RC4 cipher with 40-bit encryption and MD5 message authentication.
- No encryption, only MD5 message authentication (not recommended).
- DES with 56-bit encryption and SHA message authentication.
- RC4 cipher with 128-bit encryption and MD5 message authentication.
- Triple DES with 168-bit encryption and SHA message authentication.

Use the following procedure to choose the ciphers you want the server to use:

1. On the top-level Configuration tab of Directory Server Console, select the root node with the server name, and then select the Encryption tab in the right-hand panel.

   The tab displays the current server encryption settings. Make sure SSL is enabled for your server as described in "Activating SSL" on page 398.

2. Click Cipher Settings.

   The Cipher Preference dialog box is displayed.

3. In the Cipher Preference dialog box, specify which ciphers you want your server to use by selecting or deselecting the checkbox beside their name.

   Unless you have a security reason to not use a specific cipher, you should select all of the ciphers, except for `none,MD5`.

CAUTION Avoid selecting the cipher with no encryption and only MD5 message authentication, because the server will use this option if no other ciphers are available on the client. In this situation, the connection is not secure because no encryption is used.

4. Click OK in the Cipher Preference dialog, then click Save in the Encryption Tab.

Allowing Client Authentication

If you have configured Directory Server to *require* client authentication and Server Console to connect using SSL, you can no longer use Server Console to manage any of your Sun Java System servers. You will have to use the appropriate command-line utilities instead.

However, if you wish to change your directory configuration so that you can use Server Console, you must follow these steps to no longer *require* but *allow* client authentication:

1. Modify the `cn=encryption,cn=config` entry with the following command:

   ```
   ldapmodify -h host -p port -D "cn=Directory Manager" -w password
   dn: cn=encryption,cn=config
   changetype: modify
   replace: nsSSLClientAuth
   nsSSLClientAuth: allowed
   ^D
   ```

2. Restart Directory Server as described in "Starting and Stopping the Server From the Command Line" on page 25.

   You can now start Server Console.

Configuring Client Authentication

Client authentication is a mechanism for the server to verify the identity of the client. Client authentication may be performed simply (by providing a dn and a password), using a certificate presented by the client, or through a SASL-based mechanism such as DIGEST-MD5. On the Solaris operating system, the Directory Server now supports the GSSAPI mechanism through SASL, which allows the authentication of a client through Kerberos V5.

Certificate-based authentication uses the client certificate obtained through the SSL protocol to find a user entry for identification. This mechanism is also known as `EXTERNAL` because it relies on an authentication mechanism that has already been established at a lower layer. (External authentication may be used with the IP Security Protocol (ipsec) in a future release.)

Certificate-based authentication is fully described in "Using Client Authentication" in Chapter 9 of the *Administration Server Administration Guide*.

The following sections describe how to configure the two SASL mechanisms on Directory Server. See also "Configuring LDAP Clients to Use Security" on page 411.

SASL Authentication Through DIGEST-MD5

The DIGEST-MD5 mechanism authenticates clients by comparing a hashed value sent by the client with a hash of the user's password. However, because the mechanism must read user passwords, all users wishing to be authenticated through DIGEST-MD5 must have `{CLEAR}` passwords in the directory. When storing `{CLEAR}` passwords in the directory, you must ensure that access to password values is properly restricted through ACIs, as described in Chapter 6, "Managing Access Control". You may wish to further protect `{CLEAR}` passwords by configuring attribute encryption in that suffix, as described in "Encrypting Attribute Values" on page 83.

Configuring the DIGEST-MD5 Mechanism

The following procedure explains the steps necessary to configure Directory Server to use DIGEST-MD5:

1. Using either the console or the `ldapsearch` command, verify that `DIGEST-MD5` is a value of the `supportedSASLMechanisms` attribute on the root entry. For example, the following command will show which SASL mechanisms are enabled:

   ```
   ldapsearch -h host -p port -D "cn=Directory Manager" -w password \
   -s base -b "" "(objectclass=*)" supportedSASLMechanisms
   ```

   ```
   dn:
   supportedSASLMechanisms: EXTERNAL
   supportedSASLMechanisms: DIGEST-MD5
   supportedSASLMechanisms: GSSAPI
   ^D
   ```

2. If DIGEST-MD5 is not enabled, use the following `ldapmodify` command to enable it:

   ```
   ldapmodify -h host -p port -D "cn=Directory Manager" -w password
   dn: cn=SASL, cn=security, cn=config
   changetype: modify
   add: dsSaslPluginsEnable
   dsSaslPluginsEnable: DIGEST-MD5
   ```

```
-
replace: dsSaslPluginsPath
dsSaslPluginsPath: ServerRoot/lib/sasl
^D
```

3. Use the default identity mapping for DIGEST-MD5, or create new ones as described in "DIGEST-MD5 Identity Mappings" on page 404.

4. Ensure that the password is stored in `{CLEAR}` for all users who will access the server through SSL using DIGEST-MD5. See Chapter 7, "Managing User Accounts and Passwords," for instructions on how to configure password storage schemes.

CAUTION

5. Restart the directory server if you modified the SASL configuration entry or one of the DIGEST-MD5 identity mapping entries.

DIGEST-MD5 Identity Mappings

Identity mappings for SASL mechanisms try to match credentials of the SASL identity with a user entry in the directory. See "Identity Mapping" on page 408 for a complete description of this mechanism. Authentication will fail if the mapping cannot find a DN that corresponds to the SASL identity.

The SASL identity is a string called the *Principal* that represents a user in a format specific to each mechanism. In DIGEST-MD5, it is recommended that clients create a Principal which contains either a `dn:` prefix and an LDAP DN or a `u:` prefix followed by any text determined by the client. During the mapping, the Principal sent by the client is available in the `${Principal}` place-holder.

The default identity mapping for DIGEST-MD5 is given by the following entry in your server configuration:

```
dn: cn=default,cn=DIGEST-MD5,cn=identity mapping,cn=config
objectClass: top
objectClass: nsContainer
objectClass: dsIdentityMapping
objectClass: dsPatternMatching
cn: default
dsMatching-pattern: ${Principal}
dsMatching-regexp: dn:(.*)
dsMappedDN: $1
```

This identity mapping assumes the `dn` field of the Principal contains the exact DN of an existing user in the directory.

To define you own identity mappings for DIGEST-MD5:

1. Edit the default mapping entry or create new mapping entries under `cn=DIGEST-MD5,cn=identity mapping,cn=config`. See "Identity Mapping" on page 408 for the definition of the attributes in an identity mapping entry. An example mapping for DIGEST-MD5 is located in the following file:

   ServerRoot`/slapd-`*serverID*`/ldif/identityMapping_Examples.ldif`

   This example assumes that the unqualified text field of the Principal contains the username of the desired identity. The following command shows how this mapping would be defined:

   ```
   ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
   dn: cn=unqualified-username,cn=DIGEST-MD5,cn=identity mapping,
    cn=config
   objectclass: dsIdentityMapping
   objectclass: dsPatternMatching
   objectclass: nsContainer
   objectclass: top
   cn: unqualified-username
   dsMatching-pattern: ${Principal}
   dsMatching-regexp: u:(.*)@(.*)\.com
   dsSearchBaseDN: dc=$2
   dsSearchFilter: (uid=$1)
   ```

2. Restart Directory Server for your new mappings to take effect.

SASL Authentication Through GSSAPI (Solaris Only)

The Generic Security Services API (GSSAPI) over SASL allows you to use a third-party security system such as Kerberos V5 to authenticate clients. The GSSAPI library is available only on the Solaris platform. Sun recommends you install the Kerberos V5 implementation in the Sun Enterprise Authentication Mechanism (SEAM) 1.0.1 server.

The server will use this API to validate the identity of the user. Then, the SASL mechanism will apply the GSSAPI mapping rules to obtain a DN that is the bind DN for all operations during this connection.

Configuring the Kerberos System

Configure the Kerberos software according to the manufacturer's instructions. If you are using the SEAM 1.0.1 server, this includes the following steps:

1. Configure the files in `/etc/krb5`.
2. Create the Kerberos database to store users and services, and in it create the principal for the LDAP service. The LDAP service principal is:

   `ldap/`*serverFQDN@REALM*

   where the *serverFQDN* is the fully qualified domain name of your server.
3. Create a keytab to store the service keys, including one for the LDAP service.
4. Start the Kerberos daemon processes.

Please refer to your software documentation for detailed instructions for each of these steps.

Configuring the GSSAPI Mechanism

The following procedure explains the steps necessary to configure Directory Server to use GSSAPI on the Solaris platform:

1. Using either the console or the `ldapsearch` command, verify that `GSSAPI` is a value of the `supportedSASLMechanisms` attribute on the root entry. For example, the following command will show which SASL mechanisms are enabled:

   ```
   ldapsearch -h host -p port -D "cn=Directory Manager" -w password \
   -s base -b "" "(objectclass=*)" supportedSASLMechanisms
   ```

   ```
   dn:
   supportedSASLMechanisms: EXTERNAL
   supportedSASLMechanisms: DIGEST-MD5
   ```

2. By default, GSSAPI is not enabled, and you may use the following `ldapmodify` command to enable it:

   ```
   ldapmodify -h host -p port -D "cn=Directory Manager" -w password
   dn: cn=SASL, cn=security, cn=config
   changetype: modify
   add: dsSaslPluginsEnable
   dsSaslPluginsEnable: GSSAPI
   -
   replace: dsSaslPluginsPath
   dsSaslPluginsPath: ServerRoot/lib/sasl
   ```

3. Create the default identity mapping for GSSAPI and any custom mappings as described in "GSSAPI Identity Mappings" on page 407.

4. Configure Kerberos for the server on its host machine:

   a. Create the following LDAP service principal in Kerberos with a session key: `ldap/`*serverHostname*`@`*Realm*, where:

      - The *serverHostname* is the fully qualified domain name of the server host machine. This value *must* be the same value as the `nsslapd-localhost` attribute in `cn=config`, except it *must* be all in lower case.

      - The *Realm* is the Kerberos Realm of your server.

   b. The LDAP service must have read access to the key database in the following file: `/etc/krbs/krb5.keytab`.

   c. DNS must be configured on the host machine.

5. Restart the directory server if you modified the SASL configuration entry or one of the GSSAPI identity mapping entries.

GSSAPI Identity Mappings

Identity mappings for SASL mechanisms try to match credentials of the SASL identity with a user entry in the directory. See "Identity Mapping" on page 408 for complete description of this mechanism. Authentication will fail if the mapping cannot find a DN that corresponds to the SASL identity.

The SASL identity is a string called the *Principal* that represents a user in a format specific to each mechanism. In Kerberos using GSSAPI, the Principal is an identity with the format *uid*`[/`*instance*`][@`*realm*`]`, where the *uid* may contain an optional *instance* identifier followed by an optional *realm* that is often a domain name. For example, the following are all valid user Principals:

```
bjensen
bjensen/Sales
bjensen@EXAMPLE.COM
bjensen/Sales@EXAMPLE.COM
```

Initially, there are no GSSAPI mappings defined in the directory. You should define a default mapping and any custom mappings you need according to how your clients define the Principal they use.

To define identity mappings for GSSAPI:

1. Create new mapping entries under `cn=GSSAPI,cn=identity mapping, cn=config`. See "Identity Mapping" on page 408 for the definition of the attributes in an identity mapping entry.

Examples of GSSAPI mappings are located in the following file:

ServerRoot`/slapd-`*serverID*`/ldif/identityMapping_Examples.ldif`

The default GSSAPI mapping suggested in this file assumes that the Principal contains only a user ID, and this determines a user in a fixed branch of the directory:

```
dn: cn=default,cn=GSSAPI,cn=identity mapping,cn=config
objectclass: dsIdentityMapping
objectclass: nsContainer
objectclass: top
cn: default
dsMappedDN: uid=${Principal},ou=people,dc=example,dc=com
```

Another example in this file shows how to determine the user ID when it is contained in a Principal that includes a known Realm.

```
dn: cn=same_realm,cn=GSSAPI,cn=identity mapping,cn=config
objectclass: dsIdentityMapping
objectclass: dsPatternMatching
objectclass: nsContainer
objectclass: top
cn: same_realm
dsMatching-pattern: ${Principal}
dsMatching-regexp: (.*)@example.com
dsMappedDN: uid=$1,ou=people,dc=example,dc=com
```

2. Restart the Directory Server for your new mappings to take effect.

Identity Mapping

Several authentication mechanisms in Directory Server require a mapping from credentials of another protocol to a DN in the directory. Currently, this is the case for the DSML-over-HTTP protocol and the DIGEST-MD5 and GSSAPI SASL mechanisms. Each of these uses identity mapping to determine a bind DN based on protocol-specific credentials provided by the client.

Identity mapping uses the entries in the `cn=identity mapping, cn=config` configuration branch. This branch includes a container for each of the protocols which must perform identity mapping:

- `cn=HTTP-BASIC, cn=identity mapping, cn=config` - Contains the mappings for DSML-over-HTTP connections.

- `cn=DIGEST-MD5, cn=identity mapping, cn=config` - Contains the mappings for client authentication using the DIGEST-MD5 SASL mechanism.
- `cn=GSSAPI, cn=identity mapping, cn=config` - Must be created to contain the mappings for client authentication using the GSSAPI SASL mechanism.

A mapping entry defines a way of extracting the elements of the protocol-specific credentials to use them in a search of the directory. If that search returns a single user entry, the mapping has succeeded and the connection will use this entry as the bind DN for all operations. If the search returns zero or more than one entry, the mapping fails and any other mappings are applied.

Each branch should contain a default mapping for that protocol and any number of custom mappings. The default mapping has the RDN `cn=default`, and custom mappings may have any other RDN that uses `cn` as the naming attribute. All of the custom mappings are evaluated first, in a non-deterministic order until one of them succeeds. If all custom mappings fail, the default mapping is applied last. If the default mapping also fails, authentication of the client fails.

A mapping entry must contain the `top`, `Container`, and `dsIdentityMapping` object classes. The entry may then contain the following attributes:

- `dsMappedDN:` *DN* - A literal string that defines a DN in the directory. This DN will be used for binding if it exists when the mapping is performed. You may also define the following attributes to perform a search in case this DN does not exist.
- `dsSearchBaseDN:` *DN* - The base DN for a search. If omitted, the mapping will search all root suffixes in the entire directory tree.
- `dsSearchScope: base|one|sub` - The scope for a search, either the search base itself, one level of children below the base, or the entire subtree below the base. The default scope for mapping searches is the entire subtree when this attribute is omitted.
- `dsSearchFilter:` *filterString* - A filter string to perform the mapping search. LDAP search filters are defined in RFC 2254 (`http://www.ietf.org/rfc/rfc2254.txt`).

Additionally, a mapping entry may also contain the `dsPatternMatching` object class which allows it to use the following attributes:

- `dsMatching-pattern:` *patternString* - Specifies a string on which to perform pattern matching.
- `dsMatching-regexp:` *regularExpression* - Specifies a regular expression to apply to the pattern string.

All of the attribute values above, except for `dsSearchScope` may contain place-holders of the format `${`*keyword*`}` where *keyword* is the name of an element in the protocol specific credentials. During the mapping, the place-holder will be substituted for the actual value of the element as provided by the client.

After all place-holders have been substituted, any pattern matching that is defined will be performed. The matching pattern will be compared to the regular expression. If the regular expression does not match the pattern string, this mapping fails. If it does match, the matching values of regular expression terms in parentheses will be available as numbered place-holders for use in other attribute values. For example, the following mapping could be defined for SASL:

```
dsMatching-pattern: ${Principal}
dsMatching-regexp: (.*)@(.*)\.(.*)
dsMappedDN: uid=$1,ou=people,dc=$2,dc=$3
```

If a client authenticates with the Principal of `bjensen@example.com`, this mapping will define the bind DN `uid=bjensen,ou=people,dc=example,dc=com`. If this DN exists in the directory, the mapping will succeed, the client will be authenticated, and all operations performed during this connection will use this bind DN.

The `dsMatching-pattern` is compared to the `dsMatching-regexp` using the Posix `regexec(3C)` and `regcomp(3C)` function calls. Directory Server uses extended regular expressions and all comparisons are case insensitive. For more information, please refer to the `man` pages for these functions.

The attribute values that may contain place-holders must encode any `$`, `{`, and `}` characters that are not part of a place-holder, even if no place-holder is used. You must encode these characters with the following values: `$` as `\24`, `{` as `\7B`, and `}` as `\7D`.

Using place-holders and substitutions allows you to create mappings that extract a username or any other value from the protocol-specific credentials and use its value to define a mapped DN or perform a search for a corresponding DN anywhere in the directory. You should define the mappings that extract the expected credentials provided by your directory clients and map them to your specific directory structure.

CAUTION Creating a poorly defined mapping is a security hole. For example, a mapping to a hard-coded DN without pattern matching will always succeed, thereby authenticating clients who might not be directory users.

It is safer to define several mappings to handle different client credential formats than to create a single, overly-generic and permissive mapping. You should always try to map client connections to specific users according to the client credentials.

Configuring LDAP Clients to Use Security

The following sections explain how to configure and use SSL in LDAP clients that wish to establish secure connections with the directory server. In an SSL connection, the server sends its certificate to the client. The client must first authenticate the server by trusting its certificate. Then, the client may optionally initiate one of the client authentication mechanisms by sending its own certificate or information for one of the two SASL mechanism, either DIGEST-MD5 or GSSAPI using Kerberos V5.

The following sections use the `ldapsearch` tool as an example of an SSL-enabled LDAP client. The `ldapmodify`, `ldapdelete` and `ldapcompare` tools provided with the directory server are configured in the same way. These directory access tools are based on the Directory SDK for C and are further documented in the *Directory Server Resource Kit Tools Reference*.

To configure SSL connections on other LDAP clients, please refer to the documentation provided with your application.

NOTE Some client applications implement SSL but do not verify that the server has a trusted certificate. They use the SSL protocol to provide data encryption but cannot guarantee confidentiality nor protect against impersonation.

Configuring Server Authentication in Clients

When a client establishes an SSL connection with a server, it must trust the certificate presented by the server. In order to do so, the client must:

- Have a certificate database.
- Trust the Certificate Authority (CA) that issues the server certificate.
- Specify the SSL options of the LDAP client.

Mozilla is a client application that uses SSL to communicate with web servers over the HTTP protocol. You can use Mozilla to manage the certificates that your LDAP client will also use. Alternatively, you may use the `certutil` tool to manage certificate databases.

Managing Client Certificates Through Mozilla

The following procedure describes how to use Mozilla to manage a certificate database on the client machine.

1. Upon startup, Mozilla will ensure that a certificate database exists, or it will create one if needed. The certificate database will be stored in a file along with other Mozilla preferences, for example `.mozilla/`*username*`/`*string*`.slt/cert8.db`

   If you use this procedure, find the certificate database created by Mozilla and remember the path for use by your client applications.

2. Use Mozilla to browse the website of the Certificate Authority that issued the certificate for the directory server you wish to access. Mozilla will automatically retrieve the Certificate Authority's certificate and ask you if it should be trusted.

   For example, if you are using an internally deployed Sun Java System Certificate Server, you will go to a URL of the form `https://`*hostname*`:444`.

3. Trust the Certificate Authority's certificate when prompted to do so by Mozilla. You should trust the CA certificate for server authentication.

   This step may not be possible depending on the CA's website. If Mozilla does not automatically prompt you to trust the CA certificate, use the following procedure to do it manually.

Managing Client Certificates Through the Command Line

Use the `certutil` tool to manage certificates through the command line. This tool is provided in the `SUNWtlsu` package.

1. On the client host machine, create a certificate database with the following command:

   ```
   certutil -N -d path -P prefix
   ```

   The tool will prompt the user for a password to protect the certificates. The tool will then create the following files: *path*`/`*prefix*`cert8.db` and *path*`/`*prefix*`key3.db`.

   The certificate database should be created individually by the users of the LDAP client application in a location that is accessible only to them, for example a protected subdirectory of their home directory.

2. Contact the Certificate Authority that issued the certificate for Directory Server that you wish to access and request their CA certificate. You may send email or access their website to obtain a PEM encoded text version of their PKCS #11 certificate. Save this certificate in a file.

   For example, if you are using an internally deployed Sun Java System Certificate Server, you will go to a URL of the form `https://`*hostname*`:444`. From the top-level Retrieval tab, select Import CA Certificate Chain and copy the encoded certificate there.

   Alternatively, if you obtain your client and server certificates from the same CA, you may reuse the CA certificate obtained through the procedure for "Trusting the Certificate Authority" on page 396.

3. Import the CA certificate as a trusted CA for issuing server certificates used in SSL connections. Use the following command:

   ```
   certutil -A -n "certificateName" -t "C,," -a -i certFile -d path -P prefix
   ```

   where *certificateName* is a name you give to identify this certificate, *certFile* is the text file containing the PKCS #11 certificate of the CA in PEM encoded text format, and *path* and *prefix* are the same as in Step 1.

   Every user of the LDAP client application must import the CA certificate into his or her certificate database. All users may import the same certificate located in *certFile*.

Specifying SSL Options for Server Authentication

To perform server authentication in SSL with the `ldapsearch` tool, users only need to specify the path of their certificate database. When establishing the SSL connection through the secure port, the server will send its certificate. The `ldapsearch` tool will then find in the user's certificate database the trusted CA certificate of the CA that issued the server certificate.

The following command shows how a user would specify his or her certificate database if it was created by Mozilla:

```
ldapsearch -h host -p securePort \
           -D "uid=bjensen,dc=example,dc=com" -w bindPassword \
           -Z -P .mozilla/bjensen/string.slt/cert8.db \
           -b "dc=example,dc=com" "(givenname=Richard)"
```

Configuring Certificate-Based Authentication in Clients

The default mechanism for client authentication uses certificates to securely identify users to the directory server. In order to perform certificate-based authentication of clients, you must:

- Obtain a certificate for every directory user and install it where the client application may access it.
- Configure the user's directory entry with a binary copy of the same certificate. During authentication, the server will match the certificate presented by the client application with this copy to positively identify the user.
- Configure the server for certificate-based authentication, as described in "Using Client Authentication" in Chapter 9 of the *Administration Server Administration Guide*.
- Specify the SSL options of the LDAP client for certificate-based authentication.

These procedures require the `certutil` tool to manage certificates through the command line. This tool is provided in the `SUNWtlsu` package.

Obtaining and Installing a User Certificate

Client certificates must be requested and installed by each user wishing to access the directory with certificate-based authentication. This procedure assumes the user has already configured a certificate database as described in "Configuring Server Authentication in Clients" on page 412.

1. Create a request for a user certificate with the following command:

   ```
   certutil -R \
   -s "cn=Babs Jensen,ou=Sales,o=example.com,l=city,st=state,c=country"\
   -a -d path -P prefix
   ```

   The `-s` option specifies the DN of the requested certificate. Certificate Authorities usually require all of the attributes shown in this example in order to completely identify the owner of the certificate. The certificate DN will be mapped to the user's directory DN through the certificate mapping mechanism in Step 9.

   The *path* and *prefix* locate the user's certificate and key databases. The `certutil` tool will prompt the user for the password to their key database. The tool will then generate a PKCS #10 certificate request in PEM encoded text format.

2. Save the encoded certificate request in a file and transmit it to your Certificate Authority, according to its procedures. For example, you may be asked to send the certificate request in an email, or you may be able to enter the request through the CA's website.

3. Once you have sent your request, you must wait for the CA to respond with your certificate. Response time for your request varies. For example, if your CA is internal to your company, it may only take a day or two to respond to your request. If your selected CA is external to your company, it could take several weeks to respond to your request.

4. When the CA sends a response, download or copy the PEM encoded text of your new certificate to a text file.

5. Install the new user certificate in your certificate database with the following command:

   ```
   certutil -A -n "certificateName" -t "u,," -a -i certFile -d path -P prefix
   ```

   where *certificateName* is a name you give to identify your certificate, *certFile* is the text file containing the PKCS #11 certificate in PEM format, and *path* and *prefix* are the same as in Step 1.

   Alternatively, if you are managing your certificate database through Mozilla, there may be a link on your CA's website to install the certificate directly. Click this link and step through the dialog boxes that Mozilla presents to you.

6. Create a binary copy of your certificate with the following command:

   ```
   certutil -L -n "certificateName" -d path -r > userCert.bin
   ```

where *certificateName* is the name you gave to your certificate when you installed it, *path* is the location of your certificate database, and *userCert.bin* is the name of the output file that will contain the certificate in binary format.

7. On the Directory Server, add the `userCertificate` attribute to the directory entry for the user who owns the client certificate.

- To add the certificate through the console:

  a. From the top-level Directory tab of Directory Server Console, locate the user entry in the directory tree, right click on it, and select Edit with Generic Editor from the pop-up menu.

  b. In the Generic Editor, click Add Attribute.

  c. Select the `userCertificate` attribute from the pop-up dialog and `binary` from the Subtype dropdown list. You must specify the `binary` subtype, otherwise certificate mapping will fail.

  d. Locate the new `userCertificate` field in the Generic Editor. Click the corresponding Set Value button to set a binary value for this attribute.

  e. In the Set Value dialog, enter the name of the *userCert.bin* file created in Step 6, or click Browse to locate the file.

  f. Click OK in the Set Value dialog and then click Save in the Generic Editor.

- To add the certificate from the command line, use the `ldapmodify` command as shown in the following example. This command uses SSL to send the certificate over a secure connection:

```
ldapmodify -h host -p securePort \
           -D "uid=bjensen,dc=example,dc=com" -w bindPassword \
           -Z -P .mozilla/bjensen/string.slt/cert8.db
version: 1
dn: uid=bjensen,dc=example,dc=com
changetype: modify
add: userCertificate
userCertificate;binary: < file:///path/userCert.bin
```

  You must include the `binary` subtype, otherwise certificate mapping will fail. The spaces before and after < are significant and must be used exactly as shown. In order to use the < syntax to specify a filename, you must begin the LDIF statement with the line `version: 1`. When `ldapmodify` processes this statement, it will set the attribute to the value read from the entire contents of the given file.

8. On Directory Server, install and trust the certificate of the CA that issued your user certificate, if necessary. This CA must be trusted for accepting connections from clients. See "Trusting the Certificate Authority" on page 396.

9. Configure Directory Server for certificate-based authentication as described in "Using Client Authentication" in Chapter 9 of the *Administration Server Administration Guide*. In this procedure, you will edit the `certmap.conf` file so that the server maps the user certificate presented through the LDAP client to the corresponding user DN.

   Make sure that the `verifyCert` parameter is set to `on` in the `certmap.conf` file. The server will then verify that the user entry contains the same certificate, thereby positively identifying the user.

Specifying SSL Options for Certificate-Based Client Authentication

To perform certificate-based client authentication in SSL with the `ldapsearch` tool, users need to specify several command-line options to use their certificate. When establishing the SSL connection through the secure port, the tool will authenticate the server's certificate and then send the user certificate to the server.

The following command shows how a user would specify the options to access his or her certificate database if it was created by Mozilla:

```
ldapsearch -h host -p securePort \
           -Z -P .mozilla/bjensen/string.slt/cert8.db \
           -N "certificateName" \
           -K .mozilla/bjensen/string.slt/key3.db -W keyPassword \
           -b "dc=example,dc=com" "(givenname=Richard)"
```

The `-Z` option indicates certificate-based authentication, the *certificateName* specifies which certificate to send, and the `-K` and `-W` options allow the client application to access the certificate so that it can be sent. By not specifying the `-D` and `-w` options, the bind DN will be determined from the certificate mapping.

Using SASL DIGEST-MD5 in Clients

When using the DIGEST-MD5 mechanism in clients, you do not need to install a user certificate. However, if you wish to use encrypted SSL connections, you must still trust the server certificate as described in "Configuring Server Authentication in Clients" on page 412.

Specifying a Realm

A realm defines the namespace from which the authentication identity is selected. In DIGEST-MD5 authentication, you must authenticate to a specific realm.

Directory Server uses the fully qualified hostname of the machine as the default realm for DIGEST-MD5. The server uses the lower-case value of the hostname found in the `nsslapd-localhost` configuration attribute.

If you do not specify a realm, then the default realm offered by the server will be used.

Specifying Environment Variables

In the UNIX environment, you must set the `SASL_PATH` environment variable so the LDAP tools will find the DIGEST-MD5 libraries. The DIGEST-MD5 library is a shared library dynamically loaded by the SASL plug-in, and therefore you should set the SASL_PATH variable as follows (for example in the Korn shell):

```
export SASL_PATH=ServerRoot/lib/sasl
```

This path assumes that Directory Server is installed on the same host where the LDAP tools will be invoked.

Examples of the ldapsearch Command

You may perform DIGEST-MD5 client authentication without using SSL. The following example will use the default DIGEST-MD5 identity mapping to determine the bind DN:

```
ldapsearch -h host -p nonSecurePort -D "" -w bindPassword \
           -o mech=DIGEST-MD5 [-o realm="hostFQDN"] \
           -o authid="dn:uid=bjensen,dc=example,dc=com" \
           -o authzid="dn:uid=bjensen,dc=example,dc=com" \
           -b "dc=example,dc=com" "(givenname=Richard)"
```

The example above shows the use of the `-o` (lowercase letter o) option to specify SASL options. The Realm is optional, but if specified, it must be the fully qualified domain name of the server host machine. The `authid` and `authzid` must both be present and identical, although the `authzid` intended for proxy operations is not used.

The value of `authid` is the Principal used in identity mapping. It is recommended that the `authid` contain the `dn:` prefix followed by a valid user DN in the directory or the `u:` prefix followed by any string determined by the client. This allow you to use the mappings shown in "DIGEST-MD5 Identity Mappings" on page 404.

Usually, you will want an SSL connection to provide encryption over secure port and DIGEST-MD5 to provide the client authentication. The following example will perform the same operation over SSL:

```
ldapsearch -h host -p securePort \
           -Z -P .mozilla/bjensen/string.slt/cert8.db \
           -N "certificateName" -W keyPassword \
           -o mech=DIGEST-MD5 [-o realm="hostFQDN"] \
           -o authid="dn:uid=bjensen,dc=example,dc=com" \
           -o authzid="dn:uid=bjensen,dc=example,dc=com" \
           -b "dc=example,dc=com" "(givenname=Richard)"
```

In this example, the `-N` and `-W` options are required by the `ldapsearch` command, but they are not used for client authentication. Instead, the server will again perform a DIGEST-MD5 identity mapping of the Principal in the `authid` value.

Using Kerberos SASL GSSAPI in Clients

When using the GSSAPI mechanism in clients, you do not need to install a user certificate, but you must configure the Kerberos V5 security system. Also, if you wish to use encrypted SSL connections, you must trust the server certificate as described in "Configuring Server Authentication in Clients" on page 412.

Configuring Kerberos V5 on a Client Host

You must configure Kerberos V5 on the host machine where your LDAP clients will run:

1. Install Kerberos V5 according to its installation instructions. Sun recommends installing the Sun Enterprise Authentication Mechanism (SEAM) 1.0.1 client software.

2. Configure the Kerberos software. With SEAM, configure the files under `/etc/krb5` in order to setup the `kdc` server, define the default realm, and any other configuration required by your Kerberos system.

3. If necessary, modify the file `/etc/gss/mech` so that the first value listed is `kerberos_v5`.

Specifying SASL Options for Kerberos Authentication

1. Before using a GSSAPI-enabled client application, you must initialize the Kerberos security system with your user Principal using the following command:

   ```
   kinit userPrincipal
   ```

The *userPrincipal* is your SASL identity, for example `bjensen@example.com`.

2. The following example of the `ldapsearch` tool shows the use of the `-o` (lowercase letter o) option to specify SASL options for using Kerberos:

```
ldapsearch -h host -p securePort \
           -Z -P .mozilla/bjensen/string.slt/cert8.db \
           -N "certificateName" -W keyPassword \
           -o mech=GSSAPI [-o realm="example.com" \
           -o authid="bjensen@example.com" \
           -o authzid="bjensen@example.com"] \
           -b "dc=example,dc=com" "(givenname=Richard)"
```

3. In this example, the `-N` and `-W` options are required by the `ldapsearch` command, but they are not used for client authentication.The `realm`, `authid` and `authzid` may be omitted because they are present in the Kerberos cache which was initialized by the `kinit` command. If present, `authid` and `authzid` must be identical, although the `authzid` intended for proxy operations is not used. The value of `authid` is the Principal used in identity mapping. See "GSSAPI Identity Mappings" on page 407, for more information.

Chapter 12

Implementing Pass-Through Authentication

Pass-through authentication (PTA) is a mechanism by which one directory server consults another to authenticate bind requests. The PTA plug-in provides this functionality, allowing a directory server to accept simple bind operations (password based) for entries not stored in its local suffixes.

Directory Server uses PTA to allow you to administer your user and configuration directories on separate instances of Directory Server.

NOTE The PTA plug-in is not listed in Directory Server Console when you use the same server for your user directory and your configuration directory, but you may create it to use pass-through authentication.

This chapter describes the PTA plug-in in the following sections:

- How Directory Server Uses PTA
- Configuring the PTA Plug-In

How Directory Server Uses PTA

If you install the configuration directory and the user directory on separate instances of Directory Server, the installation program automatically sets up PTA to allow the Configuration Administrator user (usually `admin`) to perform administrative duties.

PTA is required in this case because the `admin` user entry is stored under `o=NetscapeRoot` in the configuration directory. Therefore, attempts to bind to the user directory as `admin` would normally fail. PTA allows the user directory to transmit the credentials to the configuration directory which verifies them. The user directory then allows the `admin` user to bind.

The user directory in this example acts as the PTA server, that is, the server that passes through bind requests to another directory server. The configuration directory acts as the *authenticating server*, that is, the server that contains the entry and verifies the bind credentials of the requesting client.

You will also see the term *PTA subtree* used in this chapter. The pass-through authentication subtree is the subtree *not* present on the PTA server. When a user's bind DN contains this subtree, the user's credentials are passed on to the authenticating directory.

This sequence of steps shows how pass-through authentication works:

1. You install the configuration directory server (authenticating directory) containing the pass-through authentication subtree `o=NetscapeRoot` on the host `configdir.example.com`.
2. You install the user directory server (PTA directory) containing data in the `dc=example,dc=com` suffix on the host `userdir.example.com`.
3. During the installation of the user directory, you are prompted to provide an LDAP URL that points to the configuration directory, for example:

   ```
   ldap://configdir.example.com/o=NetscapeRoot
   ```
4. The installation program configures and enables the PTA plug-in in the user directory with the LDAP URL you provided.

   The user directory is now configured as a PTA directory. It will send all bind requests for entries whose DN contains `o=NetscapeRoot` to the configuration directory `configdir.example.com`.
5. When installation is complete, the `admin` user attempts to bind to the user directory to begin creating the user data.

   The `admin` entry is stored in the configuration directory as `uid=admin, ou=Administrators,ou=TopologyManagement,o=NetscapeRoot`. So, the user directory passes the bind request through to the configuration directory as defined by the PTA plug-in configuration.
6. The configuration directory authenticates the bind credentials, including the password, and sends the confirmation back to the user directory.
7. The user directory allows the `admin` user to bind.

Configuring the PTA Plug-In

PTA plug-in configuration information is specified in the `cn=Pass Through Authentication,cn=plugins,cn=config` entry on the PTA server.

If you installed the user and configuration directories on different server instances, the PTA plug-in entry is automatically added to the user directory's configuration. If you installed both directories on the same instance, and you wish to perform pass-through authentication with other directories, you must first create the plug-in configuration entry.

Creating the Plug-In Configuration Entry

1. Run the following command to create the plug-in configuration entry:

```
ldapmodify -a -h PTAhost -p port -D "cn=Directory Manager" -w password
dn: cn=Pass Through Authentication,cn=plugins, cn=config
objectClass: top
objectClass: nsSlapdPlugin
objectClass: extensibleObject
cn: Pass Through Authentication
nsslapd-pluginPath: ServerRoot/lib/passthru-plugin.so
nsslapd-pluginInitfunc: passthruauth_init
nsslapd-pluginType: preoperation
nsslapd-plugin-depends-on-type: database
nsslapd-pluginId: passthruauth
nsslapd-pluginVersion: 5.2
nsslapd-pluginVendor: Sun Microsystems, Inc.
nsslapd-pluginDescription: pass through authentication plugin
nsslapd-pluginEnabled: on or off
nsslapd-pluginarg0: ldap[s]://authenticatingHost[:port]/PTAsubtree options
```

   where *ServerRoot* depends on your installation.

   The plug-in argument specifies the LDAP URL identifying the hostname of the authenticating directory server, an optional port, and the PTA subtree. If no port is specified, the default port is 389 with LDAP and 636 with LDAPS. You may also set the optional connection parameters described in the following sections. If the *PTAsubtree* exists in the *PTAhost*, the plug-in will *not* pass the bind request to the *authenticatingHost*, and the bind will be processed locally without any pass-through.

2. Restart the server as described in "Starting and Stopping Directory Server" on page 25.

Configuring PTA to Use a Secure Connection

Because the PTA plug-in must send bind credentials including the password to the authenticating directory, we recommend using a secure connection. To configure the PTA directory to communicate with the authenticating directory over SSL:

- Configure and enable SSL in both the PTA and authenticating directories, as described in Chapter 11, "Managing Authentication and Encryption."
- Create or modify the PTA plug-in configuration to use LDAPS and the secure port in the LDAP URL, for example:

  ```
  ldaps://configdir.example.com:636/o=NetscapeRoot
  ```

Setting the Optional Connection Parameters

The PTA plug-in arguments accept a set of optional connection parameters after the LDAP URL:

`ldap[s]://`*host*`[:`*port*`]/`*subtree* `[`*maxconns*`,`*maxops*`,`*timeout*`,`*ldapver*`,`*connlife*`]`

The parameters must be given in the order shown. Although these parameters are optional, if you specify one of them, you must specify them all. If you do not wish to customize all parameters, specify their default values given below. Make sure there is a space between the *subtree* parameter and the optional parameters.

You can configure the following optional parameters for each LDAP URL:

- *maxconns* - The maximum number of connections the PTA server can open simultaneously to the authenticating server. This parameter limits the number of simultaneous binds that can be passed-through to the authenticating server. The default value is `3`.
- *maxops* - The maximum number of bind requests the PTA directory server can send simultaneously to the authenticating directory server within a single connection. This parameter further limits the number of simultaneous pass-through authentications. The default is value is `5`.
- *timeout* - The maximum delay in seconds that you want the PTA server to wait for a response from the authenticating server. The default value is `300` seconds (five minutes).
- *ldapver* - The version of the LDAP protocol you want the PTA server to use when connecting to the authenticating server. The allowed values are `2` for LDAPv2 and `3` for LDAPv3. The default value is `3`.

- *connlife* - The time limit in seconds within which the PTA server will reuse a connection to the authenticating server. If a bind in the PTA subtree is requested by a client after this time has expired, the server closes the PTA connection and opens a new one. The server will not close the connection unless a bind request is initiated and the server determines the timeout has been exceeded. If you do not specify this option, or if only one authenticating server is listed in the LDAP URL, no time limit will be enforced. If two or more hosts are listed, the default is 300 seconds (five minutes).

The following example of a PTA plug-in argument increases the number of connections to 10, but decreases the timeout to one minute (60 seconds). The default values are give for all other parameters:

```
ldaps://configdir.example.com:636/o=NetscapeRoot 10,5,60,3,300
```

Specifying Multiple Servers and Subtrees

You may configure the PTA plug-in with multiple arguments to specify multiple authenticating servers, multiple PTA subtrees, or both. Each argument contains one LDAP URL and may have its own set of connection options.

When there are multiple authenticating servers for the same PTA subtree, they act as failover servers. The plug-in will establish connections to them in the order listed whenever a PTA connection reaches the timeout limit. If all connections time out, the authentication fails.

When there are multiple PTA subtrees defined, the plug-in will pass-through the authentication request to the corresponding server according to the bind DN. The following example shows four PTA plug-in arguments that define two PTA subtrees, each with a failover server for authentication and server-specific connection parameters:

```
nsslapd-pluginarg0: ldaps://configdir.example.com/o=NetscapeRoot
 10,10,60,3,300
nsslapd-pluginarg1: ldaps://configbak.example.com/o=NetscapeRoot
 3,5,300,3,300
nsslapd-pluginarg2: ldaps://east.example.com/ou=East,ou=People,
 dc=example,dc=com 10,10,300,3,300
nsslapd-pluginarg3: ldaps://eastbak.example.com/ou=East,ou=People,
 dc=example,dc=com 3,5,300,3,300
```

You can also specify multiple servers by separating the host names by spaces, as shown in the following example:

```
nsslapd-pluginarg0: ldaps://configdir.example.com:636
  configbak.example.com:636/o=NetscapeRoot 10,10,60,3,300
```

Modifying the PTA Plug-In Configuration

You can reconfigure the PTA plug-in at any time to enable or disable it, or to change the authenticating hosts or PTA subtrees.

1. Edit the PTA plug-in configuration entry (`cn=Pass Through Authentication,cn=plugins,cn=config`) to modify the `nsslapd-pluginenabled` and `nsslapd-pluginarg`*N* attributes. You may use either the console or the `ldapmodify` utility to edit the configuration.

   For example, the following command will enable the PTA plug-in with SSL and the connection parameters shown above.

   ```
   dn: cn=Pass Through Authentication,cn=plugins,cn=config
   changetype: modify
   replace: nsslapd-pluginenabled
   nsslapd-pluginenabled: on
   -
   replace: nsslapd-pluginarg0
   nsslapd-pluginarg0: ldaps://configdir.example.com:636/
    o=NetscapeRoot 10,10,60,3,300
   -
   replace: nsslapd-pluginarg1
   nsslapd-pluginarg1: ldaps://configbak.example.com:636/
    o=NetscapeRoot 3,5,300,3,300
   ^D
   ```

2. Restart the server as described in "Starting and Stopping Directory Server" on page 25.

Chapter 13

Monitoring Directory Server Using Log Files

This chapter describes how to monitor Directory Server by configuring a logging policy and analyzing the status information maintained by the server.

Directory Server provides three types of logs:

- Access Log - Lists the clients which connect to the server, and the operations requested.
- Errors Log - Provides information about server errors.
- Audit Log - Gives details about modifications to suffixes and to the configuration.

The status information in the server includes statistics about connections and cache activity. This information is available through Directory Server Console and in monitoring entries available through the LDAP command-line tools. For information on using SNMP to monitor your server, see Chapter 14, "Monitoring Directory Server Using SNMP."

This chapter contains the following sections:

Defining Log File Policies

The following sections describe how to define log file creation and deletion policies.

Defining a Log File Rotation Policy

If you want the directory to periodically archive the current log and start a new one, you can define a log file rotation policy from Directory Server Console. You can configure the following parameters:

- The total number of logs you want the directory to keep. When the directory reaches this number of logs, it deletes the oldest log file in the folder before creating a new log. The default is `10` logs. Do not set this value to `1`. If you do, the directory will not rotate the log and the log will grow indefinitely.
- The maximum size (in MB) for each log file. If you do not want to set a maximum size, type `-1` in this field. The default is `100` MB. Once a log file reaches this maximum size (or the maximum age defined in the next step), the directory archives the file and starts a new one. If you set the maximum number of logs to `1`, the directory ignores this attribute.
- How often the directory archives the current log file and creates a new one by entering a number of minutes, hours, days, weeks, or months. The default is every day. If you set the maximum number of logs to `1`, the directory ignores this attribute.

Defining a Log File Deletion Policy

If you want the directory to automatically delete old archived logs, you can define a log file deletion policy from Directory Server Console. The log deletion policy only makes sense if you have previously defined a log file rotation policy. Log file deletion will not work if you have just one log file.

The server evaluates and applies the log file deletion policy at the time of log rotation.

You can configure the following parameters:

- The maximum size of the combined archived logs. When the maximum size is reached, the oldest archived log is automatically deleted. If you do not want to set a maximum size, type `-1` in this field. The default is `500` MB. This parameter is ignored if the number of log files is set to `1`.

- The minimum amount of free disk space. When the free disk space reaches this minimum value, the oldest archived log is automatically deleted. The default is 5 MB. This parameter is ignored if the number of log files is set to `1`.
- The maximum age of log files. When a log file reaches this maximum age, it is automatically deleted. The default is `1` month. This parameter is ignored if the number of log files is set to `1`.

Manual Log File Rotation

You can manually rotate log files if you have not set automatic log file creation or deletion policies. By default, access, errors, and audit log files can be found in the following directory:

ServerRoot`/slapd-`*serverID*`/logs`

To manually rotate log files:

1. Shut down the server. See “Starting and Stopping Directory Server” on page 25 for instructions.
2. Move or rename the log file you are rotating in case you need the old log file for future reference.
3. Restart the server. See “Starting and Stopping Directory Server” on page 25 for instructions.

   The server automatically creates new files according to each log configuration.

Access Log

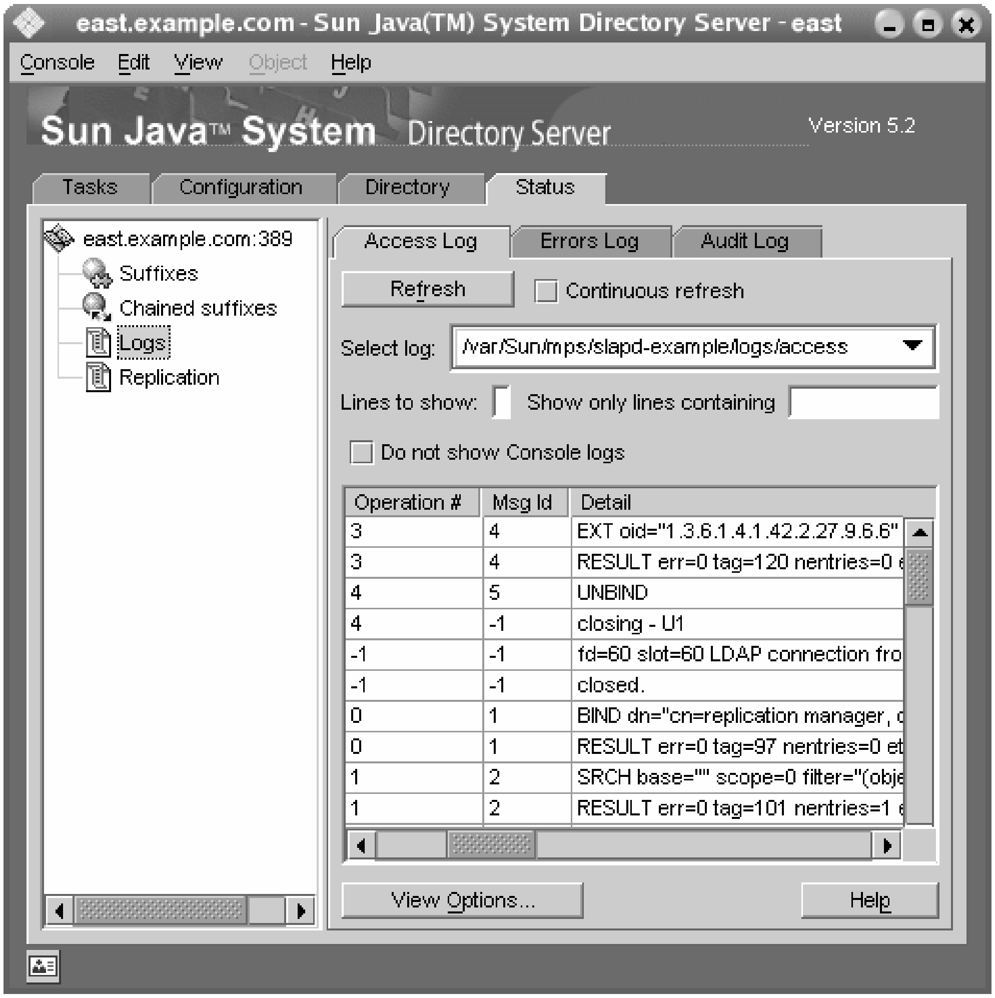
The access log contains detailed information about client connections to the directory. The Directory Server Resource Kit provides a log analyzer tool, `logconv.pl`, that enables you to analyze Directory Server access logs. The log analyzer tool extracts usage statistics and counts the occurrences of significant events. For more information this tool, refer to Chapter 24, ”The Log Analyzer Tool,” in the *Directory Server Resource Kit Tools Reference.*

Viewing the Access Log

1. On the top-level Status tab of Directory Server Console, select the Logs icon, and then select the Access Log tab in the right-hand panel.

1. This tab displays a table containing the latest entries in the selected access log, as shown in the following figure. For an explanation of the access messages, see "Access Log Content," in Chapter 3 of the *Directory Server Administration Reference*.

Figure 13-1 Viewing Log Contents



Select log: /var/Sun/mps/slapd-example/logs/access

Lines to show: Show only lines containing

Do not show Console logs

Operation #	Msg Id	Detail
3	4	EXT oid="1.3.6.1.4.1.42.2.27.9.6.6"
3	4	RESULT err=0 tag=120 nentries=0 e
4	5	UNBIND
4	-1	closing - U1
-1	-1	fd=60 slot=60 LDAP connection fro
-1	-1	closed.
0	1	BIND dn="cn=replication manager, c
0	1	RESULT err=0 tag=97 nentries=0 et
1	2	SRCH base="" scope=0 filter="(obje
1	2	RESULT err=0 tag=101 nentries=1 e

2. To refresh the current display, click Refresh. Select the Continuous checkbox if you want the display to refresh automatically every ten seconds.

3. To view a different access log file, select it from the Select Log drop-down menu.

4. To display a different number of messages, enter the number you want to view in the "Lines to show" text box and then click Refresh.

5. To filter the log messages you can enter a string in the "Show only lines containing" text box and then click Refresh. You can also select the Do Not Show Console Logs checkbox, to filter out any message that originated from the console's connections to the server.

6. To modify the columns of the table of log entries, click View Options. Use the controls of the View Options dialog to change the order of the columns, add or remove columns, and choose a column on which to sort the table.

Configuring the Access Log

You can configure a number of settings to customize the access log, including where the directory stores the access log and the creation and deletion policies.

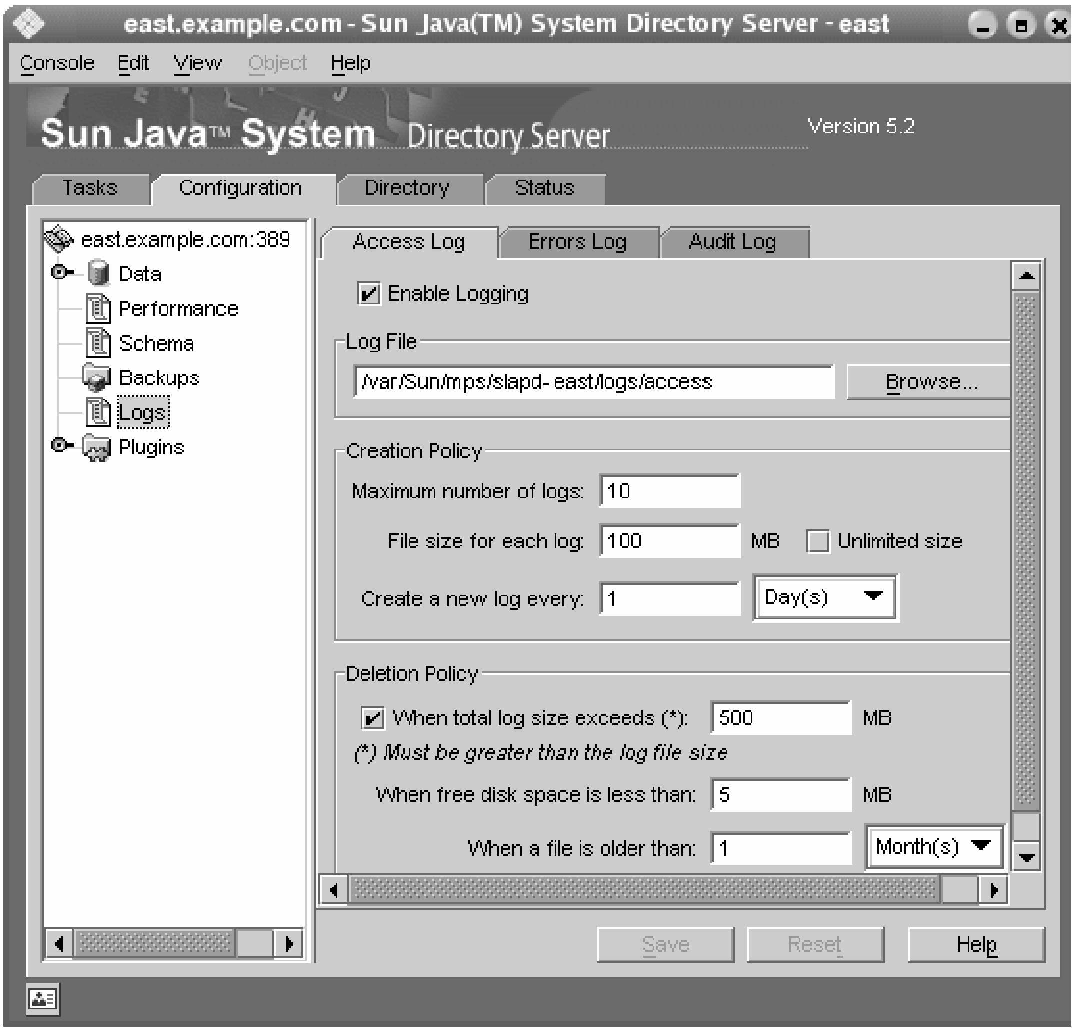
You can also disable access logging for the directory. You may do this because the access log can grow very quickly (every 2,000 accesses to your directory will increase your access log by approximately 1 MB). However, before you turn off access logging, consider that the access log provides beneficial troubleshooting information.

To configure the access log:

1. On the top-level Configuration tab of Directory Server Console, select the Logs icon, and then select the Access Log tab in the right-hand panel.

   This tab contains configuration settings for the access log, as shown in Figure 13-2:

Figure 13-2 Configuration Panel for Log File Rotation and Deletion



[✓] Enable Logging

Log File: /var/Sun/mps/slapd- east/logs/access

Creation Policy

Maximum number of logs: 10

File size for each log: 100 MB [ ] Unlimited size

Create a new log every: 1 Day(s)

Deletion Policy

[✓] When total log size exceeds (*): 500 MB

(*) Must be greater than the log file size

When free disk space is less than: 5 MB

When a file is older than: 1 Month(s)

2. To enable access logging, select the Enable Logging checkbox.

Clear this checkbox if you do not want the directory to maintain an access log.

Access logging is enabled by default.

3. In the Log File field, enter the full path and filename you want the directory to use for the access log. The default file is:

ServerRoot/`slapd-`*serverID*/`logs/access`

4. Set the maximum number of logs, log size, and archive period.

   For information on these parameters, see "Defining a Log File Rotation Policy" on page 428.

5. Set the maximum size of combined archived logs, minimum amount of free disk space, and maximum age for a log file.

   For information on these parameters, see "Defining a Log File Deletion Policy" on page 428.

6. When you have finished making changes, click Save.

Errors Log

The errors log contains detailed messages of errors and events the directory experiences during normal operation.

Viewing the Errors Log

1. On the top-level Status tab of Directory Server Console, select the Logs icon, and then select the Errors Log tab in the right-hand panel.

   This tab displays a table containing the latest entries in the selected errors log, such as the one shown in Figure 13-1 on page 430. For an explanation of error messages, see Chapter 4, "Error Log Message Reference," in the *Directory Server Administration Reference*.

2. To refresh the current display, click Refresh. Select the Continuous checkbox to refresh the display automatically every ten seconds.

3. To view an archived errors log, select it from the Select Log pull-down menu.

4. To specify a different number of messages, enter the number you want to view in the "Lines to show" text box and click Refresh.

5. To filter the log messages you can enter a string in the "Show only lines containing" text box and then click Refresh. You can also select the Do Not Show Console Logs checkbox, to filter out any error message that originated from the console's connections to the server.

6. To modify the columns of the table of log entries, click View Options. Use the controls of the View Options dialog to change the order of the columns, add or remove columns, and choose a column on which to sort the table.

Configuring the Errors Log

You can change several settings for the errors log, including where the directory stores the log and what you want the directory to include in the log.

To configure the errors log:

1. On the top-level Configuration tab of Directory Server Console, select the Logs icon, and then select the Errors Log tab in the right-hand panel.

   This tab contains configuration settings for the errors log, such as those shown in Figure 13-2 on page 432.

2. To enable error logging, select the Enable Logging checkbox.

   Clear this checkbox if you do not want the directory to maintain an errors log. Error logging is enabled by default.

3. To set the level of detail in the errors log, click the Log Level button to display the Errors Log Level dialog. Select one or more internal product components for which you want more error and debugging information. Optionally, select the Verbose checkbox to return the maximum amount of runtime output, including trivial messages.

   Changing these values from the defaults may cause your errors log to grow very rapidly, so you must plan to have plenty of disk space. It is recommended that you do not change your logging level unless you are asked to do so by Sun Java System Customer Support.

4. In the Log File field, enter the full path and filename you want the directory to use for the errors log. The default file is:

   ServerRoot`/slapd-`*serverID*`/logs/error`

5. Set the maximum number of logs, log size, and archiving period.

   For information on these parameters, see “Defining a Log File Rotation Policy” on page 428.

6. Set the maximum size of combined archived logs, minimum amount of free disk space, and maximum age for a log file.

   For information on these parameters, see “Defining a Log File Deletion Policy” on page 428.

7. When you have finished making changes, click Save.

Audit Log

The audit log contains detailed information about changes made to each suffix as well as to server configuration. Unlike the access log and errors log, the audit log is not enabled by default. Before viewing the log, you must enable it.

Configuring the Audit Log

You can use Directory Server Console to enable and disable audit logging and to specify where the audit log file is stored.

To configure the audit log:

1. On the top-level Configuration tab of Directory Server Console, select the Logs icon, and then select the Audit Log tab in the right-hand panel.

   This tab contains configuration settings for the audit log, such as those shown in Figure 13-2 on page 432.

2. To enable audit logging, select the Enable Logging checkbox.

   To disable audit logging, clear the checkbox. By default, audit logging is disabled.

3. In the Log File field, enter the full path and filename you want the directory to use for the audit log. The default file is:

   ServerRoot`/slapd-`*serverID*`/logs/audit`

4. Set the maximum number of logs, log size, and archiving period.

   For information on these parameters, see "Defining a Log File Rotation Policy" on page 428.

5. Set the maximum size of combined archived logs, minimum amount of free disk space, and maximum age for a log file.

   For information on these parameters, see "Defining a Log File Deletion Policy" on page 428.

6. When you have finished making changes, click Save.

Viewing the Audit Log

1. On the top-level Status tab of Directory Server Console, select the Logs icon, and then select the Audit Log tab in the right-hand panel.

   This tab displays a table containing the latest entries in the selected audit log, such as the one shown in Figure 13-1 on page 430.

2. To refresh the current display, click Refresh. Select the Continuous checkbox to refresh the display automatically every ten seconds.
3. To view an archived audit log, select it from the Select Log pull-down menu.
4. To display a different number of messages, enter the number you want to view in the “Lines to show” text box and click Refresh.
5. To filter the log messages you can enter a string in the “Show only lines containing” text box and then click Refresh.

Monitoring Server Activity

The server always maintains counters and statistics about its activity, for example the number of connections, operations, and cache activity for all suffixes. This information can help you troubleshoot any errors and observe the performance of your server. You can monitor Directory Server’s current activities from Directory Server Console or from the command line.

Many of the parameters that can be monitored reflect Directory Server performance and may be influenced by configuration and tuning. For more information about the configurable attributes and how to tune them, see the *Directory Server Performance Tuning Guide*.

Monitoring Your Server Using the Console

1. On the top-level Status tab of Directory Server Console, select the server icon at the root of the status tree.

   The right-hand panel displays current information about server activity. If the server is currently not running, this tab will not provide performance monitoring information.

2. Click Refresh to refresh the current display. If you want the server to continuously update the displayed information, select the Continuous checkbox.

   This server status panel shows:

- The date and time the server was started.
- The current date and time on server. When replication is enabled, you should periodically check that the dates on each server do not begin to diverge.

- The Resource Summary Table. For each of the following resources, the table lists the total number since startup and the average per minute since startup.

Table 13-1 Resource Summary Table

Resource	Total and Per-Minute Average Since Startup
Connections	Number of client connections established.
Operations Initiated	Number of operations requested by clients.
Operations Completed	Number of operations not aborted by clients, and for which the server returned a result.
Entries Sent to Clients	Number of entries returned in search results.
Bytes Sent to Clients	Number of bytes in all responses to client requests.

- The Current Resource Usage Table. This table shows the following resources that were in use when the panel was last refreshed.

Table 13-2 Current Resource Usage

Resource	Most Current Real-Time Usage
Active Threads	Number of threads used for handling requests. Additional threads may be created by internal server mechanisms such as replication and chaining.
Open Connections	Number of current open connections. Each connection can account for multiple operations, and therefore multiple threads.
Remaining Available Connections	Total number of remaining connections that the server can concurrently open. This number is based on the number of currently open connections and the total number of concurrent connections that the server is allowed to open. In most cases, the latter value is determined by the operating system, and is expressed as the number of file descriptors available to a task.
Threads Waiting to Read from Client	Threads may be waiting to read if the server starts to receive a request from the client and then the transmission of that request is halted for some reason. Generally, threads waiting to read are an indication of a slow network or slow client.
Databases in Use	Number of suffixes hosted on this server. This number does not include chained suffixes.

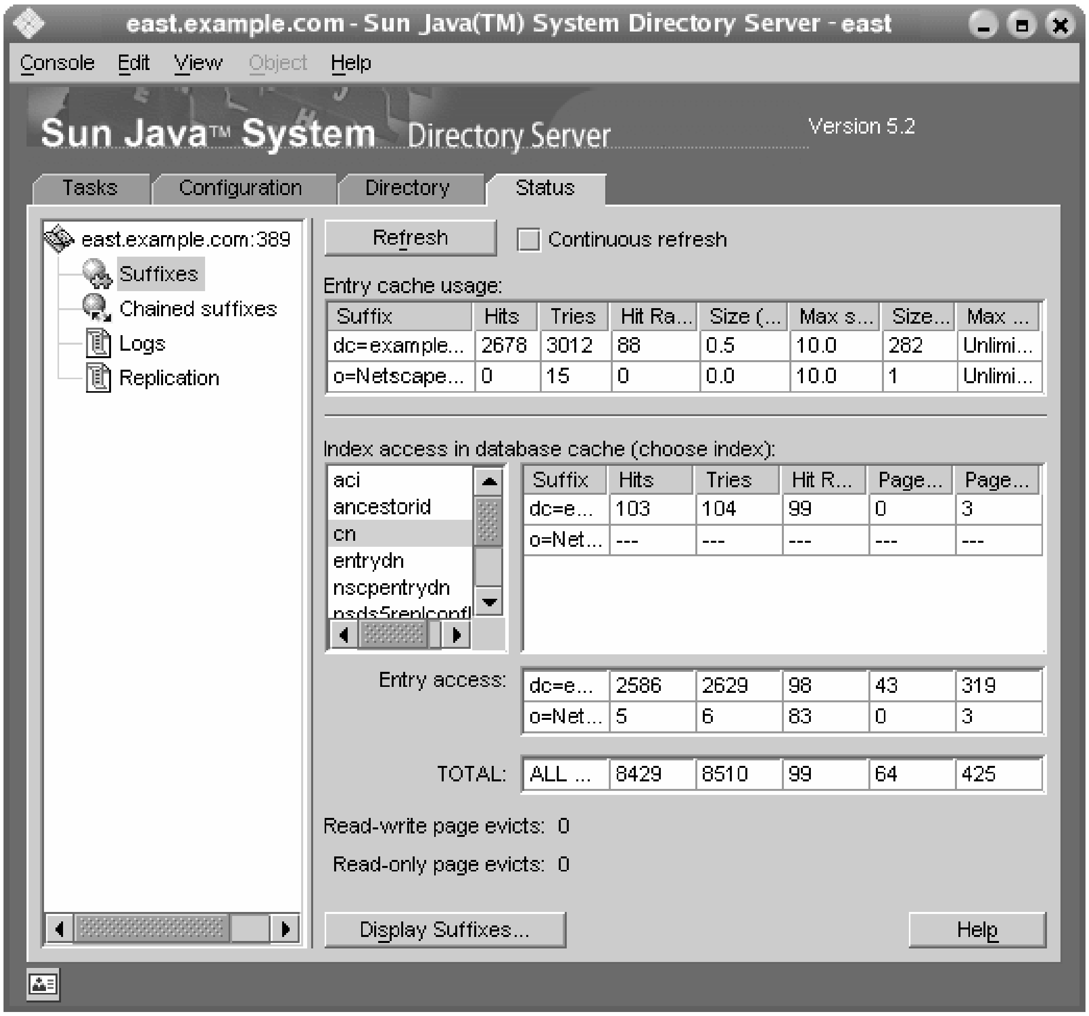
- The Connection Status Table. This table shows the following information about each currently open connection.

Table 13-3 Connections Status Table

Column Header	Description
Time Opened	The time on the server when the connection was established.
Initiated	The number of operations requested during this connection.
Completed	The number of operations not aborted by the client and completed by the server during this connection.
Bound As	Gives the distinguished name used by the client to bind to the server. If the client has not authenticated to the server, this column displays `not bound`.
State	• `Not blocked` - Indicates that the server is idle, or actively sending or receiving data over the connection. • `Blocked` - Indicates that the server is waiting to read or write data over the connection. The probable cause is a slow network or a slow client.
Type	Indicates whether it is an LDAP or DSML-over-HTTP connection.

3. Click on the Suffixes node in the left-hand status tree. This panel displays monitoring information about the entry cache and index usage in the database cache of each suffix, as shown in the following figure.

Figure 13-3 Suffix Monitoring Panel


east.example.com - Sun Java(TM) System Directory Server - east
Console Edit View Object Help
Sun Java™ System Directory Server
Version 5.2
Tasks Configuration Directory Status
east.example.com:389
Suffixes
Chained suffixes
Logs
Replication
Refresh
Continuous refresh
Display Suffixes...
Help

Entry cache usage:

Suffix	Hits	Tries	Hit Ra...	Size (...	Max s...	Size...	Max ...
dc=example...	2678	3012	88	0.5	10.0	282	Unlimi...
o=Netscape...	0	15	0	0.0	10.0	1	Unlimi...

Index access in database cache (choose index):

aci
ancestorid
cn
entrydn
nscpentrydn
nsds5replconfi

	Suffix	Hits	Tries	Hit R...	Page...	Page...
	dc=e...	103	104	99	0	3
	o=Net...	---	---	---	---	---
Entry access:	dc=e...	2586	2629	98	43	319
	o=Net...	5	6	83	0	3
TOTAL:	ALL ...	8429	8510	99	64	425

Read-write page evicts: 0

Read-only page evicts: 0

Set the refresh mode if desired. Click on Display Suffixes at the bottom of the panel to select which suffixes will be listed in the tables.

- The first table shows the following information about each entry cache.

Table 13-4 Entry Cache Usage

Column Header	Description
Suffix	Base DN of the suffix.

Table 13-4 Entry Cache Usage *(Continued)*

Column Header	Description
Hits	The number of entries read from the cache instead of the disk.
Tries	The number of entries that were requested from the cache.
Hit Ratio (%)	The ratio of hits to tries, expressed as a percentage.
Size (MB)	Current size of entry cache contents from the given suffix.
Max Size (MB)	Maximum size of the cache in current configuration.
Size (Entries)	Current number of entries in the cache from the given suffix.
Max Size (Entries)	Maximum number of cached entries in current configuration.

The following tables show access to the database cache of each suffix.

- The first table shows the access to the database cache through the configured indexes. From the list of attribute names, select the one for which you wish to see index statistics. The table will show data only for suffixes in which the chosen attribute is indexed.
- The Entry Access table shows access to the database caches to retrieve entries.
- The Totals in the last table show all combined access to all database caches.

All three tables have the following columns:

Table 13-5 Access to Database Cache

Column Header	Description
Suffix	Base DN of the suffix.
Hits	The number of entries read through the index.
Tries	The number of entries requested from through the index.
Hit Ratio (%)	The ratio of hits to tries, expressed as a percentage.
Pages read in	The number of pages read from disk into the suffix cache.
Pages written out	The number of pages written from the cache back to disk. A suffix page is written to disk whenever a read-write page has been modified and then subsequently removed from the cache to make room for new pages.

- Below the tables, the following page evicts are cumulative for all database caches. Pages discarded from the cache have to be written to disk, possibly affecting server performance. The lower the number of page evicts, the better:
  - Read-write page evicts - Indicates the number of read-write pages discarded from the cache to make room for new pages. This value differs from Pages Written Out in that these are discarded read-write pages that have not been modified.
  - Read-only page evicts - Indicates the number of read-only pages discarded from the caches to make room for new pages.

4. If applicable, click on the Chained Suffixes node in the left-hand status tree. This panel displays information about access to the chained suffixes configured in your directory. Set the refresh mode if desired.

   Select the DN of a chained suffix in the list to view its statistics. The table to the right lists the count of all different operations performed on the chained suffix.

Monitoring Your Server From the Command Line

You can monitor Directory Server's current activities from any LDAP client by performing a search operation on the following entries:

- `cn=monitor`
- `cn=monitor, cn=ldbm database, cn=plugins, cn=config`
- `cn=monitor,cn=`*dbName*`,cn=ldbm database,cn=plugins,cn=config`
- `cn=monitor,cn=`*dbName*`,cn=chaining database,cn=plugins,cn=config`

where *dbName* is the database name of the suffix that you want to monitor. Note that except for information about each connection, by default, the `cn=monitor` entry is readable by anyone, including clients bound anonymously.

The following example shows how to view the general server statistics:

```
ldapsearch -h host -p port -D "cn=Directory Manager" -w password \
           -s base -b "cn=monitor" "(objectclass=*)"
```

For the description of all monitoring attributes available in these entries, see "Monitoring Attributes", "Database Monitoring Attributes", "Database Monitoring Attributes under cn=NetscapeRoot", and "Chained Suffix Monitoring Attributes" in Chapter 2 of the *Directory Server Administration Reference*.

Chapter 14

Monitoring Directory Server Using SNMP

The Simple Network Management Protocol (SNMP) is a standardized management protocol for monitoring and managing devices and applications in real time. Directory Server provides a subagent interface so that it can be monitored by an SNMP manager application. This allows network applications to determine the status of the directory server and obtain information about its activity.

The Directory Server SNMP subagent contains read-only values. SNMP management applications cannot perform actions on the server.

In general, the access and error logs described in Chapter 13, “Monitoring Directory Server Using Log Files,” provide much more detailed information about the server, and LDAP is the protocol of choice for securely accessing and modifying the server configuration. However, the SNMP subagent does allow Directory Server instances to participate in existing network management systems.

This chapter contains the following topics:

- SNMP in Sun Java System Servers
- Overview of the Directory Server MIB
- Setting Up SNMP
- Configuring SNMP in Directory Server
- Starting and Stopping the SNMP Subagent

SNMP in Sun Java System Servers

SNMP allows a management application to query applications and devices which run an agent or subagent application. The SNMP agent or subagent gathers information from the application or device in response to a query from the SNMP manager. This information is structured as variables in tables which are defined by a management information base (MIB) for the agent.

Usually, the network manager queries the SNMP variables in the subagent, and the subagent returns the requested value. SNMP also defines a mechanism that allows an agent to report an event by sending a *trap* message to all network managers. If the subagent and master agent are running before the Directory Server daemon is launched, the Directory Server subagent sends a SMUX trap to the master agent on Directory Server startup or shutdown. The master agent converts this to an SNMP trap.

Multiple subagents can be installed on a host machine. For example, if Directory Server, Application Server, and Messaging Server all installed on the same host, the subagents for each of these servers communicate with the same master agent. The master agent is installed with Administration Server.

For further information, see Chapter 10, "Using SNMP to Monitor Servers," in the *Administration Server Administration Guide*.

The general procedure for setting up your server to be monitored through SNMP is the following:

1. Compile the Directory Server MIB and integrate it into your SNMP management system. Refer to your system documentation.
2. Set up SNMP on your machine, then configure and start the SNMP master agent through Sun Java System Server Console.
3. Configure the SNMP subagent through Directory Server Console.
4. Start the SNMP subagent through Directory Server Console.
5. Access the SNMP managed objects defined by the MIB and exposed through the agents. This step is entirely dependent on your SNMP management system.

The steps that are specific to Directory Server configuration are described in the following sections.

Overview of the Directory Server MIB

The Directory Server MIB has the following object identifier:

```
iso.org.dod.internet.private.enterprises.netscape.nsldap
(nsldapd OBJECT IDENTIFIER ::= { 1.3.6.1.4.1.1450.7 })
```

It is defined in the following file:

ServerRoot`/plugins/snmp/netscape-ldap.mib`

The MIB defines the variables that can be monitored through SNMP and the type of values they contain. The directory MIB is broken into four distinct tables of managed objects:

- Operations table - Contains statistics about binds, operations, referrals and errors in the directory. Values for these variables are also available in the attributes of the `cn=snmp,cn=monitor` entry of the directory. See “Monitoring Attributes,” in Chapter 2 of the *Directory Server Administration Reference*.
- Entries Table - Contains counts of entries in the directory and entry cache hits. Values for these variables are also mixed in with operation variables in the attributes of the `cn=snmp,cn=monitor` entry of the directory. See “Monitoring Attributes,” in Chapter 2 of the *Directory Server Administration Reference*.
- Interactions Table - Contains statistics about the last 5 directory servers with which this directory server has communicated. See the “Interactions Table of Supported SNMP Managed Objects,” in Chapter 2 of the *Directory Server Administration Reference*.
- Entity Table - Contains variables that describe this instance of Directory Server, such as its server ID and version. See the “Entity Table of SNMP Supported Managed Objects,“ in Chapter 2 of the *Directory Server Administration Reference*.

Before you can use the directory’s MIB, you must compile it along with the MIBs that you will find in the following directory:

ServerRoot`/plugins/snmp/mibs`

For information on how to compile MIBs, see your SNMP product documentation.

Setting Up SNMP

If your system is already running a native SNMP agent that supports SMUX communication, you do not need to install a master agent. However, you must change the native agent's configuration. If your system is not running a native SNMP agent, you must configure and start the master agent using Server Console.

If you are using the default port settings (161 for SNMP) then Administration Server and Directory Server must be run as the root user. If you reconfigure the master agent to use ports higher than 1000, it is not necessary to be root.

By default, the master agent uses port 161 which conflicts with the default port of the native SNMP agent on most platforms. You must either disable the native SNMP agent before starting the master agent or configure the master agent to use another port. To disable the native SNMP agent, refer to your platform documentation. To configure and start the master agent, follow the instructions in "Configuring the Master Agent," in Chapter 10 of the *Administration Server Administration Guide*.

Configuring SNMP in Directory Server

After setting up the SNMP agent or service on your platform, you must configure the SNMP parameters in your Directory Server instance. To configure SNMP settings from Directory Server Console:

1. On the top-level Configuration tab of Directory Server Console, select the server node at the root of the configuration tree, then select the SNMP tab in the right-hand panel.

2. Select the "Enable statistics collection" checkbox. By default, statistics for SNMP variables are not collected in order to improve resource usage. If you do not use SNMP and do not monitor the attributes of the `cn=snmp,cn=monitor` entry through LDAP, you should leave this checkbox disabled.

3. Enter the hostname and port number of the master agent in the corresponding text fields.

   The defaults are `localhost` and port `199,` respectively.

4. Enter information in the text fields of the Descriptive Properties box. These values will be reflected in the SNMP Entity table exposed by this server:

   ❍ Description - Enter a description of your directory server, similar to the description field for this instance in the topology tree of Server Console.

- Organization - Enter the name of the company or internal organization to which the directory server belongs.
- Location - Enter a geographical location for the directory server host.
- Contact - Enter the email address or contact information of the directory server administrator.

5. Click Save to store your changes.
6. Start or restart the SNMP subagent, as described in the following section.

Starting and Stopping the SNMP Subagent

The following procedures describe how to start, restart or stop the SNMP subagent from Directory Server Console. For information on starting and stopping the subagent from the command line, refer to the "`directoryserver sagt`" command in the *Directory Server Administration Reference*.

NOTE If you add another server instance on the same host, and you want the instance to be part of the SNMP network, you must restart the SNMP subagent.

To start, stop, and restart the SNMP subagent:

1. On the top-level Configuration tab of Directory Server Console, select the server node at the root of the configuration tree, then select the SNMP tab in the right-hand panel.
2. Use the subagent control buttons below the Descriptive Properties box to start stop, or restart the subagent.

   Stopping the directory does not stop the directory subagent. If you want to stop the subagent, you must do so from this tab.

Chapter 15

Enforcing Attribute Value Uniqueness

The UID uniqueness plug-in ensures that the value of a given attribute is unique among all entries of the directory or of a subtree. The plug-in will stop any operation that tries to add an entry which contains an existing value for the given attribute, or any operation that adds or modifies the attribute to a value that already exists in the directory.

The UID uniqueness plug-in is disabled by default. When it is enabled, it ensures the uniqueness of the `uid` attribute by default. You can create new instances of the plug-in to enforce unique values on other attributes. The UID uniqueness plug-in is limited to ensuring attribute value uniqueness on a single server.

This chapter contains the following sections:

Overview

The UID uniqueness plug-in is a preoperation plug-in. It checks all LDAP operations before the server performs an update of the directory. The plug-in determines whether the operation will cause two entries to have the same attribute value, in which case the server terminates the operation and returns an error 19, `LDAP_CONSTRAINT_VIOLATION`, to the client.

You can configure the plug-in to enforce uniqueness in one or more subtrees in the directory or among entries of a specific object class. This configuration determines the set of entries for which unique attribute values will be enforced. An operation may be terminated only if it targets an entry of this set and if the attribute value is not unique among all entries of this set.

You can define several instances of the UID uniqueness plug-in if you want to enforce the uniqueness of other attributes. Define one plug-in instance for each set of entries and attribute whose value must be unique. You can also have several plug-in instances for the same attribute to enforce “separate” uniqueness in several sets of entries. A given attribute value will be allowed only once in each set.

When you enable attribute uniqueness on an existing directory, the server does not check for uniqueness among existing entries. Uniqueness is only enforced when an entry is added or when the attribute is added or modified.

By default, the UID uniqueness plug-in is disabled because it affects the operation of multi-master replication. You may enable the UID uniqueness plug-in when using replication, but you should be aware of the behavior described in “Using the Uniqueness Plug-In With Replication” on page 454.

Enforcing Uniqueness of the uid Attribute

This section explains how to enable and configure the default uniqueness plug-in for the `uid` attribute. To enforce uniqueness for another attribute, see “Enforcing Uniqueness of Another Attribute” on page 453.

Configuring the Plug-In Using the Console

When using the console, you must not modify the default `uid` uniqueness plug-in to enforce uniqueness of another attribute. If you do not wish to have a `uid` uniqueness plug-in, leave it disabled and create a new plug-in instance for another attribute, as described in “Enforcing Uniqueness of Another Attribute” on page 453.

1. On the top-level Configuration tab of Directory Server Console, expand the Plug-Ins node and select the `uid uniqueness` plug-in.
2. In the right-hand panel, select the checkbox to enable the plug-in.

   Do not modify the fields for the initialization function or the plug-in module path.

3. Modify the plug-in arguments according to how you wish to specify the subtrees where uniqueness is enforced:

   ❍ To specify the base DN of a single subtree, edit the value of Argumen t2. To specify more than one subtree, click Add to add more arguments and enter the base DN of a subtree in each new text field.

   ❍ To specify subtrees by the object class of their base entries, set the arguments to the following values:

     Argument 1: `attribute=uid`
     Argument 2: `markerObjectClass=`*baseObjectClass*

     The plug-in will enforce `uid` uniqueness in the subtree below every entry in the directory with the given *baseObjectClass*. For example, if you have user entries in many branches such as `ou=Employees` and `ou=Contractors`, specify `markerObjectClass=organizationalUnit`.

     Because the scope of branches under the marker object classes may be quite large, you can further restrict the enforcement of attribute uniqueness to certain entries, according to their object class. Click on Add to add a third plug-in argument and set it to the following value:

     Argument 3: `requiredObjectClass=`*entryObjectClass*

     Within the subtree of entries with the *baseObjectClass*, the plug-in will enforce uniqueness only in operations that target entries with the *entryObjectClass*. For example, if you have traditional user entries, specify `requiredObjectClass=inetorgperson`.

4. Click Save when you have finished editing the `uid` uniqueness plug-in. You will be reminded that you must restart the server for the changes to take effect.

5. Restart the server to begin enforcing unique values for the `uid` attribute.

Configuring the Plug-In From the Command Line

The following procedure describes how to enable and configure the `uid` uniqueness plug-in using the `ldapmodify` command. The DN of the plug-in configuration entry is `cn=uid uniqueness,cn=plugins,cn=config`.

1. Enable or disable the plug-in by setting the `nsslapd-pluginEnabled` attribute to `on` or `off`, respectively:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: cn=uid uniqueness,cn=plugins,cn=config
changetype: modify
replace: nsslapd-pluginEnabled
nsslapd-pluginEnabled: on or off
^D
```

2. Modify the plug-in arguments according to how you wish to specify the subtrees where uniqueness is enforced:

- To specify the base DN of a single subtree, modify the value of `nsslapd-pluginarg1`:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: cn=uid uniqueness,cn=plugins,cn=config
changetype: modify
replace: nsslapd-pluginArg1
nsslapd-pluginArg1: subtreeBaseDN
^D
```

To specify more than one subtree, add more arguments with the full base DN of a subtree as the value of each argument:

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: cn=uid uniqueness,cn=plugins,cn=config
changetype: modify
add: nsslapd-pluginArg2
nsslapd-pluginArg2: subtreeBaseDN
-
add: nsslapd-pluginArg3
nsslapd-pluginArg3: subtreeBaseDN
-
...
^D
```

- To specify subtrees according to the object class of their base entries, set the arguments to the following values. Uniqueness of the `uid` attribute will be enforced in the subtree below every entry with the *baseObjectClass*. Optionally, you may specify the *entryObjectClass* in the third argument so that the plug-in enforces uniqueness only in operations that target entries with this object class.

```
ldapmodify -h host -p port -D "cn=Directory Manager" -w password
dn: cn=uid uniqueness,cn=plugins,cn=config
changetype: modify
replace: nsslapd-pluginArg0
nsslapd-pluginArg0: attribute=uid
-
replace: nsslapd-pluginArg1
```

```
nsslapd-pluginArg1: markerObjectClass=baseObjectClass
-
replace: nsslapd-pluginArg2
nsslapd-pluginArg2: requiredObjectClass=entryObjectClass
^D
```

3. Restart the server for your changes to take effect.

Enforcing Uniqueness of Another Attribute

The UID uniqueness plug-in may be used to enforce the uniqueness of any attribute. You must create a new instance of the plug-in by creating a new entry under `cn=plugins,cn=config` in the directory.

1. Use the `ldapmodify` command to add the configuration entry of the new plug-in instance. The first part of the command is shown below. The rest of the command is shown in the following steps.

```
ldapmodify -a -h host -p port -D "cn=Directory Manager" -w password
dn: cn=plug-in_name,cn=plugins,cn=config
objectClass: top
objectClass: nsSlapdPlugin
objectClass: extensibleObject
cn: plug-in_name
nsslapd-pluginDescription: Enforce unique attribute values
nsslapd-pluginType: preoperation
nsslapd-plugin-depends-on-type: database
nsslapd-pluginPath: ServerRoot/lib/uid-plugin.so
nsslapd-pluginVersion: 5.2
nsslapd-pluginVendor: Sun Microsystems, Inc.
nsslapd-pluginId: NSUniqueAttr
nsslapd-pluginInitfunc: NSUniqueAttr_Init
nsslapd-pluginEnabled: on or off
...
^D
```

In this first part of the command, *plug-in_name* should be a short and descriptive name that includes the name of the attribute, for example `cn=mail uniqueness`. Specify the enabled state of your new instance as either `on` or `off` when the server is restarted.

2. The rest of the command specifies the plug-in arguments that depend on how you wish to determine the subtrees where uniqueness is enforced:

- To define one or more subtrees according to their base DN, the first argument must be the name of the attribute that should have unique values, and the subsequent arguments are the full DNs of the base entries of the subtrees:

  ```
  nsslapd-pluginarg0: attribute_name
  nsslapd-pluginarg1: subtreeBaseDN
  nsslapd-pluginarg2: subtreeBaseDN
  ...
  ^D
  ```

- To define subtrees according to the objectclass of their base entries, the first argument must contain `attribute=`*attribute_name* to specify the name of the attribute that should have unique values. The second argument must be the *baseObjectClass* that determines the base entry of subtrees where uniqueness is enforced. Optionally, you may specify an *entryObjectClass* in the third argument so that the plug-in enforces uniqueness only in operations that target entries with this object class.

  ```
  nsslapd-pluginarg0: attribute=attribute_name
  nsslapd-pluginarg1: markerObjectClass=baseObjectClass
  nsslapd-pluginarg2: requiredObjectClass=entryObjectClass
  ^D
  ```

  In all plug-in arguments, there must be no white space before or after the = sign.

3. Restart the server to load this new instance of the uniqueness plug-in into the server.

Using the Uniqueness Plug-In With Replication

The UID uniqueness plug-in does not perform any checking on attribute values when an update is performed as part of a replication operation. This does not affect single-master replication, but the plug-in cannot automatically enforce attribute uniqueness for multi-master replication.

Single-Master Replication Scenario

Because all modifications by client applications are performed on the master replica, the UID uniqueness plug-in should be enabled on the master server. The plug-in should be configured to enforce uniqueness in the replicated suffix. Because the master ensures that the values of the desired attribute are unique, it is unnecessary to enable the plug-in on the consumer server.

Enabling the UID uniqueness plug-in on the consumer of a single master will not interfere with replication or normal server operations, but it may cause a slight performance degradation.

Multi-Master Replication Scenario

The UID uniqueness plug-in was not designed for use in a multi-master replication scenario. Because multi-master replication uses a loosely consistent replication model, simultaneously adding the same attribute value on both servers will not be detected, even if the plug-in is enabled on both servers.

However, you can use the UID uniqueness plug-in under the following conditions:

- The attribute on which you are performing the uniqueness check is a naming attribute.
- The uniqueness plug-in is enabled for the same attribute in the same subtrees on all masters.

When these conditions are met, uniqueness conflicts are reported as naming conflicts at replication time. Naming conflicts require manual resolution. For information on resolving replication conflicts, refer to "Solving Common Replication Conflicts" on page 349.

Chapter 16

Troubleshooting Directory Server

This chapter provides basic troubleshooting information on installing Directory Server.

Troubleshooting Installation

Table 16-1 Common Installation Problems With Solutions

Problem	**Possible Solutions**
I get a message about missing libraries.	Run `idsktune` and fix at least all `ERROR` conditions, installing all recommended patches.
Installation did not work, and now I cannot uninstall. What do I do?	Removing the product registry file *unless doing so would negatively impact other products*: • `/var/sadm/install/productregistry` on Solaris systems when installing as super user • `/var/tmp/sw/productregistry` on AIX and HP-UX systems • `/var/tmp/productregistry` on Red Hat systems • `%SYSTEM_DIR%\system32\productregistry`, on Windows Next, remove the partially installed files by hand before reinstalling.
Installation failed and I do not know why. Is there an installation log somewhere?	Yes. The log can be found under the following location: • On Solaris systems, `/var/sadm/install/logs` (installation as super user) or `/var/tmp` (installation as a regular user) • On other UNIX systems, `/var/tmp` • On Windows systems, `%TEMP%` folder

Table 16-1 Common Installation Problems With Solutions *(Continued)*

Problem	Possible Solutions
Clients cannot locate the server.	Try using the host name such as `dirserv`. If that does not work, make sure the server is listed in the name service you are using such as DNS, and try the fully qualified domain name such as `dirserv.example.com`. If that does not work, try using the IP address for the host such as `192.168.0.30`.
The port is in use.	If upgrading, you probably did not shut down Directory Server before you upgraded it. Shut down the old server, then manually start the upgraded one. Otherwise, another server might be using the port. Examine which ports are in use with an appropriate tool such as the `netstat`(1M) utility with the `-a` option on UNIX systems to determine which ports remain available.
An LDAP authentication error causes installation to fail.	You may have provided the incorrect fully qualified domain name during installation, such as `dirserv.nisDomain.Example.COM` instead of `dirserv.example.com`.
I have forgotten the Directory Manager DN and password.	The Directory Manager DN is recorded as the value of `nsslapd-rootdn` in *ServerRoot*`/slapd-`*serverID*`/config/dse.ldif`. The Directory Manager password is recorded as the value of `nsslapd-rootpw` in `dse.ldif`. If the password is not encrypted — we strongly recommend you encrypt it! — then it appears in `dse.ldif` in clear text, not prefixed with an encryption scheme identifier such as `{SSHA}`. If the password is encrypted, you must fix the problem manually. 1. Stop Directory Server. 2. Change the value of `nsslapd-rootpw` in `dse.ldif`, taking care not to add trailing spaces. 3. Save and close `dse.ldif`. 4. Restart the server. 5. Login as Directory Manager using the value you assigned to `nsslapd-rootpw`. 6. Set an encryption scheme for the Directory Manager password as described in the *Directory Server Administration Guide*, and then change the password again.

Table 16-1 Common Installation Problems With Solutions *(Continued)*

Problem	Possible Solutions
I installed the 32-bit version of the Directory Server by mistake. How do I run the 64-bit version instead?	1. Export all suffixes to LDIF as described in the *Directory Server Administration Guide*. 2. Remove all database files. Database files are found under the path indicated by the value of `nsslapd-directory` on `cn=config,cn=ldbm database,cn=plugins,cn=config` for the instance. 3. Install 64-bit components if you have not done so already. 4. Make *ServerRoot*`/bin/slapd/server/64/ns-slapd` executable. 5. If the operating system is running in 32-bit mode, reboot it in 64-bit mode. 6. If necessary, change cache size settings to work in 32-bit mode. 7. Initialize all suffixes with the LDIF you exported as described in the *Directory Server Administration Guide*. 8. Restart the server.
I installed the 64-bit version of the Directory Server by mistake. How do I run the 32-bit version instead?	1. Export all suffixes to LDIF as described in the *Directory Server Administration Guide*. 2. Remove all database files. Database files are found under the path indicated by the value of `nsslapd-directory` on `cn=config,cn=ldbm database,cn=plugins,cn=config` for the instance. 3. Change the mode of *ServerRoot*`/bin/slapd/server/64/ns-slapd` so it is not executable. 4. Initialize all suffixes with the LDIF you exported as described in the *Directory Server Administration Guide*. 5. Restart the server.

Table 16-1 Common Installation Problems With Solutions *(Continued)*

Problem	Possible Solutions

I wrote a script to handle installation. When I tried installing using my script, the installer returned `73`, rather than `0`.
 	
What is going on here?
	The installation program return codes are as follows:
	`0 - SUCCESS`
	`1 - WARNING_REBOOT_REQUIRED`
	`2 - WARNING_PLATFORM_SUPPORT_LIMITED`
	`3 - WARNING_RESOURCE_NOT_FOUND`
	`4 - WARNING_CANNOT_WRITE_LOG`
	`5 - WARNING_LOCALE_NOT_SUPPORTED`
	`50 - ERROR_FATAL`
	`51 - ERROR_ACCESS`
	`52 - ERROR_PLATFORM_NOT_SUPPORTED`
	`53 - ERROR_NO_WINDOWING_SYSTEM_AVAILABLE`
	`54 - ERROR_RESOURCE_NOT_FOUND`
	`55 - ERROR_TASK_FAILURE`
	`56 - ERROR_USER_EXIT`
	`57 - ERROR_CANNOT_UPGRADE`
	`58 - ERROR_NOTHING_TO_DO`
	`59 - ERROR_IN_SERIALIZATION`
	`60 - ERROR_ABNORMAL_EXIT`
	`61 - ERROR_INCOMPATIBLE_STATEFILE`
	`62 - ERROR_UNKNOWN_COMMANDLINE_OPTION`
	`70 - ERROR_NOT_INSTALLED`
	`71 - PARTIALLY_UNINSTALLED`
	`72 - FULLY_UNINSTALLED`
	`73 - INSTALLED`
	`74 - ERROR_FAILED`
	`75 - ERROR_STOPPED`
	`76 - ERROR_STOPPED_ON_ERROR`
	`77 - PARTIALLY_INSTALLED`
	
	In other words, `73` indicates successful installation.

Appendix A

Using the Sun Crypto Accelerator Board

This appendix provides instructions on using a Sun Crypto Accelerator board with Directory Server to enhance performance for connections using the Secure Sockets Layer (SSL) protocol with certificate-based authentication.

Before You Start

Table A-1 covers items that must be completed before attempting to use the Sun Crypto Accelerator board to enhance SSL connection performance.

Table A-1 Prerequisites to Using the Board

Prerequisite	**Remarks**
Board installation	Refer to the product documentation provided for the board when installing the hardware, drivers, patches, and administrative utilities on the host.
Directory Server installation	Refer to the *Sun Java Enterprise System 2004Q2 Installation Guide* for instructions.
Server cert. (PKCS#12 format)	Obtain a server certificate for Directory Server as a `.p12` file
CA cert. (PEM format)	Obtain the CA certificate for your Certificate Authority (CA) as a Privacy Enhanced Mail (PEM) format file.

Refer to Chapter 11, “Managing Authentication and Encryption,” both for a discussion of the SSL protocol itself and of SSL certificates, and for instructions on how to use the protocol with Sun Java System servers supporting administration through the Server Console.

Creating a Token

Directory Server uses a token and password to access the appropriate cryptographic key material on the accelerator board. The token takes the form *user@realm*, where *user* is a user in terms of the accelerator board — an owner of cryptographic keying material — and *realm* is a realm in terms of the accelerator board — a logical partition of users and their keying material. The accelerator board *user* need not bear any relation to a user account on the system. It is specific to the board. Refer to the accelerator board product documentation for further explanation of users and realms.

You may create a user and realm for the token using the `secadm`(1M) utility provided for use with the board. The accelerator board also permits creation of multiple *slots* to manage tokens for multiple applications. It is assumed here that for performance reasons, you dedicate the host to Directory Server and therefore use only one slot, the default. Refer to the accelerator board product documentation for details on using the board with multiple software applications.

Perform the following steps to create the user and realm for a token to access the default slot.

1. Start the `secadm` utility.

   ```
   $ CryptoPath/bin/secadm
   ```

   The default *CryptoPath* is `/opt/SUNWconn/crypto`.

2. Create a realm for the token.

   ```
   secadm> create realm=dsrealm
   System Administrator Login Required
   Login: super-user
   Password:
   Realm dsrealm created successfully.
   ```

3. Set the realm in which to create a user.

   ```
   secadm> set realm=dsrealm
   secadm{dsrealm}> su
   System Administrator Login Required
   Login: super-user
   Password:
   secadm{root@dsrealm}#
   ```

4. Create the user `nobody` to use the default slot, supplying the password used when restarting Directory Server with SSL configured.

```
secadm{root@dsrealm}# create user=nobody
Initial password: password
Confirm password: password
User nobody created successfully.
secadm{root@dsrealm}# exit
```

At this point you have created the user and realm for the token `nobody@dsrealm`, and supplied a password used when restarting Directory Server.

Generating Bindings for the Board

Bindings for the accelerator board take the form of an external security module you generate so Directory Server may bind to the board. Perform the following steps to generate a binding between the external security module and Directory Server certificate database with support for several SSL algorithms.

1. Set `LD_LIBRARY_PATH` before using `modutil`.

   ```
   $ set LD_LIBRARY_PATH=ServerRoot/lib ; export LD_LIBRARY_PATH
   ```

2. Create a security module database if none exists.

   ```
   $ cd ServerRoot/shared/bin
   $ ./modutil -create -dbdir ../../alias -dbprefix "slapd-serverID"
   ```

3. Add the external security module to the security module database.

   ```
   $ ./modutil -add "Crypto Mod" -dbdir ../../alias -nocertdb \
   -libfile CryptoPath/lib/libpkcs11.so \
   -mechanisms "RSA:DSA:RC4:DES" -dbprefix "slapd-serverID"
   ```

   The default *CryptoPath* is `/opt/SUNWconn/crypto`.

4. List the security modules to ensure the add succeeded.

   ```
   $ ./modutil -list -dbdir ../../alias -dbprefix "slapd-serverID"
   ```

   You should see an entry for the `Crypto Mod` you added in Step 3.

5. Make the external security module the default for RSA, DSA, RC4, and DES.

   ```
   $ ./modutil -default "Crypto Mod" -dbdir ../../alias \
   -mechanisms "RSA:DSA:RC4:DES" -dbprefix "slapd-serverID"
   ```

   This should successfully change the default security module.

At this point you have generated bindings for the accelerator board and may import certificates.

Importing Certificates

Before configuring SSL, you must import the server and CA certificates you obtained as described in Table A-1 on page 461. Perform the following steps to import the certificates.

1. Import the server certificate `.p12` file.

```
$ cd ServerRoot/shared/bin
$ ./pk12util -i ServerCert.p12 -d ../../alias -P "slapd-serverID" \
-h "nobody@dsrealm"
Enter Password or Pin for "nobody@dsrealm": password
Enter Password for PKCS12 file: password
```

2. Import the CA certificate.

```
$ ./certutil -A -n "Crypto CA Cert" -t CT -i CACert.txt \
-d ../../alias -P "slapd-serverID" -h "nobody@dsrealm"
```

3. List the certificates associated with the token to ensure the imports succeeded.

```
$ ./certutil -L -d ../../alias -P "slapd-serverID" \
-h "nobody@dsrealm"
```

   You should see entries for the certificates you added in Step 1 and Step 2.

At this point you have imported the certificates and may configure Directory Server to listen for SSL connections.

Configuring SSL

Using the token and password you created, bindings you generated between the external security module and Directory Server certificate database, and the certificates you imported, you may configure Directory Server to start in secure mode. Perform these steps to configure SSL and restart Directory Server in secure mode.

1. Create a file, `ssl.ldif`, of modifications to change SSL related Directory Server configuration entries.

Code Example A-1 Modifications to Activate SSL Using the Board (`ssl.ldif`)

```
dn: cn=RSA,cn=encryption,cn=config
changetype: add
objectclass: top
objectclass: nsEncryptionModule
cn: RSA
nsSSLToken: nobody@dsrealm
nsSSLPersonalitySSL: ServerCertNickname[1]
nsSSLActivation: on

dn: cn=encryption,cn=config
changetype: modify
replace: nsSSL3
nsSSL3: on
-
replace: nsSSLClientAuth
nsSSLClientAuth: allowed
-
replace: nsSSL3Ciphers
nsSSL3Ciphers: -rsa_null_md5,+rsa_rc4_128_md5,+rsa_rc4_40_md5,
 +rsa_rc2_40_md5,+rsa_des_sha,+rsa_fips_des_sha,+rsa_3des_sha,
 +rsa_fips_3des_sha,+fortezza,+fortezza_rc4_128_sha,
 +fortezza_null,+tls_rsa_export1024_with_rc4_56_sha,
 +tls_rsa_export1024_with_rc4_56_sha,
 +tls_rsa_export1024_with_des_cbc_sha
-
replace: nsCertfile
nsCertfile: alias/slapd-serverID-cert8.db
-
replace: nsKeyFile
nsKeyFile: alias/slapd-serverID-key3.db

dn: cn=config
changetype: modify
replace: nsslapd-secureport
nsslapd-secureport: port
-
replace: nsslapd-security
nsslapd-security: on
```

1. This nickname is contained in the certificate for Directory Server.

Here *port*, the value of `nsslapd-secureport`, is the port on which Directory Server listens for SSL connections once started in secure mode.

2. Apply the modifications to change Directory Server configuration.

```
$ ldapmodify -p currPort -D "cn=directory manager" -w password -f ssl.ldif
```

where *currPort* is the number of the port on which the Directory Server currently listens for client requests.

3. Restart the Directory Server in secure mode.

```
$ ServerRoot/slapd-serverID/restart-slapd
Enter PIN for nobody@dsrealm: password
```

Here *password* is the user password for `nobody` provided when the token `nobody@dsrealm` was created.

At this point, Directory Server listens for SSL traffic over the port you specified. You may configure Sun Java System Administration Server and client applications to access Directory Server over SSL through that port. Refer to Chapter 11, "Managing Authentication and Encryption" for details.

Appendix B

Third Party Licence Acknowledgements

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The source code to the Standard Version of Perl can be obtained from CPAN sites, including http: / / www.perl.com / .

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Glossary

Refer to the *Java Enterprise System Glossary* (http://docs.sun.com/doc/816-6873) for a complete list of terms that are used in this documentation set.

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