

Oracle® Fusion Middleware Reference for Oracle Directory Server Enterprise Edition

11 g Release 1 (11.1.1)

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Preface

This book describes product architecture, configuration, tools, APIs, and schema for Directory Server and Directory Proxy Server.

Who Should Use This Book

This *Reference* is intended for directory service administrators, designers, and developers.

Before You Read This Book

Review pertinent information in the *Oracle Fusion Middleware Release Notes for Oracle Directory Server Enterprise Edition*.

If you are deploying Directory Server Enterprise Edition software in production, also review pertinent information in the *Oracle Fusion Middleware Deployment Planning Guide for Oracle Directory Server Enterprise Edition*.

How This Book Is Organized

Chapter 1, “Directory Server Enterprise Edition File Reference,” describes the installed product layout.

Part I, “Directory Server Reference,” covers Directory Server features and architecture.

Part II, “Directory Proxy Server Reference,” covers Directory Proxy Server features and architecture.

Oracle Directory Server Enterprise Edition Documentation Set

This documentation set explains how to use Oracle Directory Server Enterprise Edition to evaluate, design, deploy, and administer directory services. In addition, it shows how to develop client applications for Directory Server Enterprise Edition. The Directory Server Enterprise Edition documentation set is available at <http://docs.sun.com/coll/1819.3>.

The following table lists the documents that make up the Directory Server Enterprise Edition documentation set.

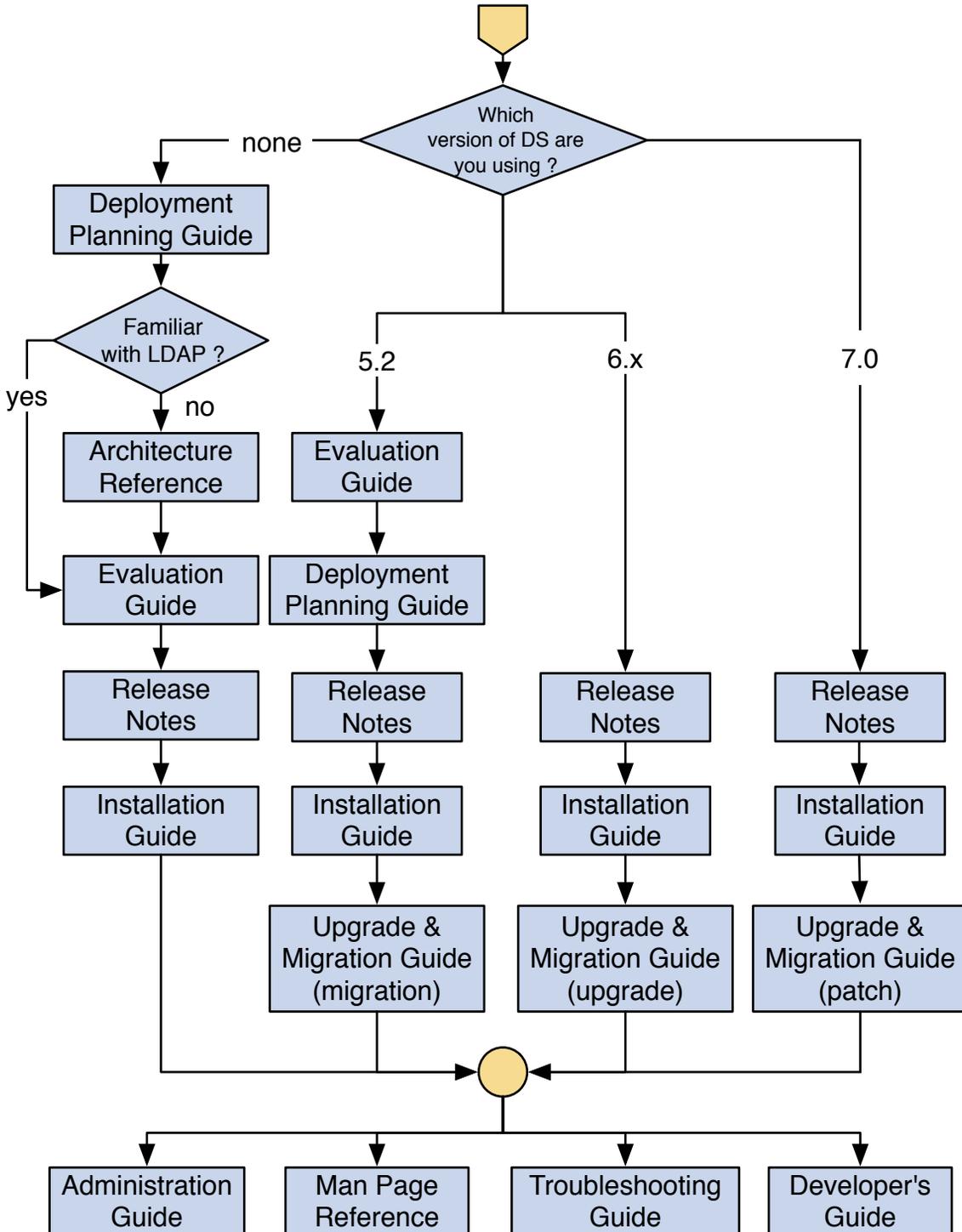
TABLE P-1 Directory Server Enterprise Edition Documentation

Document Title	Contents
<i>Oracle Fusion Middleware Release Notes for Oracle Directory Server Enterprise Edition</i>	Contains the latest information about Directory Server Enterprise Edition, including known problems.
<i>Oracle Fusion Middleware Documentation Center for Oracle Directory Server Enterprise Edition</i>	Contains links to key areas of the documentation set that help you to quickly locate the key information.
<i>Oracle Fusion Middleware Evaluation Guide for Oracle Directory Server Enterprise Edition</i>	Introduces the key features of this release. Demonstrates how these features work and what they offer in the context of a deployment that you can implement on a single system.
<i>Oracle Fusion Middleware Deployment Planning Guide for Oracle Directory Server Enterprise Edition</i>	Explains how to plan and design highly available, highly scalable directory services based on Directory Server Enterprise Edition. Presents the basic concepts and principles of deployment planning and design. Discusses the solution life cycle, and provides high-level examples and strategies to use when planning solutions based on Directory Server Enterprise Edition.
<i>Oracle Fusion Middleware Installation Guide for Oracle Directory Server Enterprise Edition</i>	Explains how to install the Directory Server Enterprise Edition software. Shows how to configure the installed software and verify the configured software.
<i>Oracle Fusion Middleware Upgrade and Migration Guide for Oracle Directory Server Enterprise Edition</i>	Provides upgrade instructions to upgrade the version 6 installation and migration instructions to migrate version 5.2 installations.
<i>Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition</i>	Provides command-line instructions for administering Directory Server Enterprise Edition. For hints and instructions about using the Directory Service Control Center, DSCC, to administer Directory Server Enterprise Edition, see the online help provided in DSCC.
<i>Oracle Fusion Middleware Reference for Oracle Directory Server Enterprise Edition</i>	Introduces technical and conceptual foundations of Directory Server Enterprise Edition. Describes its components, architecture, processes, and features.
<i>Oracle Fusion Middleware Man Page Reference for Oracle Directory Server Enterprise Edition</i>	Describes the command-line tools, schema objects, and other public interfaces that are available through Directory Server Enterprise Edition. Individual sections of this document can be installed as online manual pages.

TABLE P-1 Directory Server Enterprise Edition Documentation (Continued)

Document Title	Contents
<i>Oracle Fusion Middleware Troubleshooting Guide for Oracle Directory Server Enterprise Edition</i>	Provides information for defining the scope of the problem, gathering data, and troubleshooting the problem areas by using various tools.
<i>Sun Java System Identity Synchronization for Windows 6.0 Deployment Planning Guide</i>	Provides general guidelines and best practices for planning and deploying Identity Synchronization for Windows.
<i>Sun Java System Identity Synchronization for Windows 6.0 Installation and Configuration Guide</i>	Describes how to install and configure Identity Synchronization for Windows.
Installation Instructions for Identity Synchronization for Windows 6.0 Service Pack 1	Provides installation instructions for Identity Synchronization for Windows 6.0 SP1.
<i>Oracle Fusion Middleware Developer's Guide for Oracle Directory Server Enterprise Edition 11g Release 1 (11.1.1)</i>	Shows how to develop directory client applications with the tools and APIs that are provided as part of Directory Server Enterprise Edition. This guide is not provided as part of the documentation set, but is bundled, with all sample code files, in an <code>example.zip</code> file, available at (http://www.oracle.com/technology/sample_code/products/oid/index.html).

For an introduction to Directory Server Enterprise Edition, review the following documents in the order in which they are listed.



Related Reading

The SLAMD Distributed Load Generation Engine is a Java application that is designed to stress test and analyze the performance of network-based applications. This application was originally developed by Sun Microsystems, Inc. to benchmark and analyze the performance of LDAP directory servers. SLAMD is available as an open source application under the Sun Public License, an OSI-approved open source license. To obtain information about SLAMD, go to <http://www.slamd.com/>. SLAMD is also available as a java.net project. See <https://slamd.dev.java.net/>.

Java Naming and Directory Interface (JNDI) supports accessing the Directory Server using LDAP and DSML v2 from Java applications. For information about JNDI, see <http://java.sun.com/products/jndi/>. The *JNDI Tutorial* contains detailed descriptions and examples of how to use JNDI. This tutorial is at <http://java.sun.com/products/jndi/tutorial/>.

Identity Synchronization for Windows uses Message Queue with a restricted license. Message Queue documentation is available at <http://docs.sun.com/coll/1307.6>.

Identity Synchronization for Windows works with Microsoft Windows password policies.

- Information about password policies for Windows 2003, is available in the [Microsoft documentation](#) online.
- Information about the Microsoft Certificate Services Enterprise Root certificate authority, is available in the [Microsoft support documentation](#) online.
- Information about configuring LDAP over SSL on Microsoft systems, is available in the [Microsoft support documentation](#) online.

Redistributable Files

Directory Server Enterprise Edition does not provide any files that you can redistribute.

Default Paths and Command Locations

This section explains the default paths used in documentation, and provides locations of commands on different operating systems and deployment types.

Default Paths

The table in this section describes the default paths that are used in this document. For complete descriptions of the files installed, see [Chapter 1, “Directory Server Enterprise Edition File Reference.”](#)

TABLE P-2 Default Paths

Placeholder	Description	Default Value
<i>install-path</i>	Represents the base installation directory for Directory Server Enterprise Edition software.	When you install from a zip distribution using unzip, the <i>install-path</i> is the <i>current-directory/dsee7</i> . When you install from a native package distribution, the default <i>install-path</i> is <i>/opt/SUNWdsee7</i> .
<i>instance-path</i>	Represents the full path to an instance of Directory Server or Directory Proxy Server. Documentation uses <i>/local/dsInst/</i> for Directory Server and <i>/local/dps/</i> for Directory Proxy Server.	No default path exists. Instance paths must nevertheless always be found on a <i>local</i> file system. On Solaris systems, the <i>/var</i> directory is recommended:
<i>serverroot</i>	Represents the parent directory of the Identity Synchronization for Windows installation location	Depends on your installation. Note that the concept of a <i>serverroot</i> no longer exists for Directory Server and Directory Proxy Server.
<i>isw-hostname</i>	Represents the Identity Synchronization for Windows instance directory	Depends on your installation
<i>/path/to/cert8.db</i>	Represents the default path and file name of the client's certificate database for Identity Synchronization for Windows	<i>current-working-dir/cert8.db</i>
<i>serverroot/isw-hostname/logs/</i>	Represents the default path to the Identity Synchronization for Windows local log files for the System Manager, each connector, and the Central Logger	Depends on your installation
<i>serverroot/isw-hostname/logs/central/</i>	Represents the default path to the Identity Synchronization for Windows central log files	Depends on your installation

Command Locations

The table in this section provides locations for commands that are used in Directory Server Enterprise Edition documentation. To learn more about each of the commands, see the relevant man pages.

TABLE P-3 Command Locations

Command	Native Package Distribution	Zip Distribution
cacaoadm	/usr/sbin/cacaoadm	Solaris, Linux, HP—UX — <i>install-path/bin/cacaoadm</i> Windows - <i>install-path\bin\cacaoadm.bat</i>
certutil	/usr/sfw/bin/certutil	<i>install-path/bin/certutil</i>
dpadm(1M)	<i>install-path/bin/dpadm</i>	<i>install-path/bin/dpadm</i>
dpconf(1M)	<i>install-path/bin/dpconf</i>	<i>install-path/bin/dpconf</i>
dsadm(1M)	<i>install-path/bin/dsadm</i>	<i>install-path/bin/dsadm</i>
dsccon(1M)	<i>install-path/bin/dsccon</i>	<i>install-path/bin/dsccon</i>
dsccreg(1M)	<i>install-path/bin/dsccreg</i>	<i>install-path/bin/dsccreg</i>
dscctest(1M)	<i>install-path/bin/dscctest</i>	<i>install-path/bin/dscctest</i>
dsconf(1M)	<i>install-path/bin/dsconf</i>	<i>install-path/bin/dsconf</i>
dsmig(1M)	<i>install-path/bin/dsmig</i>	<i>install-path/bin/dsmig</i>
dsutil(1M)	<i>install-path/bin/dsutil</i>	<i>install-path/bin/dsutil</i>
entrycmp(1)	<i>install-path/bin/entrycmp</i>	<i>install-path/bin/entrycmp</i>
fildif(1)	<i>install-path/bin/fildif</i>	<i>install-path/bin/fildif</i>
idsktune(1M)	Not provided	At the root of the unzipped zip distribution
insync(1)	<i>install-path/bin/insync</i>	<i>install-path/bin/insync</i>
ldapsearch(1)	<i>install-path/dsrk/bin/ldapsearch</i>	<i>install-path/dsrk/bin/ldapsearch</i>
repldisc(1)	<i>install-path/bin/repldisc</i>	<i>install-path/bin/repldisc</i>

Typographic Conventions

The following table describes the typographic conventions that are used in this book.

TABLE P-4 Typographic Conventions

Typeface	Meaning	Example
AaBbCc123	The names of commands, files, and directories, and onscreen computer output	Edit your <code>.login</code> file. Use <code>ls -a</code> to list all files. <code>machine_name%</code> you have mail.
AaBbCc123	What you type, contrasted with onscreen computer output	<code>machine_name%</code> su Password:
<i>aabbcc123</i>	Placeholder: replace with a real name or value	The command to remove a file is <i>rm filename</i> .
<i>AaBbCc123</i>	Book titles, new terms, and terms to be emphasized	Read Chapter 6 in the <i>User's Guide</i> . <i>A cache</i> is a copy that is stored locally. Do <i>not</i> save the file. Note: Some emphasized items appear bold online.

Shell Prompts in Command Examples

The following table shows the default UNIX system prompt and superuser prompt for shells that are included in the Solaris OS. Note that the default system prompt that is displayed in command examples varies, depending on the Solaris release.

TABLE P-5 Shell Prompts

Shell	Prompt
Bash shell, Korn shell, and Bourne shell	\$
Bash shell, Korn shell, and Bourne shell for superuser	#
C shell	<code>machine_name%</code>
C shell for superuser	<code>machine_name#</code>

Symbol Conventions

The following table explains symbols that might be used in this book.

TABLE P-6 Symbol Conventions

Symbol	Description	Example	Meaning
[]	Contains optional arguments and command options.	ls [-l]	The -l option is not required.
{ }	Contains a set of choices for a required command option.	-d {y n}	The -d option requires that you use either the y argument or the n argument.
\${ }	Indicates a variable reference.	\${com.sun.javaRoot}	References the value of the com.sun.javaRoot variable.
-	Joins simultaneous multiple keystrokes.	Control-A	Press the Control key while you press the A key.
+	Joins consecutive multiple keystrokes.	Ctrl+A+N	Press the Control key, release it, and then press the subsequent keys.
→	Indicates menu item selection in a graphical user interface.	File → New → Templates	From the File menu, choose New. From the New submenu, choose Templates.

Documentation, Support, and Training

The following additional resources are provided:

- [Documentation \(http://docs.sun.com\)](http://docs.sun.com)
- [Support \(http://www.sun.com/support/\)](http://www.sun.com/support/)
- [Training \(http://education.oracle.com\)](http://education.oracle.com) – Click the Sun link in the left navigation bar.

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Directory Server Enterprise Edition File Reference

This chapter describes the files found after you install Directory Server Enterprise Edition, and after you create server instances.

The examples shown in this chapter are for Solaris systems. File extensions and path separators may differ for your operating system. This chapter includes the following sections.

- “[Software Layout for Directory Server Enterprise Edition](#)” on page 31
- “[Directory Server Instance Default Layout](#)” on page 35
- “[Directory Proxy Server Instance Default Layout](#)” on page 37

If you installed software from native packages, you may also use the packaging commands on your system to list the files installed. For example, after installing from native packages on Solaris systems, you can obtain a full list for a particular package using the `pkgchk -v package-name` command.

Software Layout for Directory Server Enterprise Edition

This section describes the file layout you find after installing Directory Server Enterprise Edition from the zip distribution. All files locations are relative to the path where you installed the product. For information on default native package installation locations, see “[Default Paths and Command Locations](#)” on page 25.

install-path/bin/

The directory houses the following files of interest.

install-path/bin/cacaoadm

Command to administer the Common Agent Container.

install-path/bin/certutil

NSS certificate manipulation command used by other tools, not intended to be used directly.

install-path/bin/dpadm

Directory Proxy Server command for local administration. See [dpadm\(1M\)](#).

install-path/bin/dpconf

Directory Proxy Server command for configuration over LDAP. See [dpconf\(1M\)](#).

install-path/bin/dsadm

Directory Server command for local administration. See [dsadm\(1M\)](#).

install-path/bin/dsccmon

Command to monitor servers managed through Directory Service Control Center. See [dsccmon\(1M\)](#).

install-path/bin/dsccreg

Command to manage the Directory Service Control Center registry. See [dsccreg\(1M\)](#).

install-path/bin/dsccsetup

Command to set up Directory Service Control Center. See [dsccsetup\(1M\)](#).

install-path/bin/dsconf

Directory Server command for configuration over LDAP. See [dsconf\(1M\)](#).

install-path/bin/dsmig

Directory Server command for migration from version 5.2 to this version of Directory Server. See [dsmig\(1M\)](#).

install-path/bin/dsutil

Directory Server command for activating or inactivating a user or users member of a role. See [dsutil\(1M\)](#).

install-path/bin/entrycmp

Directory Server command for comparing directory entries across replica. See [entrycmp\(1\)](#).

install-path/bin/fildif

Directory Server command for filtering LDIF content. See [fildif\(1\)](#).

install-path/bin/insync

Directory Server command for examining replica synchronization. See [insync\(1\)](#).

install-path/bin/ldif

Directory Server command for formatting input by adding base64 encoding to make it suitable for inclusion in an LDIF file. See [ldif\(1\)](#).

install-path/bin/mmldif

Directory Server command for combining LDIF content. See [mmldif\(1\)](#).

install-path/bin/pwdhash

Directory Server command for displaying the hashed form of a password value. See [pwdhash\(1\)](#).

install-path/bin/repldisc

Directory Server command for discovering a replication topology. See [repldisc\(1\)](#).

install-path/bin/support_tools

Directory that contains Directory Server commands, not intended for use without help of a qualified support personnel.

install-path/dsrk/bin/authrate

Directory Server Resource Kit command to measure authentication rate. See [authrate\(1\)](#).

install-path/dsrk/bin/dsmlmodify

Directory Server Resource Kit command to add, modify, rename, move, or delete directory entries through Directory Services Markup Language (DSML) v2. See [dsmlmodify\(1\)](#).

install-path/dsrk/bin/dsmlsearch

Directory Server Resource Kit command to find directory entries through Directory Services Markup Language (DSML) v2. See [dsmlsearch\(1\)](#).

install-path/dsrk/bin/ldapcmp

Directory Server Resource Kit command to compare LDAP entries from two directories. See [ldapcmp\(1\)](#).

install-path/dsrk/bin/ldapcompare

Directory Server Resource Kit command to perform LDAP compare operations. See [ldapcompare\(1\)](#).

install-path/dsrk/bin/ldapdelete

Directory Server Resource Kit command to delete directory entries. See [ldapdelete\(1\)](#).

install-path/dsrk/bin/ldapmodify

Directory Server Resource Kit command to update entries over LDAP. See [ldapmodify\(1\)](#).

install-path/dsrk/bin/ldappasswd

Directory Server Resource Kit command to change user passwords. See [ldappasswd\(1\)](#).

install-path/dsrk/bin/ldapsearch

Directory Server Resource Kit command to search a directory. See [ldapsearch\(1\)](#).

install-path/dsrk/bin/ldapsubtdel

Directory Server Resource Kit command to recursively delete a directory subtree. See [ldapsubtdel\(1\)](#).

install-path/dsrk/bin/ldifxform

Directory Server Resource Kit command to reformat LDIF content. See [ldifxform\(1\)](#).

install-path/dsrk/bin/logconv

Directory Server Resource Kit command to analyze Directory Server access logs. See [logconv\(1\)](#).

install-path/dsrk/bin/makeldif

Directory Server Resource Kit command to generate LDIF content for testing and benchmarking purposes. See [makeldif\(1\)](#).

install-path/dsrk/bin/modrate

Directory Server Resource Kit command to measure modification performance for an LDAP directory. See [modrate\(1\)](#).

install-path/dsrk/bin/searchrate

Directory Server Resource Kit command to measure search performance for an LDAP directory. See [searchrate\(1\)](#).

install-path/dsrk/lib/

Libraries used by Directory Server Resource Kit commands, not intended to be used directly.

install-path/etc/

Directory Server Enterprise Edition agent configuration information, not intended to be used directly.

install-path/examples/

Sample Directory Server plug-ins.

install-path/ext/cacao_2/

Common agent container files shared by Directory Server Enterprise Edition component products, not intended to be used directly.

install-path/ext/SUNWmfwk/

Java ES Monitoring Framework files used by Directory Server, not intended to be used directly.

install-path/include/

Directory Server plug-in header files.

install-path/jre/

Java Runtime Environment, not intended to be used directly.

install-path/legal/

Legal files.

install-path/lib/

Libraries shared by Directory Server Enterprise Edition component products, not intended to be used directly.

install-path/resources/dcc7app

DSCC files.

install-path/resources/dpadm

Localized resource files used by dpadm.

install-path/resources/dsadmin

Localized resource files used by dsadmin

install-path/resources/install/

Directory Server instance installation templates, not intended to be used directly.

install-path/resources/ldif/Example.ldif

Sample Directory Server LDIF content.

install-path/resources/ldif/Example-roles.ldif

Sample Directory Server LDIF content with grouping based on roles.

install-path/man/

Directory Server Enterprise Edition online reference manual pages. See also [Oracle Fusion Middleware Man Page Reference for Oracle Directory Server Enterprise Edition](#).

install-path/resources/plugins/

Directory Server plug-in configuration files, not intended to be used directly.

install-path/resources/schema/

Directory Server instance LDAP schema templates, not intended to be used directly.

install-path/var/ Container for runtime files, not intended to be used directly.

Directory Server Instance Default Layout

This section describes the file layout you find after creating a Directory Server instance. The *instance-path* is the file system path where you created the instance.

instance-path/alias/

NSS certificate database directory.

instance-path/alias/certmap.conf

NSS certificate mapping configuration file.

instance-path/bak/

Default data backup directory.

Each directory database backup is held in its own file system directory. The name of the backup directory corresponds to the time and date of the backup.

instance-path/config/

Server configuration directory.

instance-path/config/dse.ldif

Server configuration file, not intended to be edited directly.

instance-path/config/schema/

LDAP schema configuration files. See [dirserv\(5dssd\)](#).

instance-path/db/

Default server database files directory. When a suffix has been created, the following database files are stored in this file system directory.

__db.00x

Files used internally by the database. Do not move, delete, or modify these files.

DBVERSION	File that identifies the version of the database.
guardian	File used to store information about the state of the database, used to determine whether database recovery is required.
log. <i>xxxxxxxxxx</i>	Files used to store the database transaction logs.
<i>suffix</i>	<p>Files that store your directory suffix information. The directory name is derived from the suffix name, such that the database for a suffix identified by DN <code>dc=example,dc=com</code> is stored in a file system directory named <code>example</code>.</p> <p>For every index defined in the database, the suffix directory contains a file with a name of the form <code>suffix_indexedAttr.db3</code>, such that an index of CNs for <code>dc=example,dc=com</code> has file name <code>example_cn.db3</code>.</p> <p>Suffix directories also contain a file named <code>suffix_id2entry.db3</code>. The <code>suffix_id2entry.db3</code> file contains the directory database entries.</p> <p>If necessary, all index files can be rebuild from the <code>suffix_id2entry.db3</code> file. To recreate the index files, reindex the suffix.</p>

instance-path/locks/
Lock files directory.

Lock files stored here in subdirectories `exports/`, `imports/`, and `server/` prevent simultaneous operations from conflicting with each other. The lock mechanisms allow one server instance to run at a time. The lock mechanisms also permit only one `dsadm import` (offline import) operation at a time. As a result, no export or server instance operations can be run during import.

The lock restriction does not however apply to `dsconf import` (online import) operations. Multiple online imports can run at the same time.

instance-path/logs/
Default server logs directory. The following files are stored here.

access logs	This file records information about client access to Directory Server. For detail about access logs, see “Access Logs” on page 165 .
audit logs	This file records information about modifications to Directory Server data. For detail about audit logs, see “Audit Logs” on page 165 .

core files	By default, server core files are dumped here during a crash.
errors logs	This file records errors, warnings, and informational messages logged during Directory Server operation. For detail about errors logs, see “Error Logs” on page 165 .
pid file	This file holds the process identifier of the running server.
<i>instance-path/plugins/DSMLv2.xsd</i> DSMLv2 schema file.	
<i>instance-path/plugins/soap-env.xsd</i> SOAP schema location for DSMLv2.	
<i>instance-path/plugins/words-english-bug.txt</i> Default dictionary file used for strong password checks.	
<i>instance-path/plugins/signatures/</i> Plug-in signatures directory, not intended to be used directly.	
<i>instance-path/tmp/</i> Server runtime files directory, not intended to be used directly.	

Directory Proxy Server Instance Default Layout

This section describes the file layout you find after creating a Directory Proxy Server instance. The *instance-path* is the file system path where you created the instance.

instance-path/alias/

Certificate database files, not intended to be used directly.

instance-path/config/

Server configuration files, not intended to be used directly.

instance-path/etc/

Additional instance configuration, not intended to be used directly.

instance-path/logs/

Default server logs directory. The following files are stored here.

access logs

This file records information about the requests processed by Directory Proxy Server. For detail about access logs, see [“Access Logs for Directory Proxy Server” on page 316](#).

errors logs

This file records errors, warnings, and informational messages logged during Directory Proxy Server operation. For detail about errors logs, see [“Error Logs for Directory Proxy Server” on page 314](#).

instance-path/tmp/

Server runtime files directory, not intended to be used directly.

PART I

Directory Server Reference

This part explains how Directory Server works. The information here is primarily descriptive. For instructions, try Part I, “Directory Server Administration,” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition* instead.

This part covers the following chapters.

- Chapter 2, “Directory Server Overview”
- Chapter 3, “Directory Server LDAP URLs”
- Chapter 4, “Directory Server LDIF and Search Filters”
- Chapter 5, “Directory Server Security”
- Chapter 6, “Directory Server Monitoring”
- Chapter 7, “Directory Server Replication”
- Chapter 8, “Directory Server Data Caching”
- Chapter 9, “Directory Server Indexing”
- Chapter 10, “Directory Server Logging”
- Chapter 11, “Directory Server Groups and Roles”
- Chapter 12, “Directory Server Class of Service”
- Chapter 13, “Directory Server DSMLv2”
- Chapter 14, “Directory Server Internationalization Support”

For additional reference information, see *Oracle Fusion Middleware Man Page Reference for Oracle Directory Server Enterprise Edition*.

Directory Server Overview

This chapter outlines the architecture of Directory Server. This chapter includes the following topics.

- [“Introduction to Directory Server” on page 41](#)
- [“Directory Server Architecture” on page 42](#)

Introduction to Directory Server

Directory Server serves directory data to standards compliant LDAP and DSML applications. Directory Server stores the data in customized, binary tree databases, allowing quick searches even for large data sets.

Directories are object oriented databases. Directories organize their data objects, called entries, into a directory information tree, often called a DIT. Each entry is identified by a distinguished name, such as `uid=bjensen,ou=people,dc=example,dc=com`. The distinguished name identifies where the entry is located in the directory information tree. For example, `uid=bjensen,ou=people,dc=example,dc=com` is a user entry for Barbara Jensen on the `ou=people` branch of the `dc=example,dc=com` part of the tree.

Each directory entry has attributes. For entries that concern people, these attributes may reflect names, phone numbers, and email addresses, for example. An attribute has at least one type name, which is the name of the attribute. For example, people entries can have an attribute `surname`, which can also be called by the shorter name `sn`. Attributes can also have one or more values. For example, if Barbara Jensen marries Quentin Cubbins, and takes Quentin's surname, her entry could have `sn: Jensen` and `sn: Cubbins`.

Directories are designed to be fast when looking up entries based on the values of their attributes. An example query might be, “Find all the entries under `dc=example,dc=com` with surname Jensen.” This fast lookup capability makes directories well suited for applications where you store information that must be read often. Directories are therefore good data stores

for telephone and email information. Directories are also good for handling authentication credentials, identity information, and application configuration data.

Directory Server is also designed to handle high update rates as the information in the directory changes. Today, the size of many directory deployments mean that handling updates well can be as important as handling lookups.

Directory Server supports many directory related standards and RFCs. Directory Server allows fast data replication across the network for high availability. Directory Server lets you configure servers comprehensively without restarting them. Furthermore, Directory Server gives you extensive control over access to directory data.

The list of Directory Server features is too long to cover in a short introduction. *Oracle Fusion Middleware Evaluation Guide for Oracle Directory Server Enterprise Edition* includes a more extensive list. The other chapters in this part of this *Reference* help you to understand many of the features in detail.

Directory Server Architecture

This section succinctly addresses key concepts of Directory Server from the point of view of someone who must install and manage Directory Server. This section touches on the following topics.

- “Comparison of Software Installation and Server Instances” on page 42
- “Communication With Client Applications” on page 43
- “Directory Server Configuration” on page 45
- “Data Storage in Directory Server” on page 45
- “Data Structuring With the Directory Information Tree” on page 46
- “Data Replication Between Server Instances” on page 47
- “Access Control in Directory Server” on page 48

Comparison of Software Installation and Server Instances

For each installation of Directory Server software, you can create multiple server instances. Although you may create server instances in the place on the file system where you install the software, nothing requires you to put both the software and the instances side by side.

The Directory Server software you install includes the executable files, template data, and sample files needed to create, run, and manage actual servers. As the software is separate from the actual servers, you can apply patches or service packs to the software without changing the server data. You therefore do not need to patch each server instance, but instead only the software installation.

A Directory Server instance holds the configuration data and the directory data required to serve directory client applications. Although in production systems you carefully control the user identity of the server, you can typically create and run a Directory Server instance as any user on the system. The directory data belongs then to the user who created the instance.

In [Chapter 1, “Directory Server Enterprise Edition File Reference,”](#) you see that “[Software Layout for Directory Server Enterprise Edition](#)” on page 31 is clearly separate from “[Directory Server Instance Default Layout](#)” on page 35. In particular, notice that the documentation mentions *install-path* when referring to the software installation, but *instance-path* when referring to a server instance.

Communication With Client Applications

Directory Server listens for LDAP and DSML client application traffic on the port numbers you configure. Directory Server listens for LDAP connections as soon as the server starts. Directory Server only listens for DSML connections over HTTP if you enable the DSML service.

By default, Directory Server listens for LDAP connections on port 389 if the instance was created by root, 1389 if the instance was created by non-root. By default, Directory Server listens for LDAP connections over SSL on port 636 if the instance was created by root, 1636 if the instance was created by non-root. The DSML/HTTP port number is not defined by default. Instead, you supply a port number when enabling the DSML service.

In order to enable client applications to reach Directory Server, you create instances on hosts with static IP addresses. The hostname is also usually referenced in DNS. Client applications typically need at least two pieces of information to access the directory.

1. The hostname, or at least the IP address, of the system on which Directory Server runs.
2. The port number on which Directory Server listens for client connections.

LDAP clients and servers do not usually open a new connection for every request. In the LDAP model, a client connects to the server to authenticate before performing other operations. The connection and authentication process is referred to as binding. Client applications can bind with credentials, but they can also bind anonymously. Directory Server lets you configure access accordingly both for known and anonymous clients. Client applications can also keep a connection open, but bind again, thus changing the authentication identity. This technique can reduce the costs of creating a new connection.

Once the bind has been performed and the client is authenticated, the client can request the following operations.

add	Add a new directory entry.
compare	Checks whether an attribute value is the same as a given value.
delete	Delete a directory entry.

modify Change one or more attributes of a directory entry.

modDN Change the distinguished name of a directory entry.

This operation is for moving directory entries from one part of the directory information tree to another. For example, you could move `uid=bjensen,ou=employees,dc=example,dc=com` to `uid=bjensen,ou=people,dc=example,dc=com`.

When you move an parent entry, such as `ou=people,dc=example,dc=com`, the operation can take a very long time as Directory Server must move all child entries of the parent as well.

modRDN Change the relative distinguished name of a directory entry.

The relative distinguished name is the attribute value used to distinguish a directory entry from the others at the same level of the directory information tree.

This operation is for renaming directory entries. For example, you could rename `uid=bjensen,ou=employees,dc=example,dc=com` to `uid=bcubbins,ou=people,dc=example,dc=com`.

This operation is a special case of `modDN`. The `modRDN` operation is always relatively fast, however, as it involves modifying only leaf entries.

search Find all the directory entries under a specified point in the directory tree that have attribute values matching a filter.

A search filter can specify one or more attribute characteristics. For example, to find entries with the surname Jensen, you use the LDAP filter `(sn=Jensen)`. To find entries with surname Jensen and user ID beginning with the letter B, you use the LDAP filter `(&(sn=Jensen)(uid=b*))`.

When finished performing operations, a client can unbind. After unbinding, the connection is dropped by the client and the server. Client applications can also abandon operations, such as a search that is taking too long.

Directory Server can handle many client connections simultaneously. To handle connections, Directory Server consumes free file descriptors, and manages a number of threads. You can limit the system resources available to Directory Server through the server configuration. See [Chapter 6, “Tuning System Characteristics and Hardware Sizing,” in *Oracle Fusion Middleware Deployment Planning Guide for Oracle Directory Server Enterprise Edition*](#) for details.

Directory Server Configuration

Directory Server stores server instance configuration data in files, but the configuration data is also accessible over LDAP.

The files are stored under *instance-path* as follows. Directory Server stores the LDAP schema, which define what directory entries can contain, under *instance-path/config/schema/*. See *Oracle Fusion Middleware Man Page Reference for Oracle Directory Server Enterprise Edition* for reference information about the schema, and Chapter 11, “Directory Server Schema,” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition* for instructions on managing schema. Directory Server stores other configuration information in the `dse.ldif(4)` file, *instance-path/config/dse.ldif*. Avoid updating this file by hand.

Over LDAP, the schema information is accessible under `cn=schema`. The other configuration information is accessible under `cn=config`. In practice, you do not generally update data under `cn=config` directly. Instead, you use either the web based Directory Service Control Center, or the `dsconf` command. Both Directory Service Control Center and the `dsconf` command change Directory Server over LDAP. Yet, both also spare you much of the complexity of making configuration adjustments with LDAP modify operations.

Almost all Directory Server product documentation is devoted to Directory Server configuration. In *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*, you find extensive instructions for accomplishing a variety of tasks using command line configuration tools. The Directory Service Control Center online help can help get you back on track when the Directory Service Control Center interface does not seem intuitive enough.

Data Storage in Directory Server

Directory Server manages many binary-tree databases to hold directory data. By default, database files are stored under *instance-path/db/*. In general, do not change or move these files.

If you examine the content of the *instance-path/db/* directory, you find database log files. You also find subdirectories for each database managed by the server. For instance, *instance-path/db/example/* holds data for the directory entries under `dc=example,dc=com`. When you examine the files, you find a number of database indexes, such as `example_sn.db3` for surname attribute values. You also find a `example_id2entry.db3` file containing directory entry information. You can configure Directory Server to encrypt the information in these files if necessary.

From the point of view of client applications, Directory Server presents the directory data stored as directory entries arranged in the directory information tree. Directory Server uses the attribute value indexes to retrieve entries quickly. You can configure which indexes Directory Server maintains.

For instructions on backing up directory data, see [Chapter 8, “Directory Server Backup and Restore,”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*. For instructions on configuring indexes, see [Chapter 12, “Directory Server Indexing,”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*. You can also back up directory data and configure indexes using Directory Service Control Center.

Data Structuring With the Directory Information Tree

The directory information tree (DIT) provides a way to structure directory data so that the data can be referred to by client applications.

DIT Terminology

A well-designed DIT provides the following:

- Simplified directory data maintenance
- Flexibility in creating replication policies and access controls
- Support for the applications that use the directory
- Simplified directory navigation for users

The DIT structure follows the hierarchical LDAP model. The DIT organizes data, for example, by group, by people, or by geographical location. It also determines how data is partitioned across multiple servers.

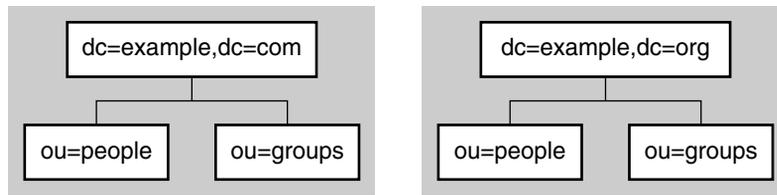
DIT design has an impact on replication configuration and on how you use Directory Proxy Server to distribute data. If you want to replicate or distribute certain portions of a DIT, consider replication and the requirements of Directory Proxy Server at design time. Also, decide at design time whether you require access controls on branch points.

A DIT is defined in terms of suffixes, subsuffixes, and chained suffixes. A *suffix* is a branch or subtree whose entire contents are treated as a unit for administrative tasks. Indexing is defined for an entire suffix, and an entire suffix can be initialized in a single operation. A suffix is also usually the unit of replication. Data that you want to access and manage in the same way should be located in the same suffix. A suffix can be located at the root of the directory tree, where it is called a *root suffix*.

Because data can only be partitioned at the suffix level, an appropriate directory tree structure is required to spread data across multiple servers.

The following figure shows a directory with two root suffixes. Each suffix represents a separate corporate entity.

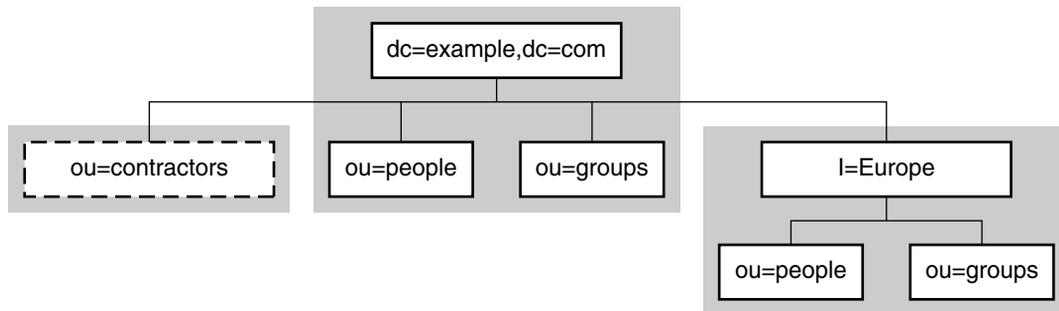
FIGURE 2-1 Two Root Suffixes in a Single Directory Server



A suffix might also be a branch of another suffix, in which case it is called a *subsuffix*. The parent suffix does not include the contents of the subsuffix for administrative operations. The subsuffix is managed independently of its parent. Because LDAP operation results contain no information about suffixes, directory clients are unaware of whether entries are part of root suffixes or subsuffixes.

The following figure shows a directory with a single root suffix and multiple subsuffixes for a large corporate entity.

FIGURE 2-2 One Root Suffix With Multiple Subsuffixes



A suffix corresponds to an individual database within the server. However, databases and their files are managed internally by the server and database terminology is not used.

In the special case of cascading chaining, the chained suffix might reference another chained suffix on the remote server, and so on. Each server forwards the operation and eventually returns the result to the server that handles the client's request.

Data Replication Between Server Instances

Directory Server allows you to replicate directory data among as many server instances as necessary. Directory Server replication works as an LDAP extended operation that replays update operations from one server to another. The protocol for Directory Server replication is

optimized to work quickly over the network. The protocol is also optimized to resolve conflicts when the same data is modified simultaneously on two different server instances.

The unit of Directory Server replication is the suffix. A replication agreement between two servers handles all the directory entries under a base entry in the directory information tree, such as `dc=example,dc=com`. Each agreement to replicate is set up point to point. On one hand, point to point agreements prevent replication from single points of failure when the network becomes partitioned. On the other hand, point to point agreements can be complex to manage as the number of replicas increases. Luckily, Directory Service Control Center handles much of the complexity for you. Directory Service Control Center allows you to manage groups of replicas that provide a common directory service.

You can configure timing, priority, and which data is replicated. You can also configure some servers, called *masters*, to accept both updates and lookups. You can configure other servers, called *consumers*, to accept only lookups. In addition, you can publish update information over LDAP for client applications that must follow updates as they happen. For further explanation of replication, see [Chapter 7, “Directory Server Replication.”](#) For instructions on configuring replication, see [Chapter 10, “Directory Server Replication,”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Access Control in Directory Server

Directory Server offers an access control mechanism that works through `aci` attributes placed on directory entries. ACI stands for Access Control Instruction.

ACIs are evaluated based on a user's bind identity. ACIs can be evaluated therefore for all users who can bind to the directory. ACIs can also be applied for anonymous users who did not provide bind credentials. Rules about the bind identity can specify not only which users, but also which systems the users connect from, what time of day they connect, or what authentication method they use.

You configure an ACI to apply to the entries in its scope. Entries that can be in scope include entries on the branch of the directory information tree starting with the entry holding the ACI. Directory Server allows you to configure ACIs to be applied according to a number of different criteria. Directory Server also lets you configure ACIs not only to allow access, but also to deny access.

ACIs can specify which operations are allowed and denied. For example, you typically allow many users to read information, but only a few to update and add directory data.

For further explanation of access control in Directory Server, see [“How Directory Server Provides Access Control”](#) on page 78. For instructions on configuring access control, see [Chapter 6, “Directory Server Access Control,”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Directory Server LDAP URLs

One way to express an LDAP query is to use a URL to specify the Directory Server host machine and the DN or filter for the search. Directory Server responds to queries sent as LDAP URLs and returns an HTML page representing the results. In this way, if anonymous searching is permitted, web browsers can perform searches of the directory. You can also use LDAP URLs to specify target entries when you manage Directory Server referrals or when you access control instructions.

For information about LDAP URLs, see the following sections:

- “Components of an LDAP URL” on page 49
- “Escaping Unsafe Characters” on page 50
- “Examples of LDAP URLs” on page 51

Components of an LDAP URL

LDAP URLs have the following syntax:

```
ldap[s]://hostname:port/base_dn?attributes?scope?filter
```

When `ldap://` is specified, standard LDAP is used to connect to the LDAP servers. When `ldaps://` is specified, LDAP over SSL is used to connect to the LDAP server.

TABLE 3-1 LDAP URL Components

Component	Description
<i>hostname</i>	Name (or IP address in dotted format) of the LDAP server. For example: <code>ldap.example.com</code> or <code>192.168.1.100</code>
<i>port</i>	Port number of the LDAP server. If no port is specified, the standard LDAP port (389) or LDAPS port (636) is used.

TABLE 3-1 LDAP URL Components (Continued)

Component	Description
<i>base_dn</i>	Distinguished name (DN) of an entry in the directory. This DN identifies the entry that is the starting point of the search. If no base DN is specified, the search starts at the root of the directory tree.
<i>attributes</i>	The attributes to be returned. To specify more than one attribute, use commas to separate the attributes. For example, "cn,mail,telephoneNumber". If no attributes are specified in the URL, all attributes are returned.
<i>scope</i>	The scope of the search. The scope can be one of these values: <ul style="list-style-type: none"> ■ base retrieves information about the distinguished name (<i>base_dn</i>) specified in the URL only. ■ one retrieves information about entries one level below the distinguished name (<i>base_dn</i>) specified in the URL. The base entry is not included in this scope. ■ sub retrieves information about entries at all levels below the distinguished name (<i>base_dn</i>) specified in the URL. The base entry is included in this scope. If no scope is specified, the server performs a base search.
<i>filter</i>	Search filter to apply to entries within the specified scope of the search. If no filter is specified, the server uses the filter <code>objectClass=*</code> .

The following components are identified by their positions in the URL: `attributes`, `scope`, and `filter` are. If you do not want to specify a component, you must include a question mark to delimit the field. Two consecutive question marks, `??`, indicate that no attributes have been specified.

For example, to specify a subtree search starting from "dc=example,dc=com" that returns all attributes for entries matching "(sn=Jensen)", use the following LDAP URL.

```
ldap://ldap.example.com/dc=example,dc=com??sub?(sn=Jensen)
```

Because no specific attributes are identified in the URL, all attributes are returned in the search.

Escaping Unsafe Characters

Unsafe characters in a URL must be represented by a special sequence of characters. The following table lists the characters that are unsafe within URLs, and provides the associated escape characters to use in place of the unsafe character.

TABLE 3-2 Characters That Are Unsafe Within URLs

Unsafe Character	Escape Characters
space	%20
<	%3c
\>	%3e
"	%22
#	%23
%	%25
{	%7b
}	%7d
	%7c
\\	%5c
^	%5e
~	%7e
[%5b
]	%5d
”	%60

Examples of LDAP URLs

The syntax for LDAP URLs does not include any means for specifying credentials or passwords. Search request initiated through LDAP URLs are unauthenticated (anonymous), unless the LDAP client that supports LDAP URLs provides an authentication mechanism. This section gives examples of LDAP URLs.

EXAMPLE 3-1 Base Search for an Entry

The following LDAP URL specifies a base search for the entry with the distinguished name `dc=example,dc=com`.

```
ldap://ldap.example.com/dc=example,dc=com
```

- Because no port number is specified, the standard LDAP port number 389 is used.
- Because no attributes are specified, the search returns all attributes.
- Because no search scope is specified, the search is restricted to the base entry `dc=example,dc=com`.

EXAMPLE 3-1 Base Search for an Entry *(Continued)*

- Because no filter is specified, the directory uses the default filter `objectClass=*`.

EXAMPLE 3-2 Retrieving `postalAddress` Attribute of an Entry

The following LDAP URL retrieves the `postalAddress` attribute of the entry with the DN `dc=example,dc=com`:

```
ldap://ldap.example.com/dc=example,dc=com?postalAddress
```

- Because no search scope is specified, the search is restricted to the base entry `dc=example,dc=com`.
- Because no filter is specified, the directory uses the default filter `objectClass=*`.

EXAMPLE 3-3 Retrieving `cn` and `mail` Attributes of an Entry

The following LDAP URL retrieves the `cn`, and `mail` attributes of the entry for Barbara Jensen.

```
ldap://ldap.example.com/cn=Barbara%20Jensen,dc=example,dc=com?cn,mail
```

- Because no search scope is specified, the search is restricted to the base entry `cn=Barbara Jensen,dc=example,dc=com`.
- Because no filter is specified, the directory uses the default filter `objectClass=*`.

EXAMPLE 3-4 Retrieving the Surname Jensen Under `dc=example,dc=com`

The following LDAP URL specifies a search for entries that have the surname Jensen and are at any level under `dc=example,dc=com`:

```
ldap://ldap.example.com/dc=example,dc=com??sub?(sn=Jensen)
```

- Because no attributes are specified, the search returns all attributes.
- Because the search scope is `sub`, the search encompasses the base entry `dc=example,dc=com` and entries at all levels under the base entry.

EXAMPLE 3-5 Retrieving the Object Class for all Entries One Level Under `dc=example,dc=com`

The following LDAP URL specifies a search for the object class for all entries one level under `dc=example,dc=com`:

```
ldap://ldap.example.com/dc=example,dc=com?objectClass?one
```

- Because the search scope is `one`, the search encompasses all entries one level under the base entry `dc=example,dc=com`. The search scope does not include the base entry.
- Because no filter is specified, the directory uses the default filter `objectClass=*`.

Directory Server LDIF and Search Filters

Directory Server uses the LDAP Data Interchange Format (LDIF) to describe a directory and its entries in text format. LDIF can be used to build the initial directory database or to add large numbers of entries to a directory. LDIF can also be used to describe changes to directory entries. Most command-line utilities rely on LDIF for input or output.

All directory data is stored by using the UTF-8 encoding of Unicode, and, therefore, LDIF files must also be UTF-8 encoded.

This chapter also provides information about searching the directory, and LDAP search filters.

For information about LDIF and searching the directory, see the following sections:

- [“LDIF File Format” on page 53](#)
- [“Directory Entries in LDIF” on page 57](#)
- [“Guidelines for Defining Directories by Using LDIF” on page 60](#)
- [“Storing Information in Multiple Languages” on page 62](#)
- [“Guidelines for Providing LDIF Input” on page 63](#)
- [“Searching the Directory” on page 66](#)

LDIF File Format

LDIF files consist of one or more directory entries separated by a blank line. Each LDIF entry consists of the following parts:

- Entry ID (optional)
- Distinguished name (required)
- One or more object classes
- Multiple attribute definitions

The LDIF format is defined in RFC 2849.

The following example shows a basic directory entry in LDIF.

EXAMPLE 4-1 A Directory Entry in LDIF

```

dn: distinguished_name
objectClass: object_class
objectClass: object_class
...
attribute_type[;subtype]: attribute_value
attribute_type[;subtype]: attribute_value
...

```

All other attributes and object classes are optional. Object classes and attributes can be specified in any order. The space after the colon is optional.

The following table describes the fields in a LDIF file.

TABLE 4-1 LDIF Fields

Field	Definition
[<i>id</i>]	Optional. A positive decimal number representing the entry ID. The database creation tools generate this ID for you. Never add or edit this value yourself.
dn: <i>distinguished_name</i>	The distinguished name for the entry.
objectClass: <i>object_class</i>	An object class to use with this entry. The object class identifies the types of attributes or schema that are allowed and required for the entry.
<i>attribute_type</i>	A descriptive attribute to use with the entry. The attribute should be defined in the schema.
[<i>subtype</i>]	Optional. A subtype of one of the following types: <ul style="list-style-type: none"> ■ Language (<i>attribute;lang-subtype</i>) identifies the language in which the corresponding attribute value is expressed ■ Binary (<i>attribute;binary</i>) identifies whether the attribute value is binary ■ Pronunciation (<i>attribute;phonetic</i>) identifies whether the attribute value is a pronunciation of an attribute value
<i>attribute_value</i>	The attribute value to be used with the attribute type.

The LDIF syntax for representing a change to an entry in the directory is different from the syntax described above.

Continuing Lines in LDIF

When you specify LDIF, you can break and continue a line or fold a line by indenting the continued portion of the line by one space. For example, the following two statements are identical:

```
dn: cn=Babs Jensen,dc=example,dc=com
```

```
dn: cn=Babs J
   ensen,dc=exam
   ple,dc=com
```

You are not required to break and continue LDIF lines. However, doing so can improve the readability of an LDIF file.

Binary Data in LDIF

You can represent binary data in LDIF by using one of the following methods:

- Standard LDIF notation, the lesser than, <, symbol
- Command-line utility, `ldapmodify` with the `-b` option
- Base 64 encoding

Representing Binary Data by Using Standard LDIF Notation

The following example gives the standard LDIF notation of binary data:

```
jpegphoto:< file:/path/to/photo
```

In the example, the path is relative to the client, not to the server. To use standard notation, you do not need to specify the `ldapmodify -b` parameter. However, you must add the following line to the beginning of your LDIF file or to your LDIF update statements:

```
version:1
```

For example, you could use the `ldapmodify` command, as follows:

```
$ ldapmodify -D userDN -w passwd
version: 1
dn: cn=Barbara Jensen,ou=People,dc=example,dc=com
changetype: modify
add: userCertificate
userCertificate;binary:< file:BabsCert
```

Representing Binary Data by Using the `ldapmodify -b` Command

For backward compatibility with earlier versions of Directory Server, binary data can be represented by using the `ldapmodify -b` command. However, when possible, use the standard LDIF notation to represent binary data.

Directory Server accepts the `ldapmodify` command with the `-b` parameter and the following LDIF notation:

```
jpegphoto: /path/to/photo
```

This notation indicates that the `ldapmodify` command should read the referenced file for binary values if the attribute value begins with a slash.

Representing Binary Data by Using Base 64 Encoding

Base 64 encoded data is represented by the `::` symbol, as shown in this example:

```
jpegPhoto:: encoded_data
```

In addition to binary data, the following values must be base 64 encoded:

- Any value that begins with a semicolon, `;`, or a space
- Any value that contains non ASCII data, including new lines

Use the `ldif` command with the `-b` parameter to convert binary data to LDIF format, as follows.

```
$ ldif -b attributeName
```

For more information about how to use the `ldif` command, see the [ldif\(1\)](#) man page.

In the above example, *attributeName* is the name of the attribute to which you are supplying the binary data. The binary data is read from standard input and the results are written to standard output. Use redirection operators to select input and output files.

The command takes any input and formats it with the correct line continuation and appropriate attribute information. The command also assesses whether the input requires base-64 encoding. The following example takes a binary file containing a JPEG image and converts it into LDIF format for the attribute named `jpegPhoto`. The output is saved to `out.ldif`:

```
$ ldif -b jpegPhoto < aphoto.jpg > out.ldif
```

The `-b` option specifies that the utility should interpret the entire input as a single binary value. If the `-b` option is not present, each line is considered as a separate input value.

You can edit the output file to add the LDIF statements required to create or modify the directory entry that will contain the binary value. For example, you can open the file `out.ldif` in a text editor and add the following lines at the top of the file.

```
dn: cn=Barbara Jensen,ou=People,dc=example,dc=com
changetype: modify
add: jpegPhoto
jpegPhoto:: encoded_data
```

In this example, *encoded_data* represents the contents of the `out.ldif` file produced by the command.

Directory Entries in LDIF

This section covers the following topics:

- “Organization Entries in LDIF” on page 57
- “Organizational Unit Entries in LDIF” on page 58
- “Organizational Person Entries in LDIF” on page 59

Organization Entries in LDIF

Directories often have at least one organization entry. Typically the organization entry is the first, or topmost entry in the directory. The organization entry often corresponds to the suffix set for the directory. For example, a directory defined to use a suffix of `o=example.com` will probably have an organization entry named `o=example.com`.

The LDIF that defines an organization entry should appear as follows:

```
dn: distinguished_name
objectClass: top
objectClass: organization
o: organization_namelist_of_optional_attributes...
```

The following is an example organization entry in LDIF format:

```
dn: o=example.com
objectclass: top
objectclass: organization
o: example.com Corporation
description: Fictional company for example purposes
telephonenumber: 555-5555
```

The organization name in the following example uses a comma:

```
dn: o=example.com Chile\, S.A.
objectclass: top
objectclass: organization
o: example.com Chile\, S.A.
description: Fictional company for example purposes
telephonenumber: 555-5556
```

The following table describes each element of the organization entry.

TABLE 4-2 Organization Entries in LDIF

LDIF Element	Description
<code>dn: <i>distinguished_name</i></code>	Required. Specifies the distinguished name for the entry.
<code>objectClass: top</code>	Required. Specifies the top object class.
<code>objectClass: organization</code>	Specifies the organization object class. This line defines the entry as an organization.
<code>o: <i>organization_name</i></code>	Specifies the organization's name. If the organization name includes a comma, you must escape the comma by a single backslash or the entire organization argument must be enclosed in quotation marks. However, if you are working with a UNIX shell, you must also escape the backslash. Therefore, you must use two back slashes. For example, to set the suffix to <code>example.com Bolivia, S.A.</code> you would enter <code>o: example.com Bolivia\, S.A..</code>
<code><i>list_of_attributes</i></code>	Specifies the list of optional attributes that you want to maintain for the entry.

Organizational Unit Entries in LDIF

In a directory tree, an organizational unit represents a major subdirectory. A directory tree usually contains more than one organizational unit. An LDIF file that defines an organizational unit entry must appear as follows:

```
dn: distinguished_name
objectClass: top
objectClass: organizationalUnit
ou: organizational_unit_namelist_of_optional_attributes...
```

The following example shows an organizational unit entry in LDIF format:

```
dn: ou=people, o=example.com
objectclass: top
objectclass: organizationalUnit
ou: people
description: Fictional organizational unit for example purposes
```

The following table defines each element of the organizational unit entry.

TABLE 4-3 Organizational Unit Entries in LDIF

LDIF Element	Description
<code>dn: distinguished_name</code>	Required. Specifies the distinguished name for the entry. If there is a comma in the DN, the comma must be escaped with a backslash (\). For example: <code>dn: ou=people,o=example.com Bolivia\S.A.</code>
<code>objectClass: top</code>	Required. Specifies the top object class.
<code>objectClass: organizationalUnit</code>	Specifies the <code>organizationalUnit</code> object class. This line defines the entry as an <code>organizationalUnit</code> .
<code>ou: organizational_unit_name</code>	Specifies an attribute containing the name of the organizational unit.
<code>list_of_attributes</code>	Specifies the list of optional attributes that maintain for the entry.

Organizational Person Entries in LDIF

The majority of the entries in a directory represent organizational people. In LDIF, the definition of an organizational person is as follows:

```
dn: distinguished_name
objectClass: top
objectClass: person
objectClass: organizationalPerson
objectClass: inetOrgPerson
cn: common_name
sn: surname
list_of_optional_attributes
```

The following example shows an organizational person entry in LDIF format:

```
dn: uid=bjensen,ou=people,o=example.com
objectclass: top
objectclass: person
objectclass: organizationalPerson
objectclass: inetOrgPerson
cn: Babs Jensen
sn: Jensen
givenname: Babs
uid: bjensen
ou: Marketing
ou: people
description: Fictional person for example purposes
telephonenumber: 555-5557
userpassword: {sha}dkfljlk34r2kljdsfk9
```

The following table defines each element of the LDIF person entry.

TABLE 4-4 Organizational Person Entries in LDIF

LDIF Element	Description
<i>dn: distinguished_name</i>	Required. Specifies the distinguished name for the entry. If there is a comma in the DN, the comma must be escaped with a backslash (\). For example, <code>dn: uid=bjensen,ou=people,o=example.com</code> <code>Bolivia\,S.A.</code>
<code>objectClass: top</code>	Required. Specifies the top object class.
<code>objectClass: person</code>	Specifies the person object class. This object class specification should be included because many LDAP clients require it during search operations for a person or an organizational person.
<code>objectClass: organizationalPerson</code>	Specifies the organizationalPerson object class. This object class specification should be included because some LDAP clients require it during search operations for an organizational person.
<code>objectClass: inetOrgPerson</code>	Specifies the inetOrgPerson object class. The inetOrgPerson object class is recommended for the creation of an organizational person entry because this object class includes the widest range of attributes. The uid attribute is required by this object class, and entries that contain this object class are named based on the value of the uid attribute.
<i>cn: common_name</i>	Required. Specifies the person's common name which is the full name commonly used by the person. For example, <code>cn: Bill Anderson</code> .
<i>sn: surname</i>	Required. Specifies the person's surname, or last name. For example, <code>sn: Anderson</code> .
<i>list_of_attributes</i>	Specifies the list of optional attributes that you maintain for the entry.

Guidelines for Defining Directories by Using LDIF

Follow these guidelines to create a directory by using LDIF.

- Create an ASCII file that contains the entries you want to add in LDIF format.
- Separate entries with a single empty line. Do not allow the first line of the file to be blank, otherwise the `ldapmodify` command will exit.

- Begin each file with the topmost, or root, entry in the database. The root entry must represent the suffix or sub-suffix contained by the database. For example, if your database has the suffix `dc=example,dc=com`, the first entry in the directory must be


```
dn: dc=example,dc=com
```
- Create the branch point for a subtree before you create entries to go in the subtree.
- Create the directory from the LDIF file by using one of the following methods:
 - By using the Directory Service Control Center
 - By using the `dsadm` command and `dsconf` command
 - By using the `ldapmodify` command with the `-a` option or `-B` option

Create the directory by using `ldapmodify` command if you currently have a directory database but you are adding a new subtree to the database. Unlike the other methods for creating the directory from an LDIF file, Directory Server must be running before you can add a subtree by using the `ldapmodify` command.

The following example shows an LDIF file with one organization entry, two organizational unit entries, and three organizational person entries.

EXAMPLE 4-2 Example LDIF File With Entries for Organization, Organizational Units, and Organizational Person

```
dn: o=example.com Corp
objectclass: top
objectclass: organization
o: example.com Corp
description: Fictional organization for example purposes
dn: ou=People,o=example.com Corp
objectclass: top
objectclass: organizationalUnit
ou: People
description: Fictional organizational unit for example purposes
tel: 555-5559

dn: cn=June Rossi,ou=People,o=example.com Corp
objectClass: top
objectClass: person
objectClass: organizationalPerson
objectClass: inetOrgPerson
cn: June Rossi
sn: Rossi
givenName: June
mail: rossi@example.com
userPassword: {sha}KDIE3AL9DK
ou: Accounting
ou: people
telephoneNumber: 2616
roomNumber: 220

dn: cn=Marc Chambers,ou=People,o=example.com Corp
objectClass: top
objectClass: person
objectClass: organizationalPerson
```

EXAMPLE 4-2 Example LDIF File With Entries for Organization, Organizational Units, and Organizational Person *(Continued)*

```
objectClass: inetOrgPerson
cn: Marc Chambers
sn: Chambers
givenName: Marc
mail: chambers@example.com
userPassword: {sha}jdl2alem87dlacz1
telephoneNumber: 2652
ou: Manufacturing
ou: People
roomNumber: 167

dn: cn=Robert Wong,ou=People,o=example.com Corp
objectClass: top
objectClass: person
objectClass: organizationalPerson
objectClass: inetOrgPerson
cn: Robert Wong
cn: Bob Wong
sn: Wong
givenName: Robert
givenName: Bob
mail: bwong@example.com
userPassword: {sha}nn2msx761
telephoneNumber: 2881
roomNumber: 211
ou: Manufacturing
ou: people

dn: ou=Groups,o=example.com Corp
objectclass: top
objectclass: organizationalUnit
ou: groups
description: Fictional organizational unit for example purposes
```

Storing Information in Multiple Languages

For directories that contains a single language, it is not necessary to do anything special to add a new entry to the directory. However, for multinational organizations, it can be necessary to store information in multiple languages so that users in different locales can view directory information in their own language.

When information is represented in multiple languages, the server associates language tags with attribute values. When a new entry is added, attribute values used in the RDN (Relative Distinguished Name) must be added without any language codes.

Multiple languages can be stored within a single attribute. The attribute type is the same, but each attribute value has a different language code. The language tag has no effect on how the string is stored within the directory. All object class and attribute strings are stored using UTF-8.

For a list of the languages supported by Directory Server and their associated language tags, refer to “[Identifying Supported Locales](#)” on page 212.

For example, the example.com Corporation has offices in the United States and France. The company wants employees to be able to view directory information in their native language. When a directory entry is added for a new employee, Babs Jensen, the administrator creates the entry in LDIF. The administrator creates values for the `personalTitle` attribute in English and French, as follows:

```
dn: uid=bjensen,ou=people, o=example.com Corp
objectclass: top
objectclass: person
objectclass: organizationalPerson
name: Babs Jensen
cn: Babs Jensen
sn: Jensen
uid: bjensen
personalTitle: Miss
personalTitle;lang-en: Miss
personalTitle;lang-fr: Mlle
preferredLanguage: fr
```

Users accessing this directory entry with an LDAP client with the preferred language set to English will see the personal title `Miss`. Users accessing the directory with an LDAP client with the preferred language set to French will see the title `Mlle`.

Guidelines for Providing LDIF Input

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 “LDAP Data Interchange Format Reference” in the *Oracle Fusion Middleware Reference for Oracle Directory Server Enterprise Edition*.

Consider the following points when you provide LDIF input:

- An object is a blank line followed by a line that starts with `dn: .`. This line is the distinguished name of the object. All other lines are the object’s attributes.
- Comments start with `#` (and end with the EOL.)
- Lines starting with a single space continue the previous line.
- Binary values are base-64 encoded, and represented with a double colon (`::`) after the attribute name.
- Carriage return and line feed add unsafe characters in an LDIF entry.
- Do not unintentionally leave trailing spaces at the end of an attribute value when you change the attribute value by using the `ldapmodify` command. For example, `jensen` with a trailing space is different from `jensen` without any trailing space.

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 Control-D (^D).

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

```
prompt\> ldapmodify -h host -p port -D cn=admin,cn=Administrators,cn=config -w -  
  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:

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.

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.

Using Attribute OIDs

Attribute OIDs are by default not supported in attribute names. This was not the case in some previous versions of Directory Server. If you used attribute OIDs as attribute names in a previous version of Directory Server, you must set the attribute `nsslapd-attribute-name-exceptions` to on for the attribute OIDs to be accepted.

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.

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 processes 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.

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 multimedia 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.

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.

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.

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 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. 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.

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 **cn=admin, cn=Administrators, cn=config**. Using the symbol “-” means that you will be prompted for the password on the command line.
- 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=admin,cn=Administrators,cn=config  
-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=admin,cn=Administrators,cn=config -w -  
-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=admin,cn=Administrators,cn=config -w -  
-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=admin,cn=Administrators,cn=config  
-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=admin,cn=Administrators,cn=config -w -  
"(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 the TODO: No more AdminServerAdminGuide.

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=admin,cn=Administrators,cn=config -w -
"(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=admin,cn=Administrators,cn=config -w -
-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 "cdanielsscrtname" -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.

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)

Using Operators in Search Filters

The operators that you can use in search filters are listed in [Table 4-5](#):

TABLE 4-5 Search Filter Operators

Search Type	Operator	Description
Equality	=	Returns entries containing attribute values that exactly match the specified value. For example, <code>cn=Bob Johnson</code>
Substring	<code>=string*string</code>	Returns entries containing attributes containing the specified substring. For example, <code>cn=Bob*cn=*Johnsoncn=*John*cn=B*John</code> (The asterisk (*) indicates zero (0) or more characters.)
Greater than or equal to	<code>\>=</code>	Returns entries containing attributes that are greater than or equal to the specified value. For example, <code>buildingname \>= alpha</code>
Less than or equal to	<code><=</code>	Returns entries containing attributes that are less than or equal to the specified value. For example, <code>buildingname <= alpha</code>
Presence	<code>=*</code>	Returns entries containing one or more values for the specified attribute. For example, <code>cn=*</code> <code>telephonenumber=*</code> <code>manager=*</code>

TABLE 4-5 Search Filter Operators (Continued)

Search Type	Operator	Description
Approximate	~=	<p>Returns entries containing the specified attribute with a value that is approximately equal to the value specified in the search filter. For example,</p> <pre>cn~=suret l~=san francisco</pre> <p>could return</p> <pre>cn=surette l=san francisco</pre> <p>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.</p>

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

Using OIDs in Search Filters

LDAPv3 enables you to build match operators and rules for a particular attribute. Matching rules define how to compare attribute values with a particular syntax. In other words, a matching rule defines how potentially matching attributes are compared. For example, a matching rule can define whether or not to take text case into account when comparing attributes.

When the rules are created, they can be referred to in a search filter.

For example, the following search filter compares entries containing the surname “Jensen” by using the matching rule designated by OID 2.5.13.5:

```
(sn:2.5.13.5:=Jensen)
```

The following example illustrates the use of the ":dn" notation to indicate that OID 2.5.13.5 should be used when making comparisons, and that the attributes of an entry\qs distinguished name should be considered part of the entry when evaluating the match:

```
(sn:dn:2.5.13.5:=Jensen)
```

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 4–6.

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 4–6 Search Filter Boolean Operators

Operator	Symbol	Description
AND	&	All specified filters must be true for the statement to be true. For example, <i>(&(filter)(filter)(filter)...) </i>
OR		At least one specified filter must be true for the statement to be true. For example, <i>((filter)(filter)(filter)...) </i>
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, <i>(!(filter))</i> The use of the NOT operator results in an unindexed search.

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 given name 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=admin,cn=Administrators,cn=config -w -
-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=admin,cn=Administrators,cn=config -w -
-f searchdb sn givenname
```

Specifying Non 7-Bit ASCII Characters in Search Filters

Non 7-bit ASCII characters in search filters must be replaced with a representation of the character, where each byte of the UTF-8 encoding is preceded by a backslash. In UTF-8, characters are represented by a hexadecimal code for each byte.

For example, the character `é` has UTF-8 representation `c3a9`. Thus, in a search filter, you represent `é` as `\\c3\\a9`. So, to search for `cn=Véronique Martin`:

```
ldapsearch -h myServer -b "dc=example,dc=com" "(cn=V\\c3\\a9ronique Martin)"
```

The special characters listed in [Table 4-7](#) must also be represented in this fashion when used in search filters.

TABLE 4-7 Special Characters in Search Filters

Special character	Value With Special Character	Example Filter
*	Five*Star	(cn=Five\\2aStar)
\\	c:\\File	(cn=\\5cFile)
()	John (2nd)	(cn=John \\282nd\\29)
null	0004	(bin=\\00\\00\\00\\04)

Escaped Characters in Distinguished Names within Search Filters

When using a DN in any part of Directory Server, you must escape commas and certain other special characters with a backslash (`\\`). If you are using a DN in a search filter, the backslash used for escaping special characters in DNs must be represented by `\\5c`. For example:

```
DN: cn=Julie Fulmer,ou=Marketing\\,Bolivia,dc=example,dc=com
```

```
DN in a search filter: ldapsearch -h myServer -b "dc=example,dc=com"
"(manager=cn=Julie Fulmer,ou=Marketing\\5c,Bolivia,dc=example,dc=com)"
```

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=admin,cn=Administrators,cn=config -w -  
"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=admin,cn=Administrators,cn=config -w -  
"(objectclass=*)" aci *
```

Directory Server Security

For information about the security in Directory Server, see the following sections:

- [“How Directory Server Provides Security” on page 77](#)
- [“How Directory Server Provides Access Control” on page 78](#)
- [“How Directory Server Provides Authentication” on page 81](#)
- [“How Directory Server Provides Encryption” on page 101](#)

How Directory Server Provides Security

Directory Server provides security through a combination of the following methods:

- **Authentication**

Authentication is a means for one party to verify another’s identity. For example, a client gives a password to Directory Server during an LDAP bind operation. Policies define the criteria that a password must satisfy to be considered valid, for example, age, length, and syntax. Directory Server supports anonymous authentication, password-based authentication, certificate-based authentication, SASL-based authentication, and proxy authentication. When authentication is denied, Directory Server provides the following mechanisms to protect data: account inactivation and global lockout. For information about authentication, see [“How Directory Server Provides Authentication” on page 81](#).
- **Encryption**

Encryption protects the privacy of information. When data is encrypted, the data is scrambled in a way that only a legitimate recipient can decode. Directory Server supports SSL encryption and attribute encryption. For information about encryption, see [“How Directory Server Provides Encryption” on page 101](#).
- **Access control**

Access control tailors the access rights granted to different directory users, and provides a means of specifying required credentials or bind attributes. For information about access control, see [“How Directory Server Provides Access Control” on page 78](#).

- **Auditing**
Auditing determines whether the security of a directory has been compromised. For example, log files maintained by a directory can be audited. For information about log files, see [Chapter 10, “Directory Server Logging.”](#)

How Directory Server Provides Access Control

Directory Server uses access control instructions (ACIs) to define what rights to grant or deny to requests from LDAP clients. When a directory server receives a request, it uses the ACIs defined in the server, and any authentication information provided by the user to allow or deny access to directory information. The server can allow or deny permissions such as read, write, search, or compare.

For information about ACIs in Directory Server, see the following sections:

- [“Introduction to ACIs” on page 78](#)
- [“Tuning Access Control Instructions” on page 80](#)

Introduction to ACIs

ACIs are stored in the `aci` operational attribute. The `aci` attribute is available for use on every entry in the directory, regardless of whether the `aci` attribute is defined for the object class of the entry. The `aci` attribute is multi-valued, therefore multiple ACIs can be defined for the same portion of a directory.

ACIs can be used to control access to the following portions of a directory:

- The entire directory
- A subtree of the directory
- Specific entries in the directory, including entries that define configuration tasks
- A specific set of entry attributes
- Specific entry attribute values

ACIs can be used to define access for the following users:

- A specific user
- All users belonging to a specific group or role
- All users of the directory
- A specific client identified by its IP address or DNS name

Scope and Hierarchy in ACIs

ACIs can be created at any node in a directory tree, including the root DSE.

The scope of an ACI can be the target entry, the target entry and its immediate children, or the target entry and all of its children. When no scope is specified, the ACI applies to the target entry and all of its children.

When a server evaluates access permissions to an entry, it verifies the ACIs for the entry and the ACIs for the parent entries back up to the base of the entry's root suffix.

Access to an entry in a server must be explicitly granted by an ACI. By default, ACIs define anonymous read access and allow users to modify their own entries, except for attributes needed for security. If no ACI applies to an entry, access is denied to all users except the Directory Manager.

Access granted by an ACI is allowed unless any other ACI in the hierarchy denies it. ACIs that deny access, no matter where they appear in the hierarchy, take precedence over ACIs that allow access to the same resource.

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.

In previous versions of Directory Server, ACIs could not be added or deleted directly under the root DSE. Now this limitation has been removed in Directory Server.

ACI Limitations

The following restrictions apply to ACIs

- 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.
- You cannot grant a user the right to proxy as the Directory Manager, nor can you grant proxy rights to the Directory Manager.
- The cache settings used for ensuring that the server fits the physical memory available *do not* apply to ACI caches, which means that an excessive number of ACIs may saturate available memory.

Default ACIs

The following default ACIs are defined on the root DSE:

- 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 password.
- Users in the group `cn=Administrators`, `cn=config` have full access to all entries. This is equivalent to Directory Manager access, although unlike Directory Manager, users in the Administration Group are subject to ACIs.

ACIs and Replication

ACIs are stored as attributes of entries. Therefore, if an entry that contains ACIs is part of a replicated suffix, the ACIs are replicated like any other attribute.

ACIs are always evaluated locally, on the directory server that services the incoming LDAP requests.

When a consumer server receives an update request, the consumer server returns a referral to the master server for evaluation of whether the request can be serviced on the master.

Effective Rights

The effective rights feature can be used to obtain the following information:

- Rights information, including entry level rights, attribute level rights and logging.
- Permissions for write, self write add, and self write delete.
- Logging information for debugging access control problems.

To use the effective rights feature, you must have the access control rights to use the effective rights control and read access to the `acLRights` attribute.

If a proxy control is attached to an effective rights control-based search operation, the effective rights operation is authorized as the proxy user. Therefore the proxy user needs to have the right to use the effective rights control. The entries that the proxy user has the right to search and view are returned. For more information, see [Chapter 6, “Directory Server Access Control,” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*](#).

Tuning Access Control Instructions

Directory Server offers performance and scalability improvements for Access Control Instructions. The improvements include better memory management. The improvements also include support for macro ACIs. Improvements notwithstanding, Directory Server uses significant system resources to evaluate complex ACIs. Extensive use of complex ACIs can therefore negatively impact performance.

Macro ACIs help you limit the number of ACIs used. By limiting the number of ACIs, you render access control easier to manage and reduce the load on the system. Macros are placeholders that represent a DN, or a portion of a DN, in an ACI. A macro can be used in an ACI target, in an ACI bind rule, or in both. When Directory Server receives a request, it checks which ACI macros match against the resource targeted for the resulting operation. If a macro matches, Directory Server replaces it with the value of the actual DN. Directory Server then evaluates the ACI normally.

Testing has demonstrated that a Directory Server instance can support more than 50,000 ACIs. Nevertheless, keep the number of ACIs as small as possible. Keeping the number of ACIs small limits negative impact on performance. Keeping the number small also reduces the complexity of managing access controls. For deployments involving complex ACI environments, consider using Directory Proxy Server to provide some access control features.

How Directory Server Provides Authentication

Authentication is the process of confirming an identity. In network interactions, authentication involves the confident identification of one party by another party. Network interactions typically take place between a client, such as browser software running on a personal computer, and a server, such as the software and hardware used to host a Web site. *Client authentication* refers to the confident identification of a client by a server; *server authentication* refers to the confident identification of a server by a client.

For information about authentication, see the following sections:

- “Anonymous Access” on page 81
- “Password-Based Authentication” on page 82
- “Certificate-based Authentication” on page 86
- “Proxy Authorization” on page 84
- “Account Inactivation” on page 85
- “Global Account Lockout” on page 85
- “SASL-based Authentication” on page 100

Anonymous Access

Anonymous access lets a user bind to the directory without providing authentication credentials. With access control, you can give anonymous users whatever privileges you choose. Often, anonymous users are allowed to read non-sensitive data from the directory, such as names, telephone numbers, and email addresses.

You can also restrict the privileges of anonymous access, or limit anonymous access to a subset of attributes that contain address book information. Anonymous access should not be allowed for sensitive data.

In cases where anonymous users have access to something, you may want to prevent users who fail to bind properly nevertheless being granted access as anonymous. See the `require-bind-pwd-enabled` in [server\(5dsconf\)](#) for more information.

Password-Based Authentication

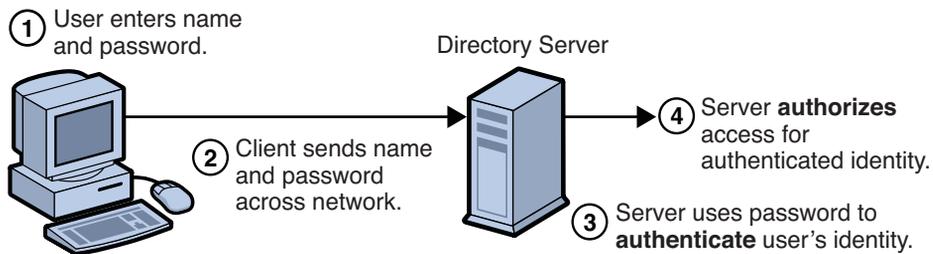
Simple password authentication offers an easy way of authenticating users. In password authentication, the user must supply a password for each server, and the administrator must keep track of the name and password for each user, typically on separate servers.

Steps in Password-Based Authentication

Figure 5–1 shows the steps involved in authenticating a client by using a name and password. The figure assumes the following points.

- The user has already decided to trust the system, either without authentication, or on the basis of server authentication via SSL.
- The user has requested a resource controlled by the server.
- The server requires client authentication before permitting access to the requested resource.

FIGURE 5–1 Password-Based Authentication



In Figure 5–1, password authentication is performed in the following steps.

1. The user enters a name and password.

For the LDAP bind to Directory Server, the client application must bind with a Distinguished Name. Therefore the client application may use the name entered by the user to retrieve the DN.
2. The client sends the DN and password across the network.
3. The server determines whether the password sent from the client matches the password stored for the entry with the DN sent from the client.

If so, the server accepts the credentials as evidence authenticating the user identity.
4. The server determines whether the identified user is permitted to access the requested resource.

If so, the server allows the client to access the resource.

Password Policy

A password policy is a set of rules that govern how passwords are administered in a system. Directory Server supports multiple password policies. The password policy can be configured to suit the security requirements of your deployment.

Instances of Directory Server are created with a default password policy.

Types of Password Policy

Directory Server provides the following password policies.

Default password policy

The default password policy is defined in the configuration entry `cn=PasswordPolicy, cn=config`. The default password policy applies to all accounts in the directory except for the directory manager.

The parameters of the default policy can be modified to override the default settings. However, because the default password policy is part of the configuration for the instance, modifications to the default password policy cannot be replicated.

Specialized password policy

A password policy can be configured for an individual user or for set of users by using the CoS and roles features. However, specialized password policies can not be applied to static groups.

A specialized password policy is defined in a subentry in the directory tree. Like the default password policy, the specialized password policy uses the `pwdPolicy` object class. For example, the following entry defines a specialized password policy:

```
dn: cn=TempPolicy,dc=example,dc=com
objectClass: top
objectClass: pwdPolicy
objectClass: LDAPsubentry
cn: TempPolicy
pwdCheckQuality: 2
pwdLockout: on
pwdLockoutDuration: 300
pwdMaxFailure: 3
pwdMustChange: on
```

A specialized password policy can be assigned to a single user account or can be assigned to a set of users by using roles. For example, in the following entry the password policy defined in `cn=TempPolicy, dc=example, dc=com` is assigned to the `pwdPolicySubentry` attribute of the user entry:

```
dn: uid=dmiller,ou=people,dc=example,dc=com
objectClass: person
objectClass: top
sn: miller
cn: david
```

```
userPassword: secret12
pwdPolicySubentry: cn=TempPolicy,dc=example,dc=com
```

When referenced by a user entry, a specialized password policy overrides the default password policy.

Because specialized password policies are defined the directory data, they can be replicated.

Configuration of Password Policy

For information about how to configure password policy, see [Chapter 7, “Directory Server Password Policy,”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

For information about the attributes used to configure password policies, see the [pwpolicy\(5dssd\)](#) man page.

Proxy Authorization

Proxy authorization allows requests from clients to be processed with a proxy identity instead of the identity of the client. A client, binding with its own identity is granted, through proxy authorization, the rights of a proxy user. The Access Control Instructions (ACIs) of the proxy user, not the ACIs of the client, are evaluated to allow or deny the operation.

Before performing an operation with proxy authorization, the account of the proxy user is validated. If the proxy user account is locked out, inactivated, if the password has been reset or has expired the client operation is aborted.

By using proxy authorization, an LDAP application can use a single bind to service multiple users who are making requests against Directory Server. Instead of having to bind and authenticate for each user, the client application binds to Directory Server and uses proxy rights.

The following conditions must be satisfied in order to use proxy authorization:

- The Directory Server must be configured with appropriate ACIs for the proxy identity.

For example, the following ACI gives the administrator the ALL access right:

```
aci: (targetattr="*") (version 3.0; acl "allowAll-Admin";
  allow (all) userdn="ldap:///uid=Administrator,
  ou=Administrators, dc=example,dc=com");
```

- The Directory Server must be configured with permission for proxy identity to act as the proxy for other users.

For example, the following ACI gives the administrator the right to act as the proxy for the user ClientApplication:

```
aci: (targetattr="*") (version 3.0; acl "allowproxy-
  accountingsoftware"; allow (proxy) userdn=
  "ldap:///dn:uid=ClientApplication,ou=Applications,
  dc=example,dc=com");)
```

The following sample shows the user `ClientApplication` performing a search operation by using the Administrator proxy identity:

```
$ ldapsearch \
-D "uid=ClientApplication,ou=Applications,dc=example,dc=com" \
-w password \
-y "uid=Administrator,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.

Proxy rights can be granted to any user except the Directory Manager.

For information about how to configure proxy authorization, see [“Proxy Authorization” in Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition](#).

Account Inactivation

A user account or a set of accounts can be inactivated temporarily or indefinitely by using the `dsutil account -inactivate` command. See [dsutil\(1M\)](#).

When the account is inactivated, the user cannot bind to Directory Server. This feature is called *account inactivation*.

User accounts and roles can be inactivated. When a role is inactivated, the members of the role are inactivated, not the role itself.

For information about how to configure account inactivation, see [“Manually Locking Accounts” in Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition](#).

Global Account Lockout

Depending on the password policy settings, a client account can be locked out of an account when the number of failed bind attempts exceeds the number of allowed bind attempts. In a replicated topology the client is locked out of all instances of Directory Server, not just the instance to which the client was attempting to bind. This feature is called *global account lockout*.

In versions of Directory Server prior to Directory Server 6, account lockout was based on integer counters. By default, these counters were not replicated.

In this version of the product, bind failures are recorded by using timestamps. By default, the timestamps are replicated, and prioritized replication is used to replicate updates to the lockout data that are caused by failed bind requests.

Global account lockout can be used in the following scenarios:

- When replication is used to propagate bind failures

Bind requests must not be directed to read-only consumers. When a client fails to bind to a read-only consumer, the lockout data is not replicated. Therefore, if a bind request fails on a read-only consumer, the lockout data is updated on that instance only and is not replicated across the topology.

Even if all bind attempts are directed at master replicas, the client might be able to perform bind attempts on multiple servers faster than the lockout data can be replicated. In this way, a client can exceed the limit on failed bind attempts for the password policy. Note that this risk is present even though bind failures are replicated by using prioritized replication.
- When Directory Proxy Server manages the routing of bind operations

The Directory Proxy Server can achieve global account lockout by using the hash algorithm for load-balancing to route all bind requests for a given account to the same Directory Server. For information about using the hash algorithm for global account lockout, see [“Operational Affinity Algorithm for Global Account Lockout” on page 234](#).

Certificate-based Authentication

For information about client authentication with certificates, see the following sections:

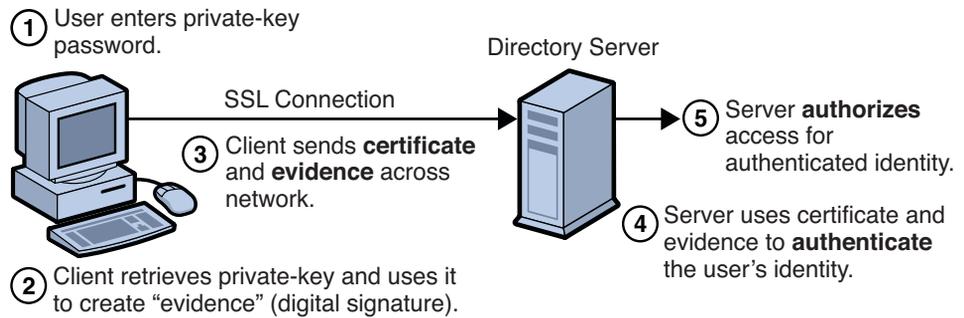
- [“Introduction to Certificate-based Authentication” on page 86](#)
- [“Certificates and Certificate Authorities \(CA\)” on page 87](#)
- [“Types of Certificates” on page 94](#)
- [“Contents of a Certificate” on page 95](#)
- [“Certificate Management” on page 97](#)

Introduction to Certificate-based Authentication

[Figure 5–2](#) shows how certificates and the SSL protocol are used together for authentication. To authenticate a user to a server, a client digitally signs a randomly generated piece of data and sends both the certificate and the signed data across the network. For the purposes of this discussion, the digital signature associated with some data can be thought of as evidence provided by the client to the server. The server authenticates the user’s identity on the strength of this evidence.

Like for password-based authentication illustrated in [Figure 5–1](#), [Figure 5–2](#) assumes that the user has already decided to trust the server and has requested a resource. The server has requested client authentication in the process of evaluating whether to grant access to the requested resource.

FIGURE 5-2 Certificate-Based Authentication



Unlike for password-based authentication illustrated in Figure 5-1, Figure 5-2 requires the use of SSL. In Figure 5-2 it is assumed that the client has a valid certificate that can be used to identify the client to the server.

Certificate-based authentication is generally considered preferable to password-based authentication because it is based on what the user has, the private key, as well as what the user knows, the password that protects the private key. However, it's important to note that these two assumptions are true only if unauthorized personnel have not gained access to the user's machine or password, the password for the client software's private key database has been set, and the software is set up to request the password at reasonably frequent intervals.

Note – Neither password-based authentication nor certificate-based authentication address security issues related to physical access to individual machines or passwords. Public-key cryptography can only verify that a private key used to sign some data corresponds to the public key in a certificate. It is the user's responsibility to protect a machine's physical security and to keep the private-key password secret.

Certificates replace the authentication portion of the interaction between the client and the server. Instead of requiring a user to send passwords across the network throughout the day, single sign-on requires the user to enter the private-key database password just once, without sending it across the network. For the rest of the session, the client presents the user's certificate to authenticate the user to each new server it encounters. Existing authorization mechanisms based on the authenticated user identity are not affected.

Certificates and Certificate Authorities (CA)

A certificate is an electronic document that identifies an individual, a server, a company, or some other entity. A certificate also associates that identity with a public key. Like a driver's license, a passport, or other commonly used personal IDs, a certificate provides generally recognized proof of someone's or something's identity.

Certificate authorities, CAs, validate identities and issue certificates. CAs can be independent third parties or organizations that run their own certificate-issuing server software. The methods used to validate an identity vary depending on the policies of a given CA. In general, before issuing a certificate, the CA must use its published verification procedures for that type of certificate to ensure that an entity requesting a certificate is in fact who it claims to be.

A certificate issued by a CA binds a particular public key to the name of the entity the certificate identifies, such as the name of an employee or a server. Certificates help prevent the use of fake public keys for impersonation. Only the public key certified by the certificate works with the corresponding private key possessed by the entity identified by the certificate.

In addition to a public key, a certificate always includes the name of the entity it identifies, an expiration date, the name of the CA that issued the certificate, a serial number, and other information. Most importantly, a certificate always includes the digital signature of the issuing CA. The CA's digital signature allows the certificate to function as a "letter of introduction" for users who know and trust the CA but don't know the entity identified by the certificate.

Any client or server software that supports certificates maintains a collection of trusted CA certificates. These CA certificates determine which other certificates the software can validate, in other words, which issuers of certificates the software can trust. In the simplest case, the software can validate only certificates issued by one of the CAs for which it has a certificate. It's also possible for a trusted CA certificate to be part of a chain of CA certificates, each issued by the CA above it in a certificate hierarchy.

For information about CAs, see the following sections:

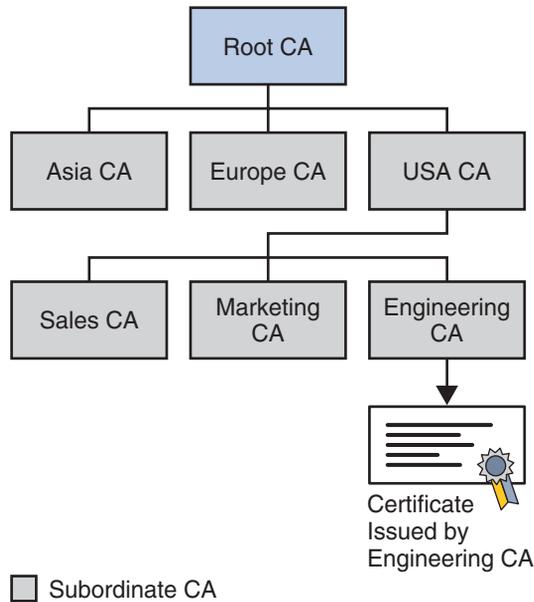
- ["CA Hierarchies" on page 88](#)
- ["Certificate Chains" on page 89](#)
- ["Verifying a Certificate Chain" on page 91](#)

CA Hierarchies

In large organizations, it may be appropriate to delegate the responsibility for issuing certificates to several different certificate authorities. For example, the number of certificates required may be too large for a single CA to maintain; different organizational units may have different policy requirements; or it may be important for a CA to be physically located in the same geographic area as the people to whom it is issuing certificates.

It's possible to delegate certificate-issuing responsibilities to subordinate CAs. The X.509 standard includes a model for setting up a hierarchy of CAs.

FIGURE 5-3 Hierarchy of Certificate Authorities



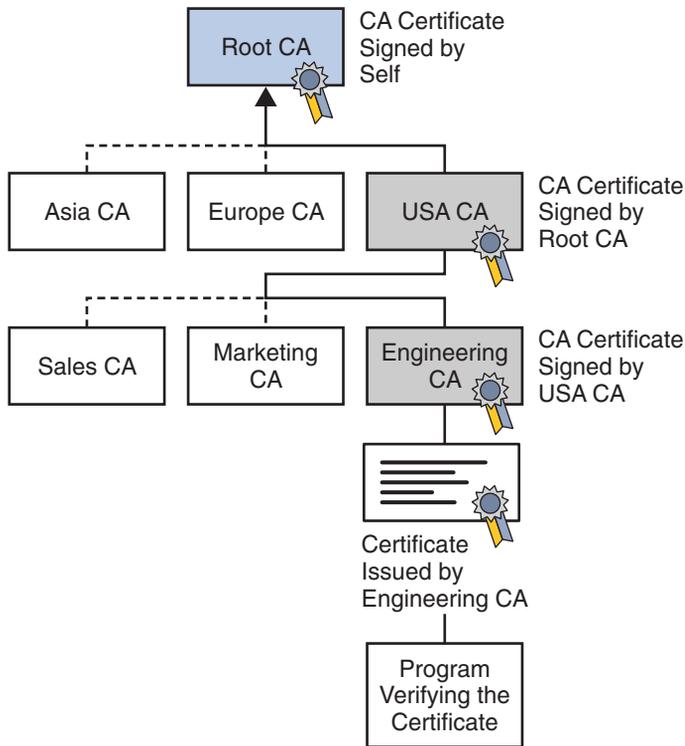
In this model, the root CA is at the top of the hierarchy. The root CA's certificate is a *self-signed certificate*. That is, the certificate is digitally signed by the same entity, the root CA, that the certificate identifies. The CAs that are directly subordinate to the root CA have CA certificates signed by the root CA. CAs under the subordinate CAs in the hierarchy have their CA certificates signed by the higher-level subordinate CAs.

Organizations have a great deal of flexibility in terms of the way they set up their CA hierarchies. [Figure 5-3](#) shows just one example; many other arrangements are possible.

Certificate Chains

CA hierarchies are reflected in certificate chains. A *certificate chain* is a series of certificates issued by successive CAs. [Figure 5-4](#) shows a certificate chain leading from a certificate that identifies some entity through two subordinate CA certificates to the CA certificate for the root CA (based on the CA hierarchy shown in the following figure).

FIGURE 5-4 Certificate Chain



- Trusted Authority
- Untrusted Authority

A certificate chain traces a path of certificates from a branch in the hierarchy to the root of the hierarchy. In a certificate chain, the following occur:

- Each certificate is followed by the certificate of its issuer.
- In [Figure 5-4](#), the Engineering CA certificate contains the DN of the CA (that is, USA CA), that issued that certificate. USA CA's DN is also the subject name of the next certificate in the chain.
- Each certificate is signed with the private key of its issuer. The signature can be verified with the public key in the issuer's certificate, which is the next certificate in the chain.

In [Figure 5-4](#), the public key in the certificate for the USA CA can be used to verify the USA CA's digital signature on the certificate for the Engineering CA.

Verifying a Certificate Chain

Certificate chain verification is the process of making sure a given certificate chain is well-formed, valid, properly signed, and trustworthy. Directory Server software uses the following steps to form and verify a certificate chain, starting with the certificate being presented for authentication:

1. The certificate validity period is checked against the current time provided by the verifier's system clock.
2. The issuer's certificate is located. The source can be either the verifier's local certificate database (on that client or server) or the certificate chain provided by the subject (for example, over an SSL connection).
3. The certificate signature is verified using the public key in the issuer certificate.
4. If the issuer's certificate is trusted by the verifier in the verifier's certificate database, verification stops successfully here. Otherwise, the issuer's certificate is checked to make sure it contains the appropriate subordinate CA indication in the Directory Server certificate type extension, and chain verification returns to step 1 to start again, but with this new certificate.

FIGURE 5-5 Verifying A Certificate Chain

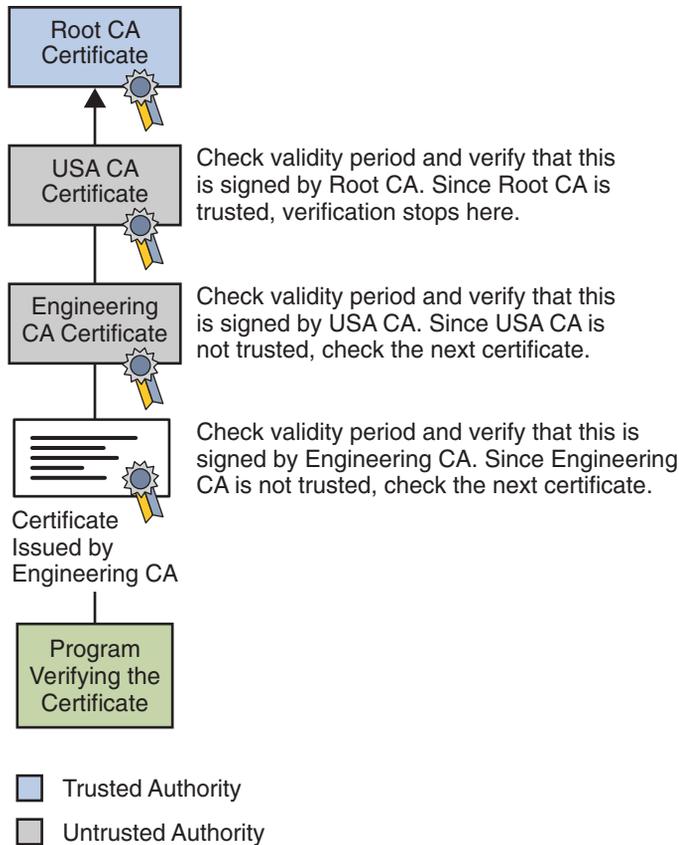
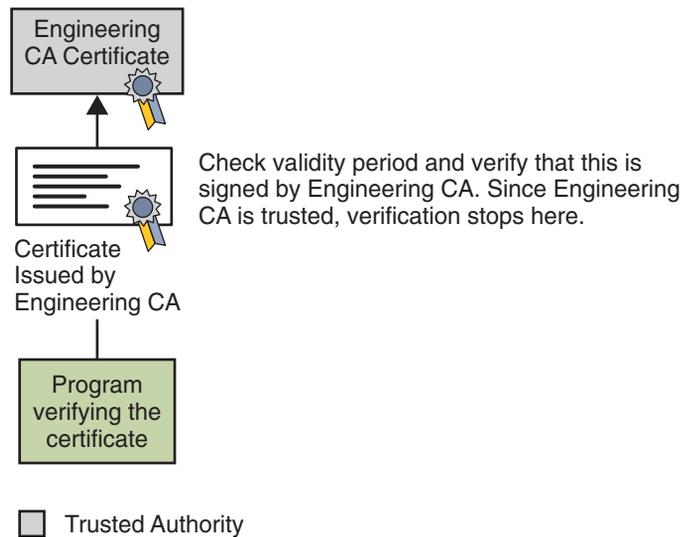


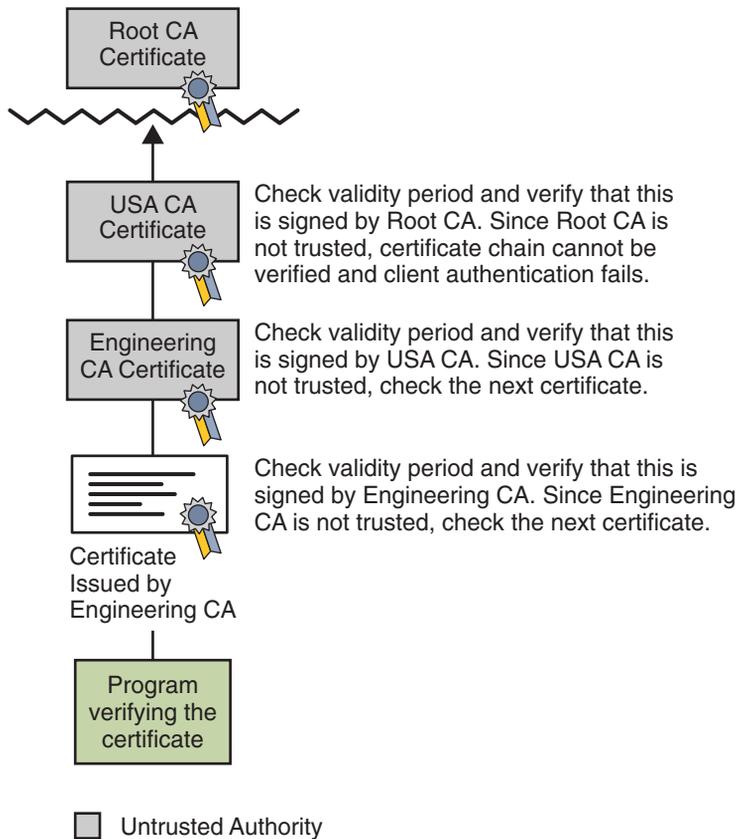
Figure 5-5 shows what happens when only Root CA is included in the verifier’s local database. If a certificate for one of the intermediate CAs shown in Figure 5-6, such as Engineering CA, is found in the verifier’s local database, verification stops with that certificate, as shown in the following figure.

FIGURE 5-6 Verifying A Certificate Chain to an Intermediate CA



Expired validity dates, an invalid signature, or the absence of a certificate for the issuing CA at any point in the certificate chain causes authentication to fail. For example, the following figure shows how verification fails if neither the Root CA certificate nor any of the intermediate CA certificates are included in the verifier's local database.

FIGURE 5-7 Certificate Chain That Cannot Be Verified



For general information about the way digital signatures work, see [“Digital Signatures” on page 112](#).

Types of Certificates

Directory Server uses the following types of certificate:

Client SSL certificates

Client SSL certificates are used to identify clients to servers via SSL (client authentication). Typically, the identity of the client is assumed to be the same as the identity of a human being, such as an employee in an enterprise. Client SSL certificates can also be used for form signing and as part of a single sign-on solution.

For example, a bank gives a customer a client SSL certificate that allows the bank’s servers to identify that customer and authorize access to the customer’s accounts. A company might give a new employee a client SSL certificate that allows the company’s servers to identify that employee and authorize access to the company’s servers.

Server SSL certificates

Server SSL certificates are used to identify servers to clients via SSL (server authentication). Server authentication may be used with or without client authentication. Server authentication is a requirement for an encrypted SSL session.

For example, internet sites that engage in electronic commerce usually support certificate-based server authentication, at a minimum, to establish an encrypted SSL session and to assure customers that they are dealing with a web site identified with a particular company. The encrypted SSL session ensures that personal information sent over the network, such as credit card numbers, cannot easily be intercepted.

S/MIME certificates

S/MIME certificates are used for signed and encrypted email. As with client SSL certificates, the identity of the client is typically assumed to be the same as the identity of a human being, such as an employee in an enterprise. A single certificate may be used as both an S/MIME certificate and an SSL certificate. S/MIME certificates can also be used for form signing and as part of a single sign-on solution.

For example, a company deploys combined S/MIME and SSL certificates solely for the purpose of authenticating employee identities, thus permitting signed email and client SSL authentication but not encrypted email. Another company issues S/MIME certificates solely for the purpose of both signing and encrypting email that deals with sensitive financial or legal matters.

Object-signing certificates

Object-signing certificates are used to identify signers of Java code, JavaScript scripts, or other signed files.

For example, a software company signs software distributed over the Internet to provide users with some assurance that the software is a legitimate product of that company. Using certificates and digital signatures in this manner can also make it possible for users to identify and control the kind of access downloaded software has to their computers.

CA certificates

CA certificates are used to identify CAs. Client and server software use CA certificates to determine what other certificates can be trusted.

For example, the CA certificates stored in client software determine what other certificates that client can authenticate. An administrator can implement some aspects of corporate security policies by controlling the CA certificates stored in each user's client.

Contents of a Certificate

The contents of certificates supported by Directory Server and many other software companies are organized according to the X.509 v3 certificate specification, which has been recommended by the International Telecommunications Union (ITU), an international standards body, since 1988. Examples in this section show samples of the data and signature sections of a certificate.

Every X.509 certificate consists of the following sections.

- A data section, including the following information.
 - The version number of the X.509 standard supported by the certificate.
 - The certificate's serial number. Every certificate issued by a CA has a serial number that is unique among the certificates issued by that CA.
 - Information about the user's public key, including the algorithm used and a representation of the key itself.
 - The DN of the CA that issued the certificate.
 - The period during which the certificate is valid (for example, between 1:00 p.m. on November 15, 2003 and 1:00 p.m. November 15, 2004).
 - The DN of the certificate subject (for example, in a client SSL certificate this would be the user's DN), also called the subject name.
 - Optional *certificate extensions*, which may provide additional data used by the client or server. For example, the certificate type extension indicates the type of certificate—that is, whether it is a client SSL certificate, a server SSL certificate, a certificate for signing email, and so on. Certificate extensions can also be used for a variety of other purposes.
- A signature section, includes the following information.
 - The cryptographic algorithm, or cipher, used by the issuing CA to create its own digital signature.
 - The CA's digital signature, obtained by hashing all of the data in the certificate together and encrypting it with the CA's private key.

EXAMPLE 5-1 Data and Signature Sections of a Certificate in Human-Readable Format

Certificate:

Data:

```

Version: v3 (0x2)
Serial Number: 3 (0x3)
Signature Algorithm: PKCS #1 MD5 With RSA Encryption
Issuer: OU=Certificate Authority, O=Example Industry, C=US
Validity:
  Not Before: Fri Oct 17 18:36:25 2003
  Not After: Sun Oct 17 18:36:25 2004
Subject: CN=Jane Doe, OU=Finance, O=Example Industry, C=US
Subject Public Key Info:
  Algorithm: PKCS #1 RSA Encryption
  Public Key:
    Modulus:
      00:ca:fa:79:98:8f:19:f8:d7:de:e4:49:80:48:e6:2a:2a:86:
      ed:27:40:4d:86:b3:05:c0:01:bb:50:15:c9:de:dc:85:19:22:
      43:7d:45:6d:71:4e:17:3d:f0:36:4b:5b:7f:a8:51:a3:a1:00:
      98:ce:7f:47:50:2c:93:36:7c:01:6e:cb:89:06:41:72:b5:e9:
      73:49:38:76:ef:b6:8f:ac:49:bb:63:0f:9b:ff:16:2a:e3:0e:
      9d:3b:af:ce:9a:3e:48:65:de:96:61:d5:0a:11:2a:a2:80:b0:
      7d:d8:99:cb:0c:99:34:c9:ab:25:06:a8:31:ad:8c:4b:aa:54:
      91:f4:15
    Public Exponent: 65537 (0x10001)
  
```

EXAMPLE 5-1 Data and Signature Sections of a Certificate in Human-Readable Format *(Continued)*

```

Extensions:
  Identifier: Certificate Type
  Critical: no
  Certified Usage:
  SSL Client
  Identifier: Authority Key Identifier
  Critical: no
  Key Identifier:
    f2:f2:06:59:90:18:47:51:f5:89:33:5a:31:7a:e6:5c:fb:36:
    26:c9
Signature:
  Algorithm: PKCS #1 MD5 With RSA Encryption
  Signature:
6d:23:af:f3:d3:b6:7a:df:90:df:cd:7e:18:6c:01:69:8e:54:65:fc:06:
30:43:34:d1:63:1f:06:7d:c3:40:a8:2a:82:c1:a4:83:2a:fb:2e:8f:fb:
f0:6d:ff:75:a3:78:f7:52:47:46:62:97:1d:d9:c6:11:0a:02:a2:e0:cc:
2a:75:6c:8b:b6:9b:87:00:7d:7c:84:76:79:ba:f8:b4:d2:62:58:c3:c5:
b6:c1:43:ac:63:44:42:fd:af:c8:0f:2f:38:85:6d:d6:59:e8:41:42:a5:
4a:e5:26:38:ff:32:78:a1:38:f1:ed:dc:0d:31:d1:b0:6d:67:e9:46:a8:
d:c4

```

EXAMPLE 5-2 Certificate In the 64-Byte Encoded Form Interpreted by Software

```

-----BEGIN CERTIFICATE-----
MIICKzCCAZSgAwIBAgIBAZANBgkqhkiG9w0BAQQFADA3MQswCQYDVQQGEWJVUzER
MA8GA1UEChMlTmV0c2NhcnV0c2NhcGUxFTATBgNVBAsTDfN1cHJpeWEncyBDQTAeFw05NzEw
MTgwMTM2MjVhFw05OTEwMTgwMTM2MjVhMEgxCzAJBgNVBAYTAlVMTREwDwYDVQQK
Ewh0ZXRzY2FwZTENMA5GA1UECXMUHViczEXMBUGA1UEAxMOU3Vwcm15YSB0aGV0
dHkwZ8wDQYJKoZIhvcNAQEFBQADGy0AMIGJAoGBAMr6eZiPGfjX3uRjGjEjmKiQG
7SdATYazBcABu1AVyd7chRkiQ31FbXFOGD3wNktbf6hRo6EAmM5/R1AskzZ8AW7L
iQZBcrXpc0k4du+2Q6xJu2MPm/8WKuM0nTuvzpo+SGXe1mHVChEqooCwfdiZywyZ
NMmrJgaoMa2M56pUkFQVAgMBAAGjNjA0MBEGCWCgsAGG+EIBAQQEAWIAGDAfBgNV
HSMEGDAWgBTy8gZZkBHUFwJm1oxeuZc+zYmyTANBgkqhkiG9w0BAQQFAA0BgQBT
I6/z07Z635DfzX4XbAFpjLRl/AYwQzTSYx8GfcNAqCqCwaSDKvsuj/vwbf91o3j3
UkdGYpcd2cYRCgKi4MwqdWyltpuHAH18hHZ5uvi00mJYw8W2wU0sY0RC/a/IDy84
hW3WWhBUqVK5SY4/zJ4oTjx7dwNMDGwbWfpRqjd1A==
-----END CERTIFICATE-----

```

Certificate Management

The set of standards and services that facilitate the use of public-key cryptography and X.509 v3 certificates in a network environment is called the *public key infrastructure* (PKI). For information about the certificate management issues addressed by Directory Server, see the following sections:

- “Issuing Certificates” on page 98
- “Certificates and the LDAP Directory” on page 98
- “Key Management” on page 98
- “Renewal and Revocation of Certificates” on page 99
- “Registration Authorities” on page 100

Issuing Certificates

The process for issuing a certificate depends on the certificate authority that issues it and the purpose for which it is used. The process for issuing non-digital forms of identification varies in similar ways. For example, if you want to get a generic ID card (not a driver's license) from the Department of Motor Vehicles in California, the requirements are straightforward: you need to present some evidence of your identity, such as a utility bill with your address on it and a student identity card. If you want to get a regular driving license, you also need to take a test — a driving test when you first get the license, and a written test when you renew it. If you want to get a commercial license for an eighteen-wheeler, the requirements are much more stringent. If you live in some other state or country, the requirements for various kinds of licenses differ.

Similarly, different CAs have different procedures for issuing different kinds of certificates. In some cases the only requirement may be your mail address. In other cases, your UNIX login and password may be sufficient. At the other end of the scale, for certificates that identify people who can authorize large expenditures or make other sensitive decisions, the issuing process may require notarized documents, a background check, and a personal interview.

Depending on an organization's policies, the process of issuing certificates can range from being completely transparent for the user to requiring significant user participation and complex procedures. In general, processes for issuing certificates should be highly flexible, so organizations can tailor them to their changing needs.

Issuing certificates is one of several management tasks that can be handled by separate Registration Authorities.

Certificates and the LDAP Directory

The Lightweight Directory Access Protocol (LDAP) for accessing directory services supports great flexibility in the management of certificates within an organization. System administrators can store much of the information required to manage certificates in an LDAP-compliant directory. For example, a CA can use information in a directory to pre-populate a certificate with a new employee's legal name and other information. The CA can leverage directory information in other ways to issue certificates one at a time or in bulk, using a range of different identification techniques depending on the security policies of a given organization. Other routine management tasks, such as key management and renewing and revoking certificates, can be partially or fully automated with the aid of the directory.

Information stored in the directory can also be used with certificates to control access to various network resources by different users or groups. Issuing certificates and other certificate management tasks can thus be an integral part of user and group management.

Key Management

Before a certificate can be issued, the public key it contains and the corresponding private key must be generated. Sometimes it may be useful to issue a single person one certificate and key pair for signing operations, and another certificate and key pair for encryption operations.

Separate signing and encryption certificates make it possible to keep the private signing key on the local machine only, thus providing maximum non-repudiation, and to back up the private encryption key in some central location where it can be retrieved in case the user loses the original key or leaves the company.

Keys can be generated by client software or generated centrally by the CA and distributed to users via an LDAP directory. There are trade-offs involved in choosing between local and centralized key generation. For example, local key generation provides maximum non-repudiation, but may involve more participation by the user in the issuing process. Flexible key management capabilities are essential for most organizations.

Key recovery, or the ability to retrieve backups of encryption keys under carefully defined conditions, can be a crucial part of certificate management (depending on how an organization uses certificates). Key recovery schemes usually involve an *m of n* mechanism: for example, *m* of *n* managers within an organization might have to agree, and each contribute a special code or key of their own, before a particular person's encryption key can be recovered. This kind of mechanism ensures that several authorized personnel must agree before an encryption key can be recovered.

Renewal and Revocation of Certificates

Like a driver's license, a certificate specifies a period of time during which it is valid. Attempts to use a certificate for authentication before or after its validity period fails. Therefore, mechanisms for managing certificate renewal are essential for any certificate management strategy. For example, an administrator may wish to be notified automatically when a certificate is about to expire, so that an appropriate renewal process can be completed in plenty of time without causing the certificate's subject any inconvenience. The renewal process may involve reusing the same public-private key pair or issuing a new one.

A driver's license can be suspended even if it has not expired—for example, as punishment for a serious driving offense. Similarly, it's sometimes necessary to revoke a certificate before it has expired—for example, if an employee leaves a company or moves to a new job within the company.

Certificate revocation can be handled in several different ways. For some organizations, it may be sufficient to set up servers so that the authentication process includes checking the directory for the presence of the certificate being presented. When an administrator revokes a certificate, the certificate can be automatically removed from the directory, and subsequent authentication attempts with that certificate fails even though the certificate remains valid in every other respect. Another approach involves publishing a certificate revocation list (CRL)—that is, a list of revoked certificates—to the directory at regular intervals and checking the list as part of the authentication process. For some organizations, it may be preferable to check directly with the issuing CA each time a certificate is presented for authentication. This procedure is sometimes called real-time status checking.

Registration Authorities

Interactions between entities identified by certificates (sometimes called end entities) and CAs are an essential part of certificate management. These interactions include operations such as registration for certification, certificate retrieval, certificate renewal, certificate revocation, and key backup and recovery. In general, a CA must be able to authenticate the identities of end entities before responding to the requests. In addition, some requests need to be approved by authorized administrators or managers before being serviced.

As previously discussed, the means used by different CAs to verify an identity before issuing a certificate can vary widely, depending on the organization and the purpose for which the certificate is used. To provide maximum operational flexibility, interactions with end entities can be separated from the other functions of a CA and handled by a separate service called a *Registration Authority RA*.

An RA acts as a front end to a CA by receiving end entity requests, authenticating them, and forwarding them to the CA. After receiving a response from the CA, the RA notifies the end entity of the results. RAs can be helpful in scaling a PKI across different departments, geographical areas, or other operational units with varying policies and authentication requirements.

SASL-based Authentication

Client authentication during an SSL or TLS connection can also use the Simple Authentication and Security Layer (SASL). Directory Server supports the following SASL mechanisms.

- | | |
|------------|--|
| 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 text passwords in the directory. |
| GSSAPI | GSSAPI is available on the Solaris Operating System only. The General Security Services API (GSSAPI) allows Directory Server to interact with the Kerberos V5 security system to identify a user. The client application must present its credentials to the Kerberos system, which in turn validates the user's identity to Directory Server. |

For information about how to configure SASL-based authentication, see [“Configuring Credential Levels and Authentication Methods”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

How Directory Server Provides Encryption

For information about how Directory Server encrypts data, see the following sections:

- [“Secure Sockets Layer \(SSL\)” on page 101](#)
- [“Digital Signatures” on page 112](#)
- [“Key Encryption” on page 114](#)
- [“Attribute Encryption” on page 116](#)

Secure Sockets Layer (SSL)

SSL provides encrypted communications and optional authentication between a Directory Server and its clients. SSL can be used over LDAP or DSML over HTTP. SSL is enabled by default over LDAP and can be enabled for DSML over HTTP.

Replication can be configured to use SSL for secure communications between servers. When replication is configured to use SSL, data sent to and from the server is encrypted by using SSL.

By default, Directory Server allows simultaneous unsecured and secure communications, using different port numbers. Unsecured LDAP communications are handled on one port, conventionally port number 389. Secure LDAP communications are handled on another port, conventionally port number 636.

For security reasons, you can also restrict all communications to the secure port. Client authentication is also configurable. You can set client authentication to required or allowed. This setting determines the level of security you enforce.

SSL enables support for the Start TLS extended operation that provides security on a regular LDAP connection. Clients can 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 can help simplify port allocation.

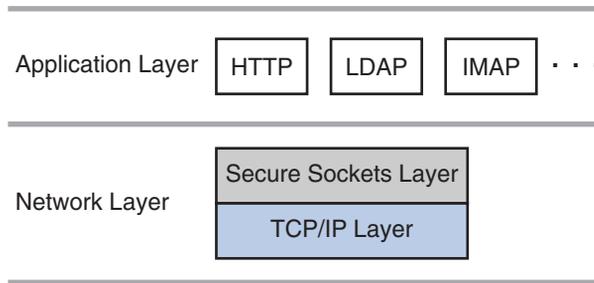
For information about SSL, see the following sections:

- [“Overview of SSL” on page 101](#)
- [“Cryptographic Algorithms Used With SSL” on page 103](#)
- [“SSL Handshake” on page 104](#)

Overview of SSL

TCP/IP governs the transport and routing of data over the Internet. Other protocols, such as the HTTP, LDAP, or IMAP use TCP/IP to support typical application tasks such as displaying web pages or running mail servers.

FIGURE 5-8 Where SSL Runs



The SSL protocol runs above TCP/IP and below higher-level protocols such as HTTP or IMAP. It uses TCP/IP on behalf of the higher-level protocols, and in the process allows an SSL-enabled server to authenticate itself to an SSL-enabled client, allows the client to authenticate itself to the server, and allows both machines to establish an encrypted connection.

SSL addresses the following concerns about communication over the Internet and other TCP/IP networks:

SSL server authentication allows a user to confirm a server's identity.

SSL-enabled client software can use standard techniques of public-key cryptography to check that a server's certificate and public ID are valid and have been issued by a certificate authority (CA) listed in the client's list of trusted CAs. This confirmation might be important if the user, for example, is sending a credit card number over the network and wants to check the receiving server's identity.

SSL client authentication allows a server to confirm a user's identity.

Using the same techniques as those used for server authentication, SSL-enabled server software can check that a client's certificate and public ID are valid and have been issued by a certificate authority (CA) listed in the server's list of trusted CAs. This confirmation might be important if the server, for example, is a bank sending confidential financial information to a customer and wants to check the recipient's identity.

An encrypted SSL connection requires all information sent between a client and a server to be encrypted by the sending software and decrypted by the receiving software, thus providing a high degree of confidentiality.

Confidentiality is important for both parties to any private transaction. In addition, all data sent over an encrypted SSL connection is protected with a mechanism for detecting tampering—that is, for automatically determining whether the data has been altered in transit.

The SSL protocol includes two sub-protocols: the SSL record protocol and the SSL handshake protocol.

The SSL record protocol defines the format used to transmit data. The SSL handshake protocol involves using the SSL record protocol to exchange a series of messages between an

SSL-enabled server and an SSL-enabled client when they first establish an SSL connection. This exchange of messages is designed to facilitate the following actions:

- Authenticate the server to the client.
- Allow the client and server to select the cryptographic algorithms, or ciphers, that they both support.
- Optionally authenticate the client to the server.
- Use public-key encryption techniques to generate shared secrets.
- Establish an encrypted SSL connection.

For more information about the handshake process, see “[SSL Handshake](#)” on page 104.

Cryptographic Algorithms Used With SSL

Cipher suites define the following aspects of SSL communication:

- The key exchange Algorithm
- The encryption cipher
- The encryption cipher key length
- The message authentication method

The SSL protocol supports many ciphers. Clients and servers can support different cipher suites, depending on factors such as the version of SSL they support, and company policies regarding acceptable encryption strength. The SSL handshake protocol determines how the server and client negotiate which cipher suites they use to authenticate each other, to transmit certificates, and to establish session keys.

SSL 2.0 and SSL 3.0 protocols support overlapping sets of cipher suites. Administrators can enable or disable any of the supported cipher suites for both clients and servers. When a client and server exchange information during the SSL handshake, they identify the strongest enabled cipher suites they have in common and use those for the SSL session. Decisions about which cipher suites to enable depend on the sensitivity of the data involved, the speed of the cipher, and the applicability of export rules.

Key-exchange algorithms like KEA and RSA govern the way in which a server and client determine the symmetric keys they use during an SSL session. The most commonly used SSL cipher suites use the RSA key exchange.

The list of ciphers enabled for Directory Server, and also the list of ciphers supported by Directory Server can be obtained with the `dsconf` command. For information about using the `dsconf` command to list available ciphers and manage ciphers, see “[Choosing Encryption Ciphers](#)” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Support for ciphers is provided by the Network Security Services, NSS, component. For details about NSS, see the [NSS project site \(http://www.mozilla.org/projects/security/pki/nss/\)](http://www.mozilla.org/projects/security/pki/nss/).

SSL Handshake

The SSL protocol uses a combination of public-key and symmetric key encryption. Symmetric key encryption is much faster than public-key encryption, but public-key encryption provides better authentication techniques. An SSL session always begins with an exchange of messages called the *SSL handshake*. The handshake allows the server to authenticate itself to the client by using public-key techniques, and then allows the client and the server to cooperate in the creation of symmetric keys used for rapid encryption, decryption, and tamper detection. Optionally, the handshake also allows the client to authenticate itself to the server.

For information about the SSL handshake, see the following sections:

- [“Messages Exchanged During SSL Handshake” on page 104](#)
- [“Server Authentication During SSL Handshake” on page 105](#)
- [“Man-In-the-Middle Attack” on page 108](#)
- [“Client Authentication During SSL Handshake” on page 109](#)

Messages Exchanged During SSL Handshake

The following steps describe the sequence of messages exchanged during an SSL handshake. These steps describe the programmatic details of the messages exchanged during the SSL handshake.

1. The client sends the server the client’s SSL version number, cipher settings, randomly generated data, and other information the server needs to communicate with the client using SSL.
2. The server sends the client the server’s SSL version number, cipher settings, randomly generated data, and other information the client needs to communicate with the server over SSL. The server also sends its own certificate and, if the client is requesting a server resource that requires client authentication, requests the client’s certificate.
3. The client can use some of the information sent by the server to authenticate the server. For details, see [“Server Authentication During SSL Handshake” on page 105](#). If the server cannot be authenticated, the user is warned of the problem and informed that an encrypted and authenticated connection cannot be established. If the server can be successfully authenticated, the client goes on to Step 4.
4. Using all data generated in the handshake so far, the client, with the cooperation of the server, depending on the cipher being used, creates the pre-master secret for the session, encrypts it with the server’s public key, obtained from the server’s certificate, sent in Step 2, and sends the encrypted pre-master secret to the server.
5. If the server has requested client authentication (an optional step in the handshake), the client also signs another piece of data that is unique to this handshake and known by both the client and server. In this case the client sends both the signed data and the client’s own certificate to the server along with the encrypted pre-master secret.

6. If the server has requested client authentication, the server attempts to authenticate the client. For details, see [“Server Authentication During SSL Handshake” on page 105](#). If the client cannot be authenticated, the session is terminated. If the client can be successfully authenticated, the server uses its private key to decrypt the pre-master secret, then performs a series of steps (which the client also performs, starting from the same pre-master secret) to generate the master secret.
7. Both the client and the server use the master secret to generate the *session keys*, which are symmetric keys used to encrypt and decrypt information exchanged during the SSL session and to verify its integrity—that is, to detect changes in the data between the time it was sent and the time it is received over the SSL connection.
8. The client sends a message to the server informing it that future messages from the client are encrypted with the session key. It then sends a separate (encrypted) message indicating that the client portion of the handshake is finished.
9. The server sends a message to the client informing it that future messages from the server are encrypted with the session key. It then sends a separate (encrypted) message indicating that the server portion of the handshake is finished.
10. The SSL handshake is now complete, and the SSL session has begun. The client and the server use the session keys to encrypt and decrypt the data they send to each other and to validate its integrity.

Before continuing with a session, directory servers can be configured to check that the client’s certificate is present in the user’s entry in an LDAP directory. This configuration option provides one way of ensuring that the client’s certificate has not been revoked.

Both client and server authentication involve encrypting some piece of data with one key of a public-private key pair and decrypting it with the other key:

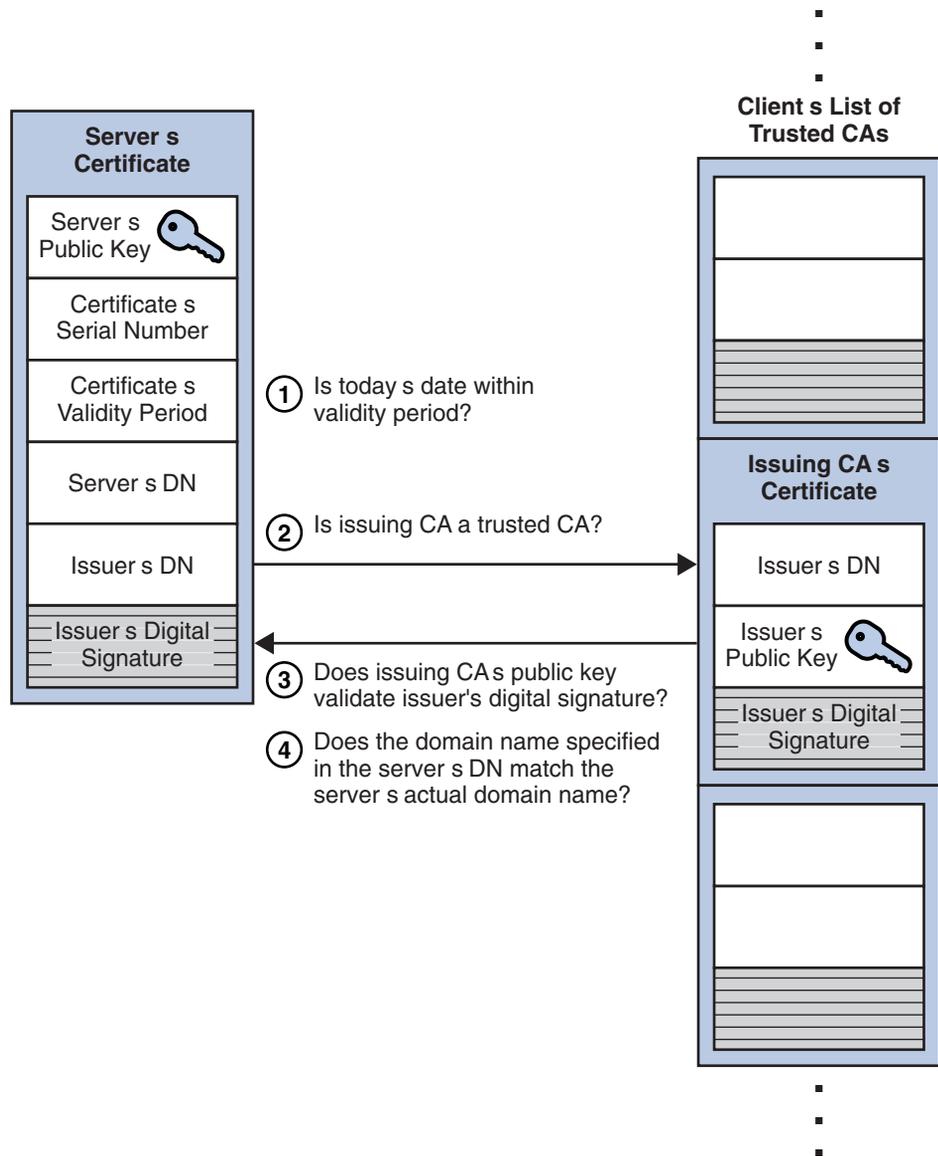
- In the case of server authentication, the client encrypts the pre-master secret with the server’s public key. Only the corresponding private key can correctly decrypt the secret, so the client has some assurance that the identity associated with the public key is in fact the server with which the client is connected. Otherwise, the server cannot decrypt the pre-master secret and cannot generate the symmetric keys required for the session, and the session is terminated.
- In the case of client authentication, the client encrypts some random data with the client’s private key—that is, it creates a digital signature. The public key in the client’s certificate can correctly validate the digital signature only if the corresponding private key was used. Otherwise, the server cannot validate the digital signature and the session is terminated.

Server Authentication During SSL Handshake

SSL-enabled client software always requires server authentication, or cryptographic validation by a client of the server’s identity. The server sends the client a certificate to authenticate itself. The client uses the certificate to authenticate the identity the certificate claims to represent.

To authenticate the binding between a public key and the server identified by the certificate that contains the public key, an SSL-enabled client must receive a yes answer to the four questions shown in the following figure.

FIGURE 5-9 Authenticating a Client Certificate During SSL Handshake



An SSL-enabled client goes through the following steps to authenticate a server's identity:

1. Is today's date within the validity period?

The client checks the server certificate's validity period. If the current date and time are outside of that range, the authentication process won't go any further. If the current date and time are within the certificate's validity period, the client goes on to the next step.

2. Is the issuing CA a trusted CA?

Each SSL-enabled client maintains a list of trusted CA certificates, represented by the shaded area on the right—hand side of [Figure 5–9](#). This list determines which server certificates the client accepts. If the distinguished name (DN) of the issuing CA matches the DN of a CA on the client's list of trusted CAs, the answer to this question is yes, and the client goes on to the next step. If the issuing CA is not on the list, the server is not authenticated unless the client can verify a certificate chain ending in a CA that is on the list.

3. Does the issuing CA's public key validate the issuer's digital signature?

The client uses the public key from the CA's certificate (which it found in its list of trusted CAs in step 2) to validate the CA's digital signature on the server certificate being presented. If the information in the server certificate has changed since it was signed by the CA or if the CA certificate's public key doesn't correspond to the private key used by the CA to sign the server certificate, the client won't authenticate the server's identity. If the CA's digital signature can be validated, the server treats the user's certificate as a valid "letter of introduction" from that CA and proceeds. At this point, the client has determined that the server certificate is valid.

4. Does the domain name in the server's certificate match the domain name of the server itself?

This step confirms that the server is actually located at the same network address specified by the domain name in the server certificate. Although step 4 is not technically part of the SSL protocol, it provides the only protection against a form of security attack known as *man-in-the-middle*. Clients must perform this step and must refuse to authenticate the server or establish a connection if the domain names don't match. If the server's actual domain name matches the domain name in the server certificate, the client goes on to the next step.

5. The server is authenticated.

The client proceeds with the SSL handshake. If the client doesn't get to step 5 for any reason, the server identified by the certificate cannot be authenticated, and the user is warned of the problem and informed that an encrypted and authenticated connection cannot be established. If the server requires client authentication, the server performs the steps described in "[Client Authentication During SSL Handshake](#)" on page 109.

After the steps described here, the server must successfully use its private key to decrypt the pre-master secret sent by the client.

Man-In-the-Middle Attack

The *man-in-the-middle* is a rogue program that intercepts all communication between the client and a server with which the client is attempting to communicate via SSL. The rogue

program intercepts the legitimate keys that are passed back and forth during the SSL handshake, substitutes its own, and makes it appear to the client that it is the server, and to the server that it is the client.

The encrypted information exchanged at the beginning of the SSL handshake is actually encrypted with the rogue program's public key or private key, rather than the client's or server's real keys. The rogue program ends up establishing one set of session keys for use with the real server, and a different set of session keys for use with the client. This allows the rogue program not only to read all the data that flows between the client and the real server, but also to change the data without being detected. Therefore, it is extremely important for the client to check that the domain name in the server certificate corresponds to the domain name of the server with which a client is attempting to communicate—in addition to checking the validity of the certificate by performing the other steps described in [“Server Authentication During SSL Handshake” on page 105](#)

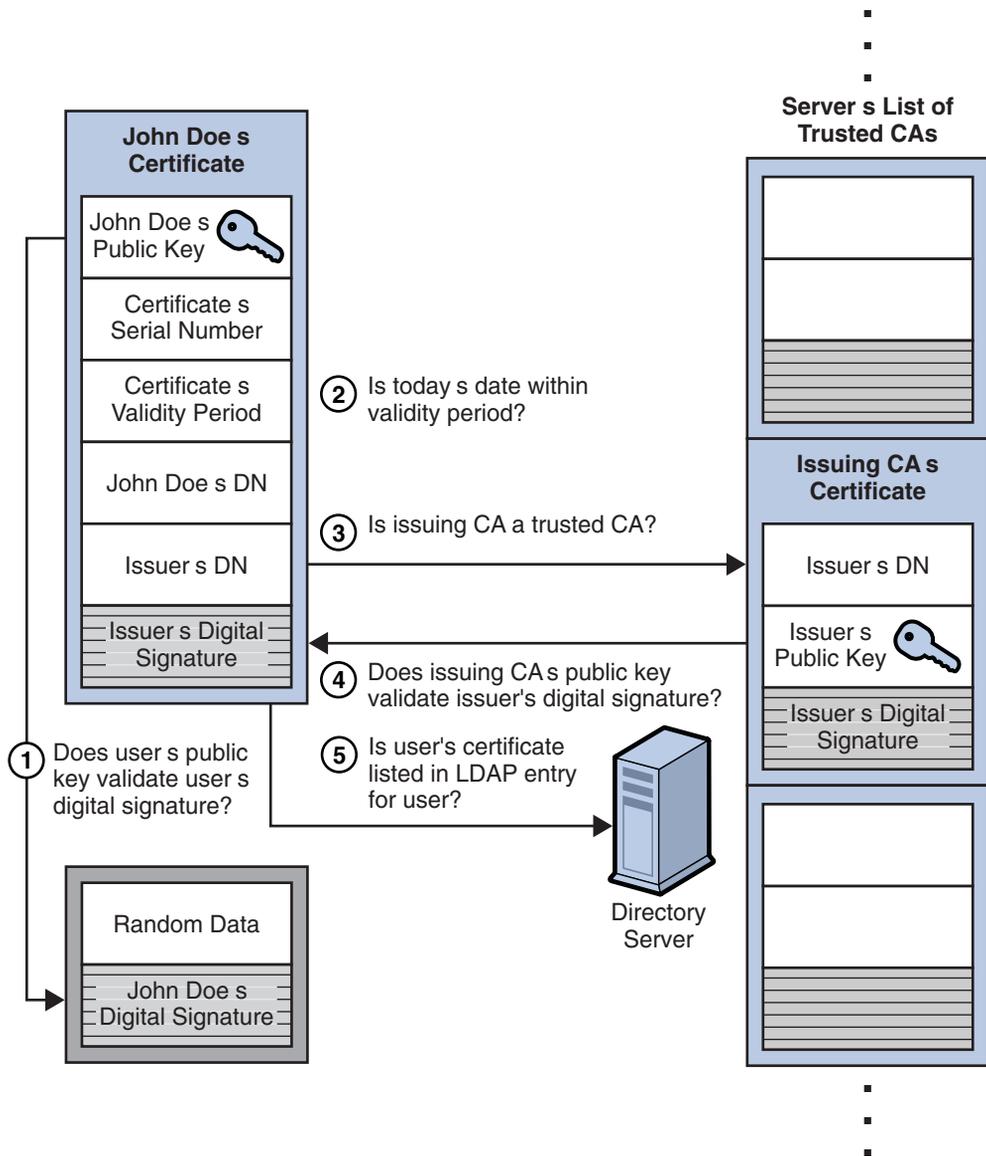
Client Authentication During SSL Handshake

SSL-enabled servers can be configured to require client authentication, or cryptographic validation by the server of the client's identity. When a server configured this way requests client authentication separate piece of digitally signed data to authenticate itself. The server uses the digitally signed data to validate the public key in the certificate and to authenticate the identity the certificate claims to represent.

The SSL protocol requires the client to create a digital signature by creating a one-way hash from data generated randomly during the handshake and known only to the client and server. The hash of the data is then encrypted with the private key that corresponds to the public key in the certificate being presented to the server.

To authenticate the binding between the public key and the person or other entity identified by the certificate that contains the public key, an SSL-enabled server must receive a yes answer to the first four questions shown in [Figure 5–10](#). Although the fifth question is not part of the SSL protocol, directory servers can be configured to support this requirement to take advantage of the user entry in an LDAP directory as part of the authentication process.

FIGURE 5-10 Authentication and Verification During SSL Handshake



An SSL-enabled server goes through the following steps to authenticate a user's identity:

1. Does the user's public key validate the user's digital signature?

The server checks that the user's digital signature can be validated with the public key in the certificate. If so, the server has established that the public key asserted to belong to John Doe matches the private key used to create the signature and that the data has not been tampered with since it was signed.

At this point, however, the binding between the public key and the DN specified in the certificate has not yet been established. The certificate might have been created by someone attempting to impersonate the user. To validate the binding between the public key and the DN, the server must also complete steps 3 and 4 in this list.

2. Is today's date within the validity period?

The server checks the certificate's validity period. If the current date and time are outside of that range, the authentication process won't go any further. If the current date and time are within the certificate's validity period, the server goes onto the next step.

3. Is the issuing CA a trusted CA?

Each SSL-enabled server maintains a list of trusted CA certificates, represented by the shaded area on the right—hand side of [Figure 5-10](#). This list determines which certificates the server accepts. If the DN of the issuing CA matches the DN of a CA on the server's list of trusted CAs, the answer to this question is yes, and the server goes on to the next step. If the issuing CA is not on the list, the client is not authenticated unless the server can verify a certificate chain ending in a CA that is trusted or not trusted within their organizations by controlling the lists of CA certificates maintained by clients and servers.

4. Does the issuing CA's public key validate the issuer's digital signature?

The server uses the public key from the CA's certificate (which it found in its list of trusted CAs in the previous step) to validate the CA's digital signature on the certificate being presented. If the information in the certificate has changed since it was signed by the CA or if the public key in the CA certificate doesn't correspond to the private key used by the CA to sign the certificate, the server won't authenticate the user's identity. If the CA's digital signature can be validated, the server treats the user's certificate as a valid "letter of introduction" from that CA and proceeds. At this point, the SSL protocol allows the server to consider the client authenticated and proceed with the connection as described in step 6. The directory servers may optionally be configured to perform step 5 before step 6.

5. Is the user's certificate listed in the LDAP entry for the user?

This optional step provides one way for a system administrator to revoke a user's certificate even if it passes the tests in all the other steps. The Certificate Management System can automatically remove a revoked certificate from the user's entry in the LDAP directory. All servers that are set up to perform this step then refuses to authenticate that certificate or establish a connection. If the user's certificate in the directory is identical to the user's certificate presented in the SSL handshake, the server goes on to the next step.

6. Is the authenticated client authorized to access the requested resources?

The server checks what resources the client is permitted to access according to the server's access control lists (ACLs) and establishes a connection with appropriate access. If the server doesn't get to step 6 for any reason, the user identified by the certificate cannot be authenticated, and the user is not allowed to access any server resources that require authentication.

Digital Signatures

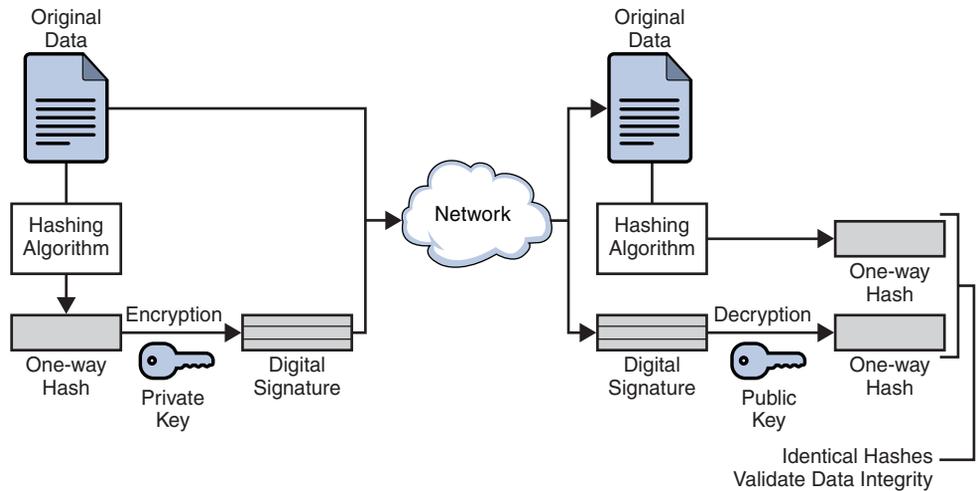
Digital signatures can be used by Directory Server to maintain integrity of information. If encryption and message digests are applied to the information being sent, the recipient can determine that the information was not tampered with during transit.

Tamper detection and related authentication techniques rely on a mathematical function called a *one-way hash*. This function is also called a *message digest*. A one-way hash is a number of fixed length with the following characteristics:

- The value of the hash is unique for the hashed data. Any change in the data, even deleting or altering a single character, results in a different value.
- The content of the hashed data cannot, for all practical purposes, be deduced from the hash — which is why it is called *one-way*.

It is possible to use a private key for encryption and a public key for decryption. Although this is not desirable when you are encrypting sensitive information, it is a crucial part of digitally signing any data. Instead of encrypting the data itself, the signing software creates a one-way hash of the data, then uses your private key to encrypt the hash. The encrypted hash, along with other information, such as the hashing algorithm, is known as a digital signature. [Figure 5–11](#) shows two items transferred to the recipient of some signed data.

FIGURE 5-11 Digital Signatures



In [Figure 5-11](#), the original data and the digital signature, which is basically a one-way hash (of the original data) that has been encrypted with the signer's private key. To validate the integrity of the data, the receiving software first uses the signer's public key to decrypt the hash. It then uses the same hashing algorithm that generated the original hash to generate a new one-way hash of the same data. (Information about the hashing algorithm used is sent with the digital signature, although this isn't shown in the figure.) Finally, the receiving software compares the new hash against the original hash. If the two hashes match, the data has not changed since it was signed. If they don't match, the data may have been tampered with since it was signed, or the signature may have been created with a private key that doesn't correspond to the public key presented by the signer.

If the two hashes match, the recipient can be certain that the public key used to decrypt the digital signature corresponds to the private key used to create the digital signature. Confirming the identity of the signer, however, also requires some way of confirming that the public key really belongs to a particular person or other entity.

The significance of a digital signature is comparable to the significance of a handwritten signature. Once you have signed some data, it is difficult to deny doing so later — assuming that the private key has not been compromised or out of the owner's control. This quality of digital signatures provides a high degree of non-repudiation — that is, digital signatures make it difficult for the signer to deny having signed the data. In some situations, a digital signature may be as legally binding as a handwritten signature.

Key Encryption

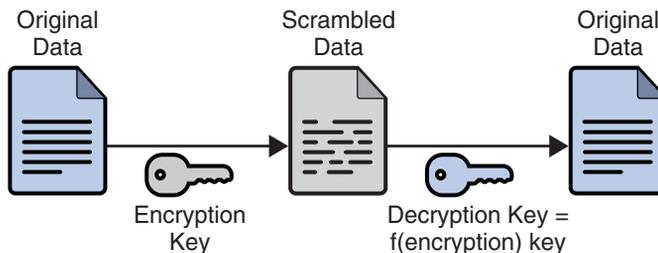
With most modern cryptography, the ability to keep encrypted information secret is based not on the cryptographic algorithm, which is widely known, but on a *key*. A key is a number that must be used with the algorithm to produce an encrypted result or to decrypt previously encrypted information. For information about encryption and decryption with keys, see the following sections:

- “Symmetric-Key Encryption” on page 114
- “Public-Key Encryption” on page 115
- “Key Length and Encryption Strength” on page 116

Symmetric-Key Encryption

With symmetric-key encryption, the encryption key can be calculated from the decryption key, and vice versa. With most symmetric algorithms, the same key is used for both encryption and decryption. The following figure shows a symmetric-key encryption.

FIGURE 5-12 Symmetric-Key Encryption



Implementations of symmetric-key encryption can be highly efficient, so that users do not experience any significant time delay as a result of the encryption and decryption. Symmetric-key encryption also provides a degree of authentication, since information encrypted with one symmetric key cannot be decrypted with any other symmetric key. Thus, as long as the symmetric key is kept secret by the two parties using it to encrypt communications, each party can be sure that it is communicating with the other as long as the decrypted messages continue to make sense.

Symmetric-key encryption is effective only if the symmetric key is kept secret by the two parties involved. If anyone else discovers the key, it affects both confidentiality and authentication. A person with an unauthorized symmetric key not only can decrypt messages sent with that key, but can encrypt new messages and send them as if they came from one of the two parties who were originally using the key.

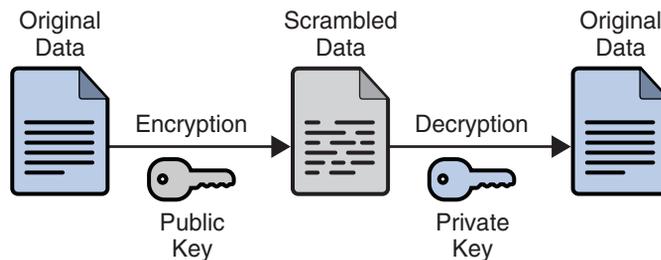
Symmetric-key encryption plays an important role in the SSL protocol, which is widely used for authentication, tamper detection, and encryption over TCP/IP networks. SSL also uses techniques of public-key encryption, which is described in the next section.

Public-Key Encryption

The most commonly used implementations of public-key encryption are based on algorithms patented by RSA Data Security. Therefore, this section describes the RSA approach to public-key encryption.

Public-key encryption (also called asymmetric encryption) involves a pair of keys—a public key and a private key—associated with an entity that needs to authenticate its identity electronically or to sign or encrypt data. Each public key is published, and the corresponding private key is kept secret. The following figure shows a simplified view of the way public-key encryption works.

FIGURE 5-13 Public-Key Encryption



Public-key encryption lets you distribute a public key, and only you can read data encrypted by this key. In general, to send encrypted data to someone, you encrypt the data with that person's public key, and the person receiving the encrypted data decrypts it with the corresponding private key.

Compared with symmetric-key encryption, public-key encryption requires more computation and is therefore not always appropriate for large amounts of data. However, it's possible to use public-key encryption to send a symmetric key, which can then be used to encrypt additional data. This is the approach used by the SSL protocol.

As it happens, the reverse of the scheme shown in [Figure 5-13](#) also works: data encrypted with your private key can be decrypted with your public key only. This would not be a desirable way to encrypt sensitive data, however, because it means that anyone with your public key, which is by definition published, could decrypt the data. Nevertheless, private-key encryption is useful, because it means you can use your private key to sign data with your digital signature—an important requirement for electronic commerce and other commercial applications of cryptography. Client software can then use your public key to confirm that the message was

signed with your private key and that it hasn't been tampered with since being signed. [“Digital Signatures” on page 112](#) and subsequent sections describe how this confirmation process works.

Key Length and Encryption Strength

The strength of encryption is related to the difficulty of discovering the key, which in turn depends on both the cipher used and the length of the key. For example, the difficulty of discovering the key for the RSA cipher most commonly used for public-key encryption depends on the difficulty of factoring large numbers, a well-known mathematical problem.

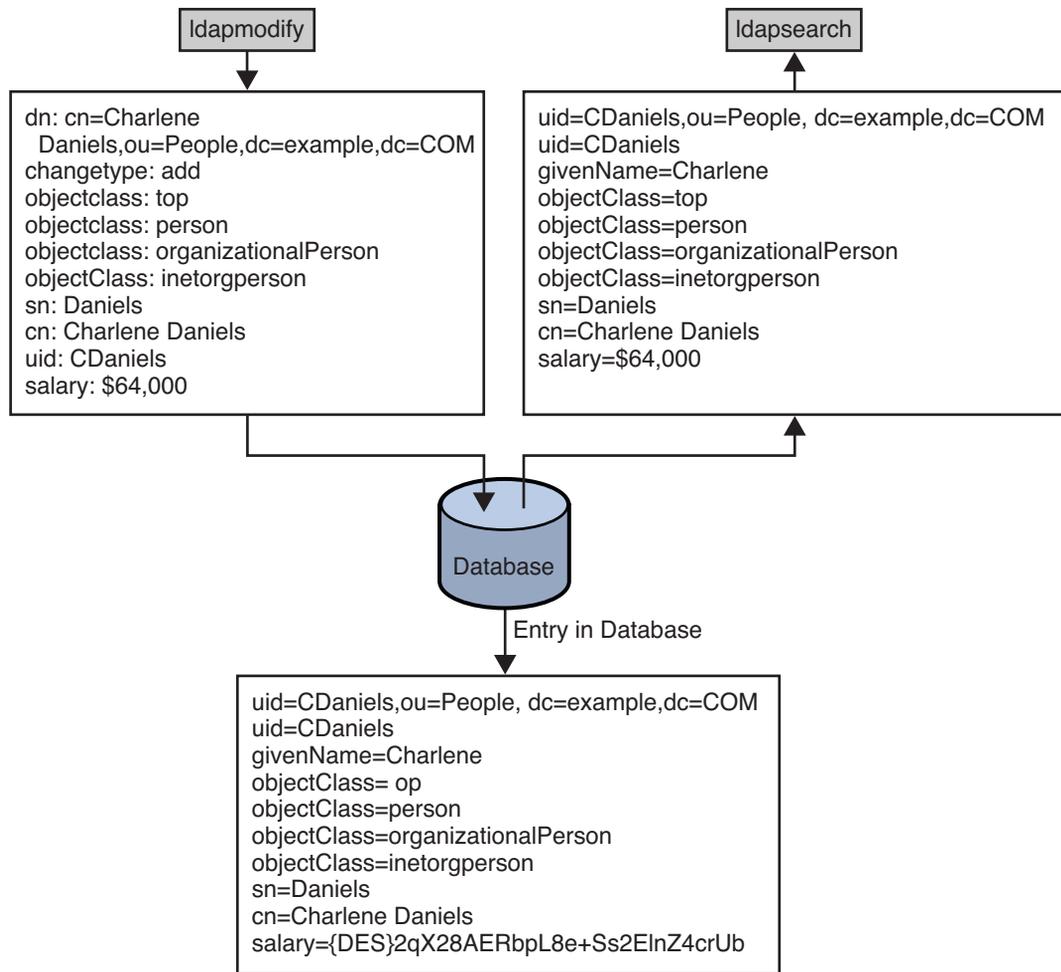
Encryption strength is often described in terms of the size of the keys used to perform the encryption: in general, longer keys provide stronger encryption. Key length is measured in bits. For example, 128-bit keys for use with the RC4 symmetric-key cipher supported by SSL provide significantly better cryptographic protection than 40-bit keys for use with the same cipher. Roughly speaking, 128-bit RC4 encryption is 3×10^{26} times stronger than 40-bit RC4 encryption.

Different ciphers may require different key lengths to achieve the same level of encryption strength. The RSA cipher used for public-key encryption, for example, can use only a subset of all possible values for a key of a given length, due to the nature of the mathematical problem on which it is based. Other ciphers, such as those used for symmetric key encryption, can use all possible values for a key of a given length, rather than a subset of those values. Thus a 128-bit key for use with a symmetric-key encryption cipher would provide stronger encryption than a 128-bit key for use with the RSA public-key encryption cipher. This difference explains why the RSA public-key encryption cipher must use a 512-bit key (or longer) to be considered cryptographically strong, whereas symmetric key ciphers can achieve approximately the same level of strength with a 64-bit key. Even this level of strength may be vulnerable to attacks in the near future.

Attribute Encryption

Attribute encryption enables sensitive attributes of an entry to be stored in encrypted form. By encrypting sensitive attributes, you can prevent them from being read while the data is stored in database files, backup files, or exported LDIF files, or while the data is exported. [Figure 5-14](#) shows a user entry being added to the database, where attribute encryption has been configured to encrypt the salary attribute.

FIGURE 5-14 Attribute Encryption



The attribute encryption feature supports a wide range of encryption algorithms and different platforms. Attribute encryption uses the private key of the server's SSL certificate to generate its own key. This key is then used to perform the encryption and decryption operations.

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. To encrypt an attribute in an entire directory, you must enable encryption for that attribute in every 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.

Encrypting the userPassword attribute provides no security benefit unless the password needs to be stored in clear text, 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.

When encrypted attributes are stored, they are prefaced with a cipher tag that indicates what encryption algorithm has been used. An encrypted attribute using the DES encryption algorithm would appear as follows:

```
{CKM_DES_CBC}3hakc&j la+=snda%
```

While attribute encryption offers increased data security, the feature does impact performance. You should think carefully about which attributes require encryption and encrypt only those attributes that are particularly sensitive. Because sensitive data can be accessed directly through index files, it is necessary to encrypt the index keys corresponding to the encrypted attributes, to ensure that the attributes are fully protected.

For information about how to encrypt attributes, see [“Encrypting Attribute Values”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Directory Server Monitoring

For information about monitoring Directory Server, see the following sections.

- “Ways to Monitor Directory Server” on page 119
- “Directory Server and SNMP” on page 120
- “Directory Server and CMM/JMX” on page 122
- “Directory Server Monitoring Attributes” on page 123

Ways to Monitor Directory Server

Directory Server can be monitored in the following ways:

Directory Service Control Center

Directory Service Control Center, DSCC, can be used to monitor current activities of a Directory Server instance.

DSCC provides general server information, including a resource summary, current resource usage, connection status, and global database cache information. It also provides general database information, such as the database type, status, and entry cache statistics. Cache information and information relative to each index file within the database is also provided. In addition, DSCC provides information relative to the connections and the operations performed on each chained suffix.

Command line

The `dsconf` command can be used to configure logging and to monitor the replication status of Directory Server. For information about how to configure logging, see “Configuring Logs for Directory Server” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*. For information about how to use the `dsconf` command for monitoring, see “Getting Replication Status by Using the Command Line” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

The `ldapsearch` command can be used to search the `cn=monitor` entry for information about current activities of a Directory Server instance. For information about `cn=monitor`, see “[Directory Server Monitoring Attributes](#)” on page 123.

Log analyzer tool

The Directory Server Resource Kit provides a log analyzer tool called `logconv(1)`.

The `logconv` tool extracts usage statistics and counts the occurrences of significant events in the access logs.

Java Management Extensions, JMX

Directory Server exposes management information through JMX according to the Common Monitoring Information and Data Model. See the *Sun Java Enterprise System 5 Update 1 Monitoring Guide* for details.

Java ES Monitoring Framework, Java ES MF, provides an JMX entry point to retrieve data. For information about the JMX entry points exposed for monitoring Directory Server, see “[Directory Server and SNMP](#)” on page 120.

Simple Network Management Protocol, SNMP

Directory Server exposes management information through SNMP. See the *Sun Java Enterprise System 5 Update 1 Monitoring Guide* for details.

Java ES MF provides an SNMP entry point to retrieve SNMP data. For information about the SNMP entry points exposed for monitoring Directory Server, see “[Directory Server and SNMP](#)” on page 120.

Simple Object Access Protocol, SOAP

Java ES MF provides a SOAP entry point to retrieve data. See the *Sun Java Enterprise System 5 Update 1 Monitoring Guide* for details.

Directory Server and SNMP

Directory Server implements the `dsTable` and the `dsAppLIfoptsTable` of the Directory Server Monitoring MIB defined by RFC 2605 (<http://www.ietf.org/rfc/rfc2605.txt>). It does not implement the `dsIntTable`.

Directory Server also implements the Network Services Monitoring MIB defined by RFC 2788 (<http://www.ietf.org/rfc/rfc2788.txt>).

Directory Server support for SNMP has the following limitations.

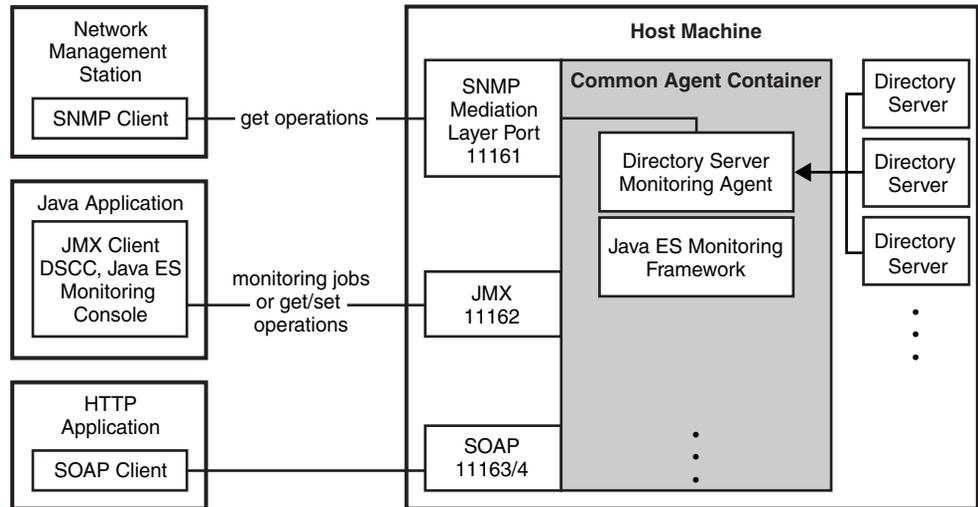
- SNMP support is for monitoring only, no SNMP management is supported.
- No SNMP traps are implemented.

This rest of this section explains how the information flows from the monitoring application to Directory Server and back, particularly in the case where you use SNMP.

The SNMP interface is exposed by Java ES MF. See the *Sun Java Enterprise System 5 Update 1 Monitoring Guide* for details.

The monitoring framework is contained within the Common Agent Container, cacao, which is installed alongside Directory Server. [Figure 6–1](#) shows the monitoring framework.

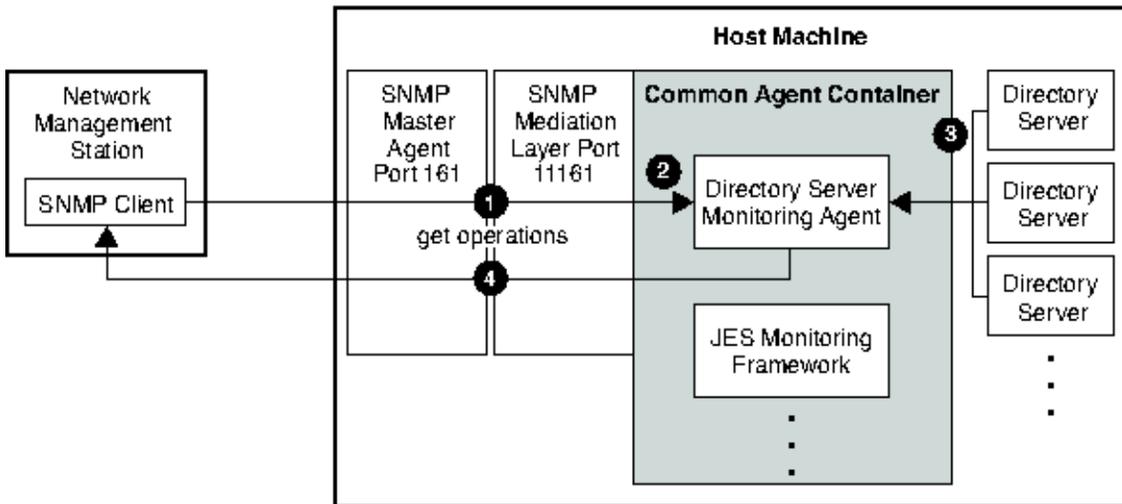
FIGURE 6–1 Overall Monitoring Information Flow



SNMP support for monitoring Directory Server is managed by a Directory Server agent in the Common Agent Container. On Directory Server startup, the Monitoring server plug-in registers the Directory Server instance with the Directory Server agent within the Common Agent Container.

[Figure 6–2](#) shows how SNMP information about Directory Server flows through the Common Agent Container.

FIGURE 6-2 SNMP Information Flow



SNMP information about Directory Server flows as follows.

1. The network management station sends a GET message through the master SNMP agent, which by default uses standard port 161, to the SNMP mediation layer, which by default uses port 11161.
For information about how to configure access to the SNMP mediation layer, see the [Sun Java Enterprise System 5 Update 1 Monitoring Guide](#).
2. The SNMP mediation layer forwards any requests destined for the Directory Server to the Directory Server agent.
3. When the server state changes, Directory Server pushes SNMP information to the Directory Server agent.
4. The Directory Server agent relays the response back to the SNMP client via the SNMP mediation layer and master SNMP agent to the network management station. The network management station then displays the data through its network management application.

Directory Server and CMM/JMX

Directory Server supports monitoring through JMX, which is exposed by Java ES MF. See the [Sun Java Enterprise System 5 Update 1 Monitoring Guide](#) for details on the interface itself.

The monitoring framework is contained within the Common Agent Container, cacao, which is installed alongside Directory Server. [Figure 6-1](#) shows the monitoring framework. The information flow for JMX is similar to the flow shown for SNMP in [Figure 6-2](#).

The monitoring information exposed through JMX is organized according to the Common Monitoring Information and Data Model, CMM. CMM allows applications exposing their monitoring information to associate human-readable descriptions with the individual counters and other information. CMM is therefore meant to be self-documenting. Directory Server implements the following CMM classes.

- CMM_ApplicationSystem
- CMM_ApplicationSystemSetting
- CMM_ApplicationSystemStats
- CMM_InstalledProduct
- CMM_RFC2605ApplicationSystemSettings
- CMM_RFC2605ApplicationSystemStats
- CMM_RFC2605ServiceAccessURIStats
- CMM_ServiceAccessBySAP
- CMM_ServiceAccessBySAPStats
- CMM_ServiceAccessURI
- CMM_ServiceAccessURIStats

When examining the content of the monitoring information, notice that CMM_ServiceAccessURI is implemented not only for LDAP and for LDAPS, but also for DSML/HTTP or DSML/HTTPS if the DSML front end has been enabled.

Java ES Monitoring Console offers a browser-based user interface to examine the information exposed. See the [Sun Java Enterprise System 5 Update 1 Monitoring Guide](#) for instructions on preparing the Monitoring Console for use.

Directory Server Monitoring Attributes

Server status, replication status, resource usage, and other monitoring information is available through DSCC.

Alternatively, you can monitor the 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

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.

cn=monitor

The `cn=monitor` entry is an instance of the `extensibleObject` object class. For `cn=monitor` configuration attributes to be taken into account by the server, this object class, in addition to the top object class, is present in the entry. The `cn=monitor` read-only attributes are presented in this section.

Read-only monitoring information is stored under the `cn=monitor` entry.

backendMonitorDN

DN for each Directory Server backend.

For further database monitoring information, refer to [dse.ldif\(4\)](#).

bytesSent

Number of bytes sent by Directory Server.

cache-avail-bytes

The number of bytes available for caching.

connection

List of open connections given in the following format:

```
connection=31:20010201164808Z:45:45::cn=admin,cn=Administrators,cn=config:LDAP
```

- 31 is number of the file descriptor used by the server in handling the connection
- 20010201164808Z is the date the connection was opened
- 45 is the number of operations received
- 45 is the number of completed operations
- `cn=admin,cn=Administrators,cn=config` is the bind DN

connectionPeak

Maximum number of simultaneous connections since server startup.

currentConnections

Number of current Directory Server connections.

currentTime

Current time usually given in Greenwich Mean Time, indicated by `GeneralizedTime` syntax Z notation, for example `20010202131102Z`.

dTableSize

Size of the Directory Server descriptor table.

entriesSent

Number of entries sent by Directory Server.

nbackEnds

Number of Directory Server backends.

opsCompleted

Number of Directory Server operations completed.

opsInitiated

Number of Directory Server operations initiated.

request-queue-backlog

The number of requests waiting to be processed by a thread. Each request received by the server is accepted, then placed in a queue until a thread is available to process it. The queue backlog should always be small, 0 or close to 0. If the queue backlog is large, use the `nsslapd-threadnumber` attribute to increase the number of threads available in the server.

readWaiters

Number of connections where some requests are pending and not currently being serviced by a thread in Directory Server.

currentpsearches

Number of persistent searches currently running on the server. You can set a maximum number of persistent searches on the server by using the command `dsconf set -server-prop max-psearch-count :number`.

startTime

Directory Server start time.

threads

Number of operation threads Directory Server creates during startup. This attribute can be set using the `nsslapd-threadnumber` attribute under `cn=config`. The `nsslapd-threadnumber` attribute is not present in the configuration by default, but can be added.

totalConnections

Total number of Directory Server connections.

version

Directory Server version and build number.

cn=disk,cn=monitor

The `cn=disk` entry enables you to monitor disk conditions over LDAP. This entry is an instance of the `extensibleObject` object class. A `cn=disknumber`, `cn=disk`, `cn=monitor` entry exists for each disk. The following disk monitoring attributes appear under each of these individual disk entries.

disk-dir

Specifies the pathname of a directory used by the server on disk. Where several database instances reside on the same disk or an instance refers to several directories on the same disk, the short pathname is displayed. The disk numbering is arbitrary.

disk-free

Indicates the amount of free disk space available to the server, in MB.

Note – The disk space available to the server process may be less than the total free disk space. For example, on some platforms a process that is not running as root may not have all the free disk space available to it.

disk-state

Indicates the state of the disk, based on the available free space and on the thresholds set for disk low and disk full with the configuration parameters `nsslapd-disk-low-threshold` and `nsslapd-disk-full-threshold`. Possible values are `normal`, `low`, and `full`.

cn=counters,cn=monitor

This entry holds counter information for the various subtree entry counter plug-ins, if they are enabled.

cn=monitor,cn=Class of Service,cn=plugins, cn=config

This entry holds counters related to the Class of Service plug-in. This entry is an instance of the `extensibleObject` object class.

classicHashAvgClashListLength

When the CoS plug-in uses the hash table for fast lookup, if more than one classic CoS template corresponds to the hash key used, the plug-in next checks for matches in what is called the clash list, a list of templates sharing an identical hash key. The value of this attribute provides the average length across all hash tables of classic CoS template clash lists, giving some indication of how much linear searching the plug-in must perform after using the hash table during fast lookup.

classicHashAvgClashPercentagePerHash

The average number of clashes per hash table. That is, the average percentage per hash of classic CoS templates sharing an identical hash key.

classicHashMemUsage

The memory overhead in bytes to hold hash tables for fast classic CoS template lookups.

classicHashValuesMemUsage

The memory in bytes used to hold hash values for fast classic CoS template lookups.

numClassicDefinitions

The number of classic CoS definition entries in use.

numClassicHashTables

The number of hash tables created for fast lookup where more than 10 classic CoS templates apply for a single CoS definition. Hash tables are not created for smaller lists of templates.

numClassicTemplates

The number of classic CoS template entries in use.

numCoSAttributeTypes

The number of distinct attributes with values calculated through CoS.

numIndirectDefinitions

The number of indirect CoS definition entries in use.

numPointerDefinitions

The number of pointer CoS definition entries in use.

numPointerTemplates

The number of pointer CoS template entries in use.

Directory Server Replication

This chapter includes the following sections:

- [“Introduction to Replication” on page 129](#)
- [“Replication and the Retro Change Log Plug-In” on page 137](#)

Introduction to Replication

Replication is a topology wide feature that always involves more than one participant.

Replication works as follows:

1. A master receives a change. Once the change has been applied to the entry in the database, then because the server is a master, it stores the change in the change log database.
2. The master updates its Replica Update Vector (RUV).
3. The master notifies the replication threads that a new change has been recorded in the change log.
4. These replication threads contact replication partners to propagate the information.

For example, Master 1 receives a change, applies it to the entry and updates its change log. When master 1 contacts the consumer, the consumer shows that master replica its RUV. The master looks at the RUV and compares it with its own RUV to see if it contains more recent changes than the consumer. If, for example, it sees that the consumer contains a higher RUV, it does not send changes. If it contains a more recent change, it sends another request to the consumer asking for a lock on replica ID 1 so that it can make updates. If the lock is unavailable, the update will be made later. If the lock is available, then the master can proceed to make the change.

This introduction to replication addresses the following topics:

- [“Suppliers and Consumers” on page 130](#)
- [“Unit of Replication” on page 131](#)

- “Replica Identity” on page 131
- “Replication Agreements” on page 132
- “Types of Replica” on page 131
- “Replication Authentication” on page 133
- “Replication Change Log” on page 133
- “Change Sequence Number” on page 134
- “Replica Update Vector” on page 134
- “Deleted Entries: Tombstones” on page 136
- “Consumer Initialization and Incremental Updates” on page 136
- “Referrals and Replication” on page 137

Suppliers and Consumers

A Directory Server that replicates to other servers is called a *supplier*. A Directory Server that is updated by other servers is called a *consumer*. The supplier replays all updates on the consumer through specially designed LDAP v3 extended operations. In terms of performance, a supplier is therefore likely to be a demanding client application for the consumer.

A server can be both a supplier and a consumer, as in the following situations:

- In multi-master replication, a master replica is mastered on two different Directory Servers. Each server acts as a supplier and a consumer of the other server.
- When the server contains a hub replica, the server receives updates from a supplier and replicates the changes to consumers.

A server that plays the role of a consumer only is called a *dedicated consumer*.

For a *master replica*, the server must do the following:

- Respond to update requests from directory clients
- Maintain historical information and a change log
- Initiate replication to consumers

The server that contains the master replica is responsible for recording any changes made to the master replica and for replicating these changes to consumers.

For a *hub replica*, the server must do the following:

- Respond to read requests
- Refer update requests to the servers that contain a master replica
- Maintain historical information and a change log
- Initiate replication to consumers

For a *consumer replica*, the server must do the following:

- Respond to read requests
- Maintain historical information

- Refer update requests to the servers that contain a master replica

Unit of Replication

The smallest logical unit of replication is a *suffix*, also known as a naming context. The term suffix arises from the way the base DN for the naming context is a suffix for all DNs in that context. For example, the suffix `dc=example,dc=com` contains all directory entries in the `Example.com` naming context.

The replication mechanism requires one suffix to correspond to one database. The unit of replication applies to both suppliers and consumers. Therefore, two suffixes on a master replica cannot be replicated to one suffix on a consumer replica, and vice versa.

Replica Identity

Master replicas require a unique replica identifier that is a 16-bit integer between 1 and 65534. Consumer and hub replicas all have the replica ID of 65535. The replica ID identifies the replica on which changes are made.

If multiple suffixes are configured on one master, you can use the same replica ID for each suffix on the master. In this way, when a change is made on that replica ID, it is possible to identify the server on which change was made.

Types of Replica

A suffix that participates in replication is called a *replica*. There are three kinds of replica:

- A *master* replica is a read-write database that contains a master copy of the directory data. A master replica can perform the following tasks:
 - Respond to update requests and read requests from directory clients
 - Maintain historical information and a change log for the replica
 - Initiate replication to consumers or hubs
- A *consumer* replica is a read-only database that contains a copy of the information held in a master replica. A consumer replica can perform the following tasks:
 - Respond to read requests
 - Maintain historical information for the replica
 - Refer update requests to servers that contain a master replica
- A *hub* replica is a read-only database, like a consumer replica, but stored on a directory server that supplies one or more consumer replicas. A hub replica can perform the following tasks:
 - Respond to read requests

- Maintain historical information and a change log for the replica
- Initiate replication to consumers
- Refer update requests to servers that contain a master replica

A single instance of Directory Server can be configured to manage several replicas.

A replica can act as a supplier of updates, or a consumer of updates, or both.

- A *supplier* is a replica that copies information to another replica.

A master replica can be a supplier to a hub replica and a consumer replica. A hub replica can be a supplier to a consumer replica. In multi-master replication, one master replica can be a supplier to another master replica.

- A *consumer* is a replica that receives updates from another replica.

A hub replica and a consumer replica can be consumers of a master replica. A consumer replica can be a consumer of a hub replica. In multi-master replication, one master replica can be a consumer of another master replica.

A replica can be *promoted* or *demoted* to change its behavior with respect to other replicas.

Dedicated consumers can be promoted to hubs, and hubs can be promoted to masters. Masters can be demoted to hubs, and hubs can be demoted to dedicated consumers.

A server that contains a consumer replica only is called a *dedicated consumer*.

Replication Agreements

Replication agreements define the relationships between a supplier and a consumer. The replication agreement is configured on the supplier. A replication agreement contains the following replication parameters:

- The suffix to replicate.
- The consumer server to which the data is pushed.
- The replication schedule.
- The bind DN and credentials the master must use to bind to the consumer.
- How the connection is secured.
- Which attributes to exclude or include in fractional replication, if fractional replication is configured.
- The group and window sizes to configure the number of changes you can group into one request and the number of requests that can be sent before consumer acknowledgement is required.
- Information about the replication status for this agreement.
- The level of compression used in replication on Solaris and Linux systems.

Replication Authentication

Before a master can update a consumer, the consumer authenticates the master by using a special entry called the *Replication Manager entry*. The master uses the Replication Manager entry to bind to the consumer.

The Replication Manager entry has a special user profile that bypasses all access control rules defined on the consumer server. The special user profile is only valid in the context of replication.

The Replication Manager entry has the following characteristics.

- On a consumer server, the Replication Manager is the user who is allowed to perform updates. The entry for Replication Manager must be present for all replicas.
- The bind DN of the Replication Manager entry is set in the replication agreement. The bind DN must be configured for hubs, or masters to point to an existing Replication Manager entry.
- For initialization and security reasons, the Replication Manager entry cannot be part of the replicated data.

The Replication Manager entry is created by default when you configure replication through the browser-based interface Directory Service Control Center. You can also create your own Replication Manager entry. For information about how to create a Replication Manager entry, see “Using a Non-Default Replication Manager” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Authentication can be performed in the following ways for SSL with replication.

- For SSL server authentication, you must have a Replication Manager entry, and its associated password, in the server you are authenticating to.
- For SSL client authentication, you must have an entry that contains a certificate in the server you are authenticating to. This entry may or may not be mapped to the Replication Manager entry.

Replication Change Log

All modifications received by a master replica are recorded in a change log. A change log is maintained on all master replicas and hub replicas.

If your application needs to read the change log, use the retro change log plug-in for backward compatibility. For more information about the retro change log plug-in, see “[Replication and the Retro Change Log Plug-In](#)” on page 137.

Change Sequence Number

Each change to a master replica is identified by a change sequence number, CSN. The CSN is generated by the master server and is not visible to the client application. The CSN contains the timestamp, a sequence number, the replica ID, and a subsequence number. The change log is ordered by the CSN.

Replication is sequential, meaning that entries are replicated in an orderly way. Because replication is orderly, any change generated by a master is labeled by a change sequence number (CSN) that is unique for any change inside a multi-master topology. The CSN is a hexadecimal string that appears in the logs as follows:

```
41e6ee93000e00640000
```

The first 8 hexa-digits represent the time when the change was generated in the master. The time is represented in seconds since January 1, 1970.

The next four digits are the sequence number, or the order in the current second in which the change occurred. For example, multiple changes occur in second 41e6ee93. The sequence number tells us the progressive numbering of the change.

The next four digits specify the replica ID of the master that received the change in the first place.

The last four digits are reserved. Most of the time, they are 0000.

CSNs are generated only when local traffic introduces a new change to a replica. So only masters that receive updates generate CSNs. Consumers always refer to masters, because all the updates they receive are through replication.

Replica Update Vector

The replica update vector, RUV, identifies the state of each replica in a topology. Stored on the supplier and on the consumer, the RUV is used to establish which changes need to be replicated. The RUV stores the URL of the supplier, the ID of the supplier, the minimum CSN, and the maximum CSN.

Any replica in a replication topology stores its current replication state in a replica update vector (RUV). The RUV is stored in memory by a process that is running and provides the exact knowledge this replica has of itself and every other participant in the replication topology. The RUV entry on a given server contains a line for each master participating in a replication topology. Each line contains an identifier of one of the masters, the URL of the replica, and the CSN of the first and last changes made on the server. The CSN records only the first and last changes known by the server, not necessarily the most recent changes made by the master.

The RUV is mainly in memory and can be accessed using `ldapsearch` on the `cn=replica,cn=suffix,cn=mapping tree,cn=config` entry. For example, an `ldapsearch` for the `ou=people` suffix might yield the following results:

```
# ldapsearch -h host1 -p 1389 -D "cn=Directory Manager" -w secret \
-b "cn=replica,cn=ou=people,cn=mapping tree,cn=config" \
-s base objectclass=* nsds50ruv

nsds50ruv: {replicageneration} 45e8296c000000010000
nsds50ruv: {replica 1 ldap://server1:1389} 45ed8751000000010000 4600f252000000010000
nsds50ruv: {replica 2 ldap://server1:2389} 45eec0e1000000020000 45f03214000000020000
```

For clarity, we will simplify the RUV syntax to `CSNchange-number-replicaID`. The *change-number* shows which change the RUV corresponds to in the successive changes that occurred on the master. For example, `45ed8751000000010000` can be written as `CSN05-1`. In the previous illustration, master 1 contains the following RUVs:

```
replica 1: CSN05-1 CSN43-1
replica 2: CSN05-2 CSN40-2
```

The first line provides information about the first change and the last change that this replica knows about from itself, master 1, as indicated by the replica ID 1. The second line provides information about the first change and the last change that it knows about from master 2. The information that is most interesting to us is the last change. In normal operations, master 1 should know more about the updates it received than master 2. We confirm this by looking at the RUV for master 2:

```
replica 2: CSN05-2 CSN50-2
replica 1: CSN01-1 CSN35-1
```

Looking at the last change, we see that master 2 knows more about the last change it received (`CSN50-2`) than master 1 (which shows the last change as having occurred at `CSN40-2`). By contrast, master 1 knows more about its last change (`CSN43-1`) than master 2 (`CSN35-1`).

When troubleshooting problems with replication, the CSNs can be useful in identifying the problem. Master 1 should always know at least as much about its own replica ID as any other participant in the replication topology because the change was first applied on master 1 and then replicated. So, `CSN43-1` should be the highest value attributed to replica ID 1 in the topology.

A problem is identified if, for example, after 30 minutes the RUV on master 1 is still `CSN40-2` but on master 2 the RUV has increased significantly to `CSN67-2`. This indicates that replication is not happening from master 2 to master 1.

If a failure occurs and you need to reinitialize the topology while saving as much data as possible, you can use the RUV picture to determine which machine contains the most recent changes. For example, in the replication topology described previously you have a hub that contains the following RUV:

2: CSN05-2 CSN50-2
1: CSN05-1 CSN43-1

In this case, server 1 seems like a good candidate for providing the most recent changes.

RUVs can be read through `nsds50ruv(5dsconf)` and `ds6ruv(5dsconf)` attributes.

Deleted Entries: Tombstones

Directory entries deleted on one replica are maintained by Directory Server until no longer needed for replication. Such deleted entries are called tombstones, as they have `objectclass: nsTombstone`. In rare cases, you might need to remove tombstones manually over LDAP.

Tombstones are visible only to Directory Manager. Furthermore, tombstones show up only in a search with filter `(objectclass=nsTombstone)`. The following `ldapsearch` command returns tombstone entries under `dc=example,dc=com`.

```
$ ldapsearch -D "cn=Directory Manager" -b dc=example,dc=com "(objectclass=nsTombstone)"
```

Consumer Initialization and Incremental Updates

During consumer initialization, or total update, all data is physically copied from a master to a consumer. When you have created a replication agreement, the consumer defined by that agreement must be initialized. When a consumer has been initialized, the master can begin to replay, or replicate, update operations to the consumer. Under normal circumstances, the consumer should not require further initialization. However, if the data on a master is restored from a backup, it might be necessary to reinitialize the consumers that depend on that master.

In a multi-master replication topology, the default behavior of a read-write replica that has been re-initialized from a backup or from an LDIF file, is to refuse client update requests. By default, the replica remains in read-only mode until it is configured to accept updates again. You set the suffix property `rep1-accept-client-update-enabled` to on using the `dsconf set-suffix-prop` command when the oldest updates are on the read-only replica.

When a consumer has been initialized, replication updates are sent to the consumer when the modifications are made on the supplier. These updates are called *incremental updates*. A consumer can be incrementally updated by several suppliers at once, provided that the updates originate from different replica IDs.

The *binary copy* feature can be used to clone master replicas or consumer replicas by using the binary backup files of one server to restore another server. For information about how to use binary copy for replication, see “[Initializing a Replicated Suffix by Using Binary Copy](#)” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Referrals and Replication

When a consumer receives a request to modify data, it *does not* forward the request to the server that contains the master replica. Instead, it returns to the client a list of the URLs of the masters that can satisfy the request. These URLs are called referrals.

The replication mechanism automatically configures consumers to return referrals for all known masters in the replication topology. However, you can also add your own referrals and overwrite the referrals set automatically by the server. The ability to control referrals helps enable you to perform the following tasks:

- Point referrals to secure ports only
- Point to a Directory Proxy Server instead for load balancing
- Redirect to local servers only in the case of servers separated by a WAN
- Limit referrals to a subset of masters in four-way multi-master topologies

Directory Proxy Server is able to follow referrals.

Replication and the Retro Change Log Plug-In

The retro change log is a plug-in used by LDAP clients for maintaining application compatibility with earlier versions of Directory Server. The retro change log is stored in a separate database from the Directory Server change log, under the suffix `cn=change log`.

A retro change log can be enabled on a standalone server or on each server in a replication topology. When the retro change log is enabled on a server, updates to all suffixes on that server are logged by default.

The retro changelog receives updates from all master replicas in the topology. The updates from each master replica are combined in the retro changelog. The retro changelog provides a way for applications to track changes so that they can be synchronized. Directory Server enables you to access a coherent version of the retro changelog on any master in a multi-master topology. You can also update your application to manage its state according to change numbers. This makes it possible to fail over between retro changelogs on different servers.

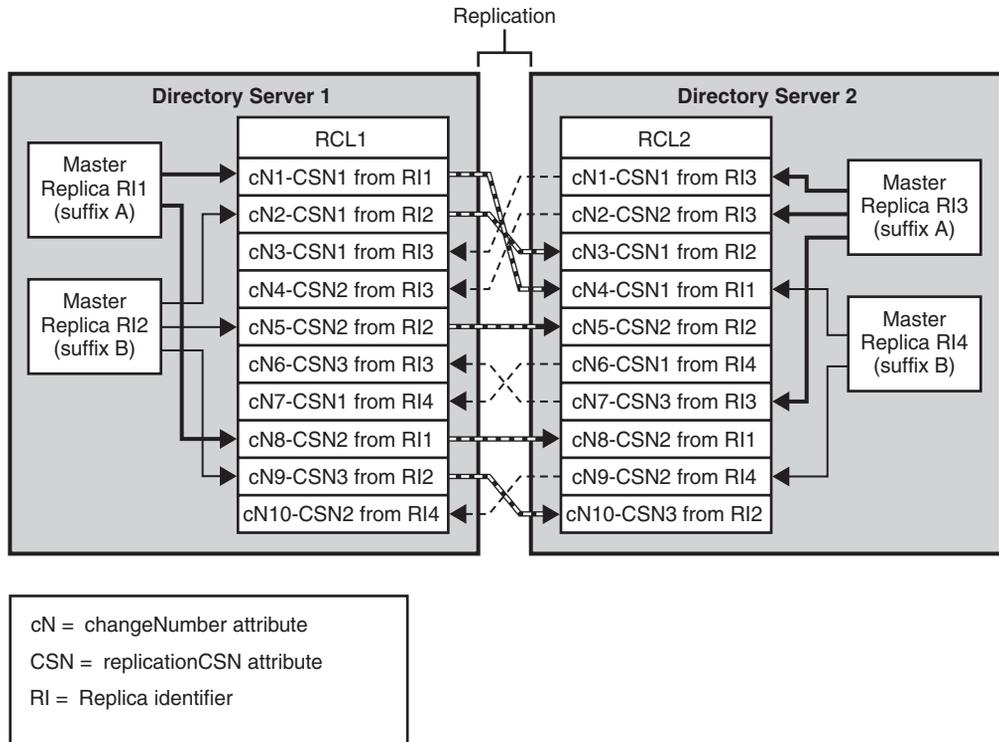
The global retro changelog contains all of the changes. If two changes occur on the same entry in two different locations, the retro changelog provides an ordered change description. If you query the retro changelog from any server, it will contain similar information.

For information about how to use the retro change log, see [“Using the Retro Change Log”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Retro Change Log and Multi-Master Replication

The following figure illustrates the retro change log on two servers in a multi-master topology.

FIGURE 7-1 Retro Change Log and Multi-Master Replication



The retro change log uses the following attributes during replication:

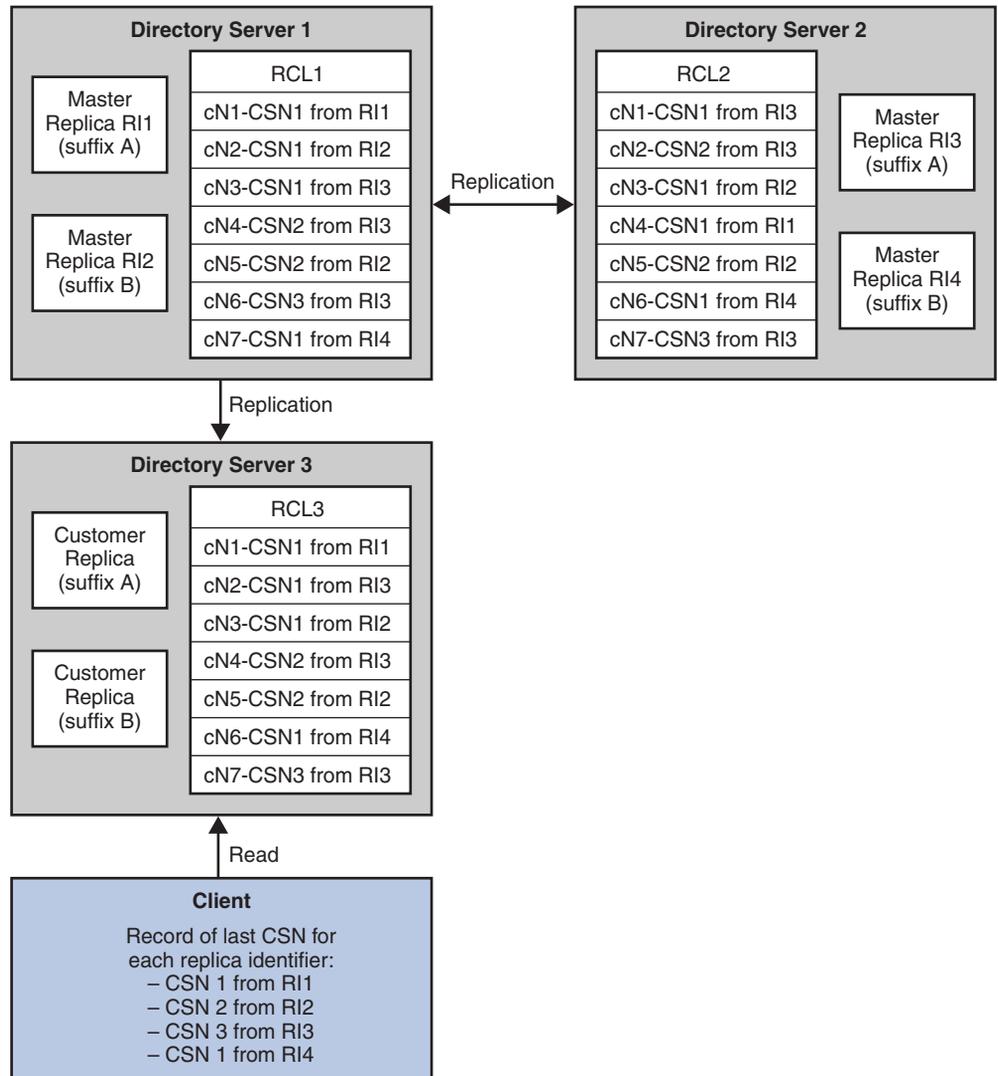
changeNumber (cN)	Identifies the order in which an update is logged to the retro change log
replicationCSN (CSN)	Identifies the time when an update is made to a given replica
replicaIdentifier (RI)	Identifies the replica that is updating the retro change log

The diagram shows that the retro change logs, RCL1 and RCL2, contain the same list of updates, but that the updates do not have the same order. However, for a given replicaIdentifier, updates are logged in the same order on each retro change log. The order in which updates are logged to the retro change log is given by the changeNumber attribute.

Failover of the Retro Change Log

The following figure illustrates a simplified replication topology where a client reads a retro change log on a consumer server.

FIGURE 7-2 Simplified Topology for Replication of the Retro Change Log

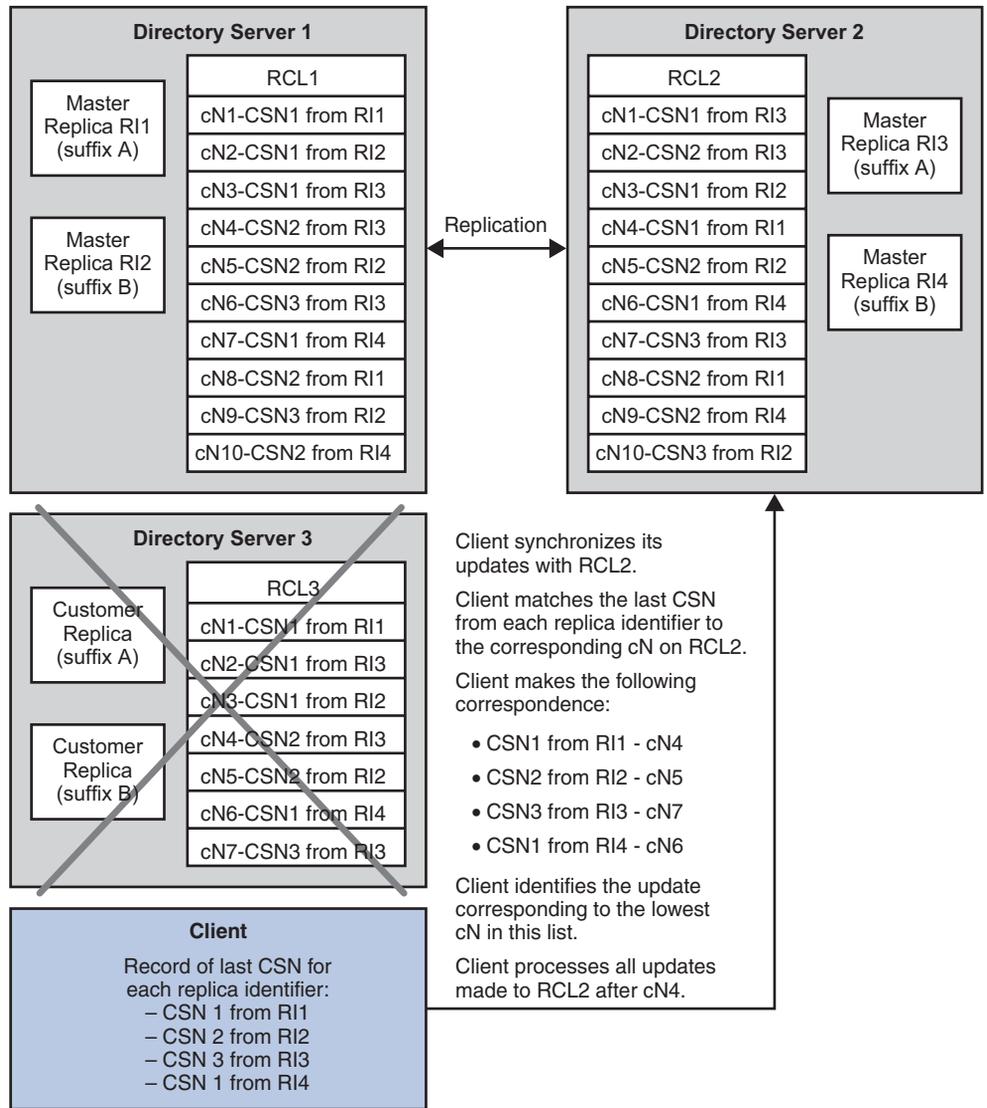


All of the updates made to each master replica in the topology are logged to each retro change log in the topology.

The client application reads the retro change log of Directory Server 3 and stores the last CSN for each replica identifier. The last CSN for each replica identifier is given by the `replicationCSN` attribute.

The following figure shows the client redirecting its reads to Directory Server 2 after the failure of Directory Server 3.

FIGURE 7-3 Failover of the Retro Change Log



After failover, the client application must use the retro change log (RCL2) of Directory Server 2 to manage its updates. Because the order of the updates in RCL2 is not the same as the order in RCL3, the client must synchronize its updates with RCL2.

The client examines RCL2 to identify the cN that corresponds to its record of the last CSN for each replica identifier. In the example in “Failover of the Retro Change Log” on page 139, the client identifies the following correspondence between last CSN and cN:

- CSN 1 from RI1 corresponds to cN4 on RCL2
- CSN 2 from RI2 corresponds to cN5 on RCL2
- CSN 3 from RI3 corresponds to cN7 on RCL2
- CSN 1 from RI4 corresponds to cN6 on RCL2

The client identifies the update corresponding to the lowest cN in this list. In the example in “[Failover of the Retro Change Log](#)” on page 139, the lowest cN in the list is cN4. To ensure that the client processes all updates, it must process all updates logged to RCL2 after cN4. The client does not process updates logged to RCL2 before cN4 nor does it process the update corresponding to cN4.

Replication Conflicts and the Retro Change Log

When a replication conflict occurs, Directory Server performs operations to resolve the conflict. When the retro change log is running and the `changeIsReplFixupOp` attribute is set to `true`, the following information about the operations is logged in the `changeHasReplFixupOp` attribute:

- Target DN of the operation
- The type of update
- The change made

For more information about these attributes, see the [Oracle Fusion Middleware Man Page Reference for Oracle Directory Server Enterprise Edition](#).

Restrictions on Using the Retro Change Log

In a replicated topology, the retro change logs on replicated servers must be up-to-date with each other. This allows switchover of the retro change log. Using the example in “[Failover of the Retro Change Log](#)” on page 139, the last CSN for each replica ID on RCL3 must be present on RCL2.

Directory Server Data Caching

For fast response time to client requests, Directory Server caches directory information in memory. If you must have top Directory Server performance, but cannot fit all directory data in available memory, you can tune cache settings to optimize performance.

This chapter covers what cache is.

Caches and How Directory Server Uses Them

This section describes the types of cache whose settings you can tune. It also describes how Directory Server uses those types of cache. This section covers the following topics:

- [“Types of Cache” on page 143](#)
- [“How Directory Server Performs Searches by Using Cache” on page 146](#)
- [“How Directory Server Performs Updates by Using the Cache” on page 148](#)
- [“How Directory Server Initializes a Suffix by Using the Cache” on page 150](#)

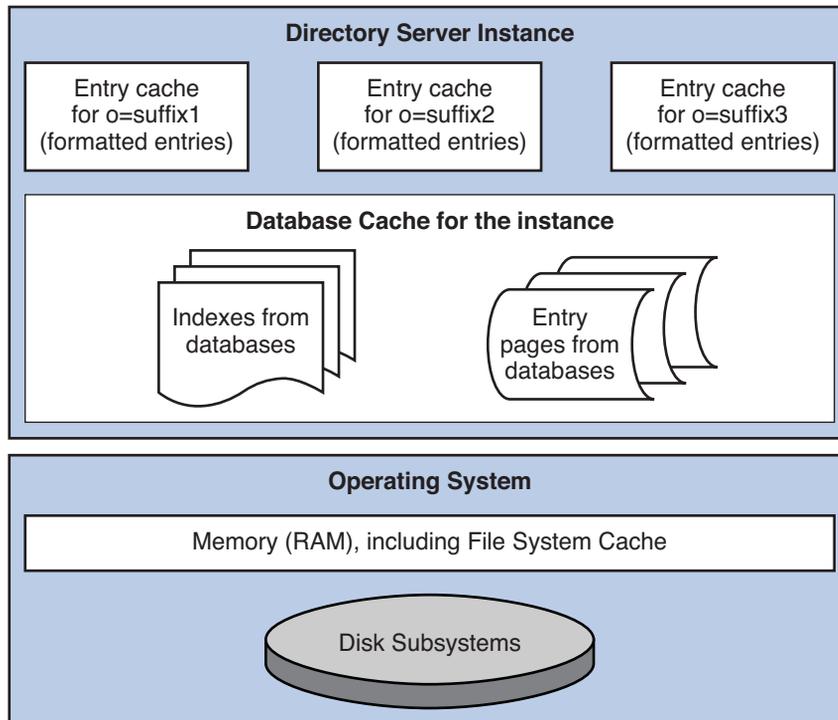
Types of Cache

This section describes the types of cache used by Directory Server.

[Figure 8–1](#) shows the caches for an instance of Directory Server with three suffixes, each with its own entry cache.

Directory Server also uses a file system cache. The file system cache is managed by the underlying operating system, and by I/O buffers in disk subsystems.

FIGURE 8-1 Entry and Database Caches in Context



Database Cache

Each instance of Directory Server has one database cache. The database cache holds pages from the databases that contain indexes and entries. Each page is not an entry, but a slice of memory that contains a portion of the database.

Directory Server moves pages between the database files and the database cache to maintain the maximum database cache size you specify. The amount of memory used by Directory Server for the database cache can be larger than the specified size. This is because Directory Server requires additional memory to manage the database cache.

The memory can be monitored by empirical testing and by the use of tools such as `pmap(1)` on Solaris systems. The `ps(1)` utility can also be used with the `-p pid` and `-o format` options to view current memory used by a particular process such as Directory Server `ns -s lapd`. For more information, refer to the operating system documentation.

Entry Cache

The entry cache holds recently accessed entries that are formatted for delivery to client applications. The entry cache is allocated as required until it reaches a size larger than, but based on the maximum entry cache size you specify.

As entries stored in the entry cache are already formatted, Directory Server returns entries from an entry cache efficiently. Entries in the database must be formatted and stored in the entry cache before they are delivered to client applications.

The maximum size you specify indicates how much memory Directory Server requests from the underlying memory allocation library. Depending on how the memory allocation library handles requests for memory, the actual memory used may be much larger than the amount of memory available to Directory Server for the entry cache.

The memory used by the Directory Server process depends on the memory allocation library that is used, and depends on the entries cached. Entries with many small attribute values usually require more overhead than entries with few large attribute values.

Import Cache

The import cache is created and used when a suffix is initialized. If the deployment involves *offline* suffix initialization only, import cache and database cache are not used together. In this case, the import cache and database cache do not need to be added together when the cache size is aggregated. See [“Total Aggregate Cache Size” on page 145](#). When the import cache size is changed, the change takes effect the next time the suffix is reset and initialized. The import cache is allocated for the initialization, then released after the initialization.

Directory Server handles import cache in the same way as it handles database cache. Sufficient physical memory must be available to prevent swapping. The benefits of having a larger import cache diminish for cache sizes larger than 2 GB.

File System Cache

The operating system allocates available memory not used by Directory Server caches and other applications to the file system cache. The file system cache holds data that was recently read from the disk, making it possible for subsequent requests to obtain data from cache rather than having to read it again from the disk. Because memory access is many times faster than disk access, leaving some physical memory available for the file system cache can boost performance.

The filesystem cache can be used as a replacement for some of the database cache. Database cache is more efficient for Directory Server use than file system cache, but file system cache is not directly associated with the Directory Server `ns -slapd` process. Potentially, a larger total cache can be made available to Directory Server than would be available by using database cache alone.

Refer to the operating system documentation for information about file system cache.

Total Aggregate Cache Size

The sum of all caches used simultaneously must remain smaller than the total size of available physical memory, minus the memory intended for file system cache, minus the memory intended for other processes such as Directory Server itself.

For 32-bit servers, the total aggregate cache size must be limited so that the total Directory Server `ns-slapd` process size is less than the maximum process size allowed by the operating system. In practice, this limit is generally in the 2-3 GB range.

If suffixes are initialized while Directory Server is online, the sum of the database cache, the entry cache, and the import cache sizes should remain smaller than the total size of available physical memory.

TABLE 8-1 Import Operations and Cache Use

Cache Type	Offline Import	Online Import
Database	no	yes
Entry	yes	yes
Import	yes	yes

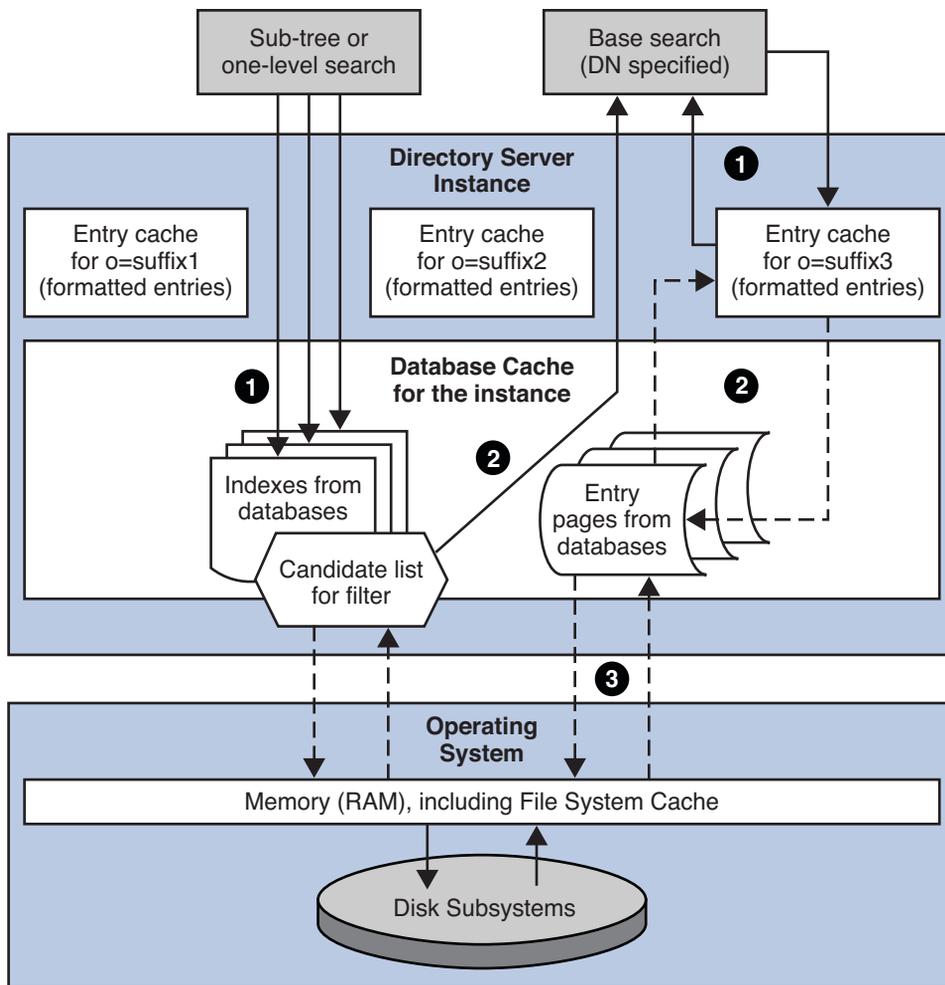
If all suffixes are initialized while Directory Server is offline, the import cache does not coexist with the database cache, so the same memory can be allocated to the import cache for offline suffix initialization and to the database cache for online use. If you opt to implement this special case, however, ensure that *no online bulk loads* are performed on a production server. The sum of the caches used simultaneously must remain smaller than the total size of available physical memory.

For very large caches, it is important that the memory used by Directory Server does not exceed the size of available physical memory. If the available physical memory is exceeded, the system pages repeatedly and performance is degraded.

How Directory Server Performs Searches by Using Cache

In [Figure 8-2](#), individual lines represent threads that access different levels of memory. Broken lines represent probable bottlenecks to minimize through effective tuning of Directory Server.

FIGURE 8-2 How Directory Server Performs Searches



The following sections describe how Directory Server performs searches by using the cache. By processing subtree searches as described in the following sections, Directory Server returns results without loading the whole set of results into memory.

How Directory Server Performs Base Searches

Base searches specify a base DN and are the simplest type of searches for Directory Server to manage. Directory Server processes base searches in the following stages.

1. Directory Server attempts to retrieve the entry from the entry cache.
 - If the entry is found in the entry cache, Directory Server checks whether the candidate entry matches the filter provided for the search.
 - If the entry matches the filter provided for the search, Directory Server returns the formatted, cached entry to the client application.
2. Directory Server attempts to retrieve the entry from the database cache.
 - If the entry is found in the database cache, Directory Server copies the entry to the entry cache for the suffix. Directory Server proceeds as if the entry had been found in the entry cache.
3. Directory Server attempts to retrieve the entry from the database itself.
 - If the entry is found in the database, Directory Server copies the entry to the database cache. Directory Server proceeds as if the entry had been found in the database cache.

How Directory Server Performs Subtree and One-Level Searches

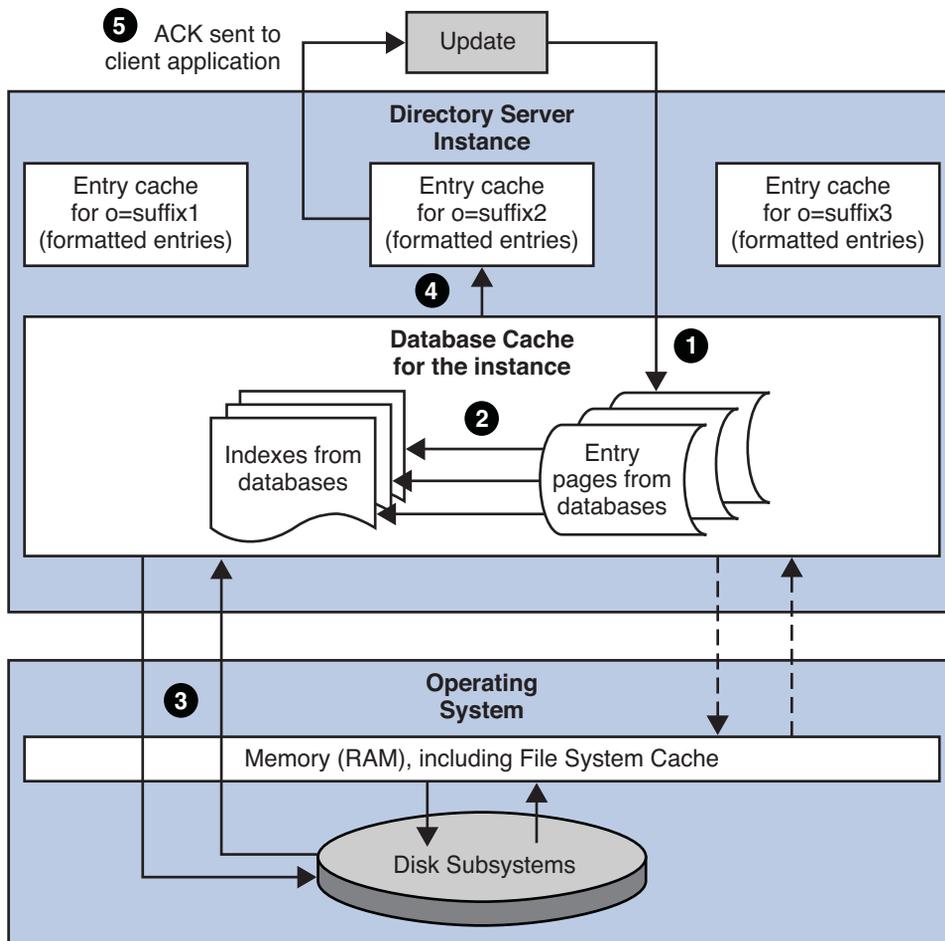
Searches on a subtree or a level of a tree involve additional processing to handle multiple entries. Directory Server processes subtree searches and one-level search in the following stages.

1. Directory Server attempts to define a set of candidate entries that match the filter from indexes in the database cache.
 - If no appropriate index is present, the set of candidate entries must be found directly in the database itself.
2. For each candidate entry, Directory Server performs the following tasks.
 - a. Performs a base search to retrieve the entry.
 - b. Checks whether the entry matches the filter provided for the search.
 - c. Returns the entry to the client application if the entry matches the filter.

How Directory Server Performs Updates by Using the Cache

In [Figure 8–3](#), individual lines represent threads that access different levels of memory. Broken lines represent probable bottlenecks to minimize through effective tuning of Directory Server.

FIGURE 8-3 How Directory Server Performs Updates



The figure does not show the impact of the internal base search performed to get the entry for update.

Directory Server processes updates in the following stages.

1. Directory Server performs a base DN search to retrieve the entry, or to update or verify the entry in the case of an add operation that it does not already exist.
2. Directory Server updates the database cache and any indexes affected.

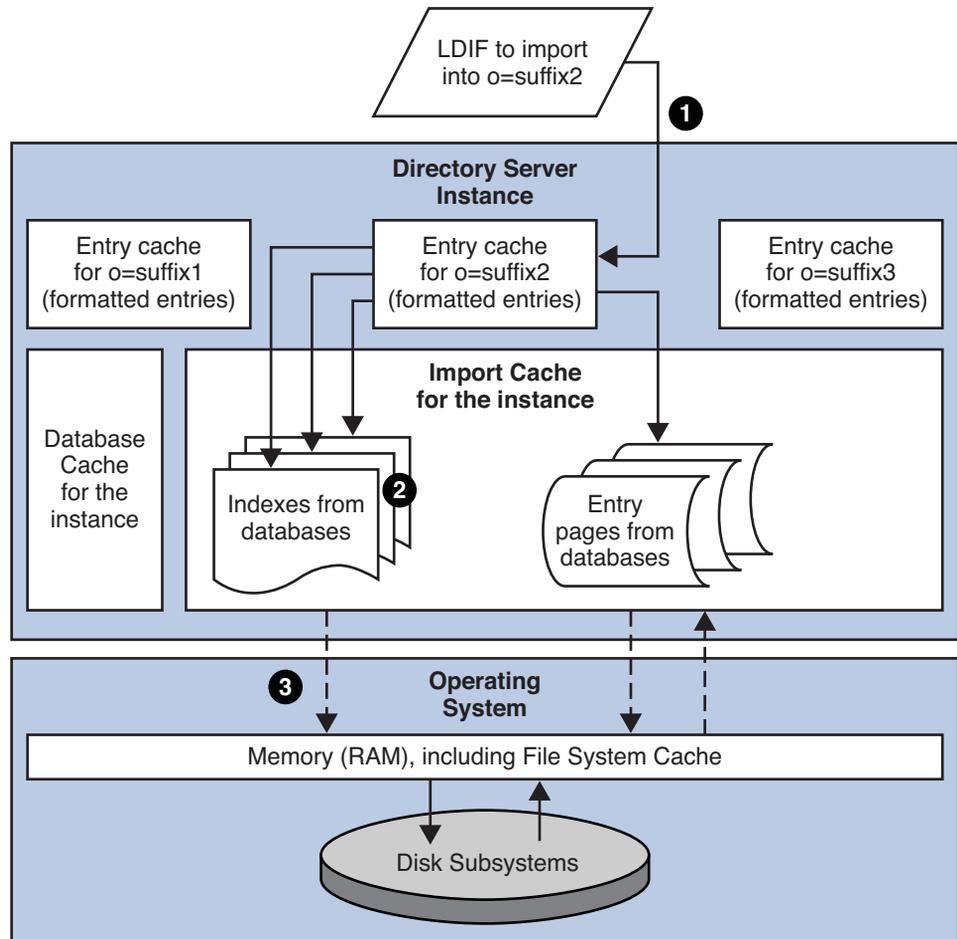
If data affected by the change have not been loaded into the database cache, this step can result in disk activity while the relevant data are loaded into the cache.

3. Directory Server writes information about the changes to the transaction log and waits for the information to be flushed to disk, which happens periodically, at each checkpoint. Directory Server database files are thus updated during the checkpoint operation, not for each write.
4. Directory Server formats and copies the updated entry to the entry cache for the suffix.
5. Directory Server returns an acknowledgement of successful update to the client application.

How Directory Server Initializes a Suffix by Using the Cache

The following figure illustrates how Directory Server initializes a suffix by using the cache. Individual lines represent threads that access different levels of memory. Broken lines represent probable bottlenecks to minimize through effective tuning of Directory Server.

FIGURE 8-4 How Directory Server Initializes a Suffix



Directory Server initializes a suffix in the following stages:

1. Starts a thread to feed a buffer from LDIF.
2. Starts a thread for each index affected and other working threads to update the indexes. These threads use the import cache.
3. Reads from and writes to the database files when import cache runs out.

Directory Server also writes log messages during suffix initialization, but does not write to the transaction log.

Tools for suffix initialization delivered with Directory Server provide feedback on the cache hit rate and import throughput. If cache hit rate and import throughput drop together, it is possible that the import cache is too small.

Directory Server Indexing

Like a book index, Directory Server indexes speed up searches by associating search strings with the contents of a directory. For information about indexes used by Directory Server, see following sections:

- “Overview of Indexes” on page 153
- “System Indexes and Default Indexes” on page 154
- “Types of Index” on page 156

Overview of Indexes

Directory Server uses indexes to speed up search operations by associating lookup information with Directory Server entries. During a search operation, Directory Server uses the index to find entries that match the search key. Without an index, Directory Server must check every entry in a suffix to find matches for the search key.

Indexes are stored in database files, and are created and managed independently for each suffix in a directory. Each index file contains all of the indexes defined in the suffix for a given attribute. For example, all indexes maintained for the `cn` attribute are stored in the `databaseName_cn.db3` file. When an indexed entry is modified, Directory Server updates the index files.

Directory Server supports the following types of indexes:

- Default indexes to improve search performance or support searches performed by other applications. Default indexes are added when a suffix is created.
- System indexes to help Directory Server to function properly and efficiently.
- User indexes, added when a user creates an attribute or defines a new index.

System Indexes and Default Indexes

This section addresses the following topics:

- “System Indexes” on page 154
- “Default Indexes” on page 154

System Indexes

System indexes are required for Directory Server to function properly and efficiently. System indexes cannot be deleted or modified. Table 9–1 lists the system indexes created automatically in every suffix.

TABLE 9–1 System Indexes in Every Suffix

Attribute	Equality Index	Presence Index	Description
aci		X	Allows the directory server to quickly obtain the access control information maintained in the directory
ancestorid	X		Enhances directory performance during subtree searches
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	Helps to find replication conflicts
numsubordinates		X	Used by Directory Service Control Center to enhance display performance on the Directory tab
objectClass	X		Accelerate subtree searches
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 eliminate index.

Table 9–2 lists the default indexes that are configured in Directory Server.

TABLE 9–2 Default Indexes in Every New Suffix

Attribute	Equality Index	Presence Index	Substring Index	Description
cn	X	X	X	Improves the performance of the most common types of directory searches.
givenName	X	X	X	Improves the performance of the most common types of directory searches.
mail	X	X	X	Improves the performance of the most common types of directory searches.
mailAlternateAddress	X			Used by Messaging Server.
mailHost	X			Used by Messaging Server.
member	X			Improves server performance. This index is also used by the referential integrity plug-in.
nsCalXItemId	X	X	X	Used by Calendar Server.
nsLIProfileName	X			Used by roaming feature of Messaging Server.
nsRoleDN	X			Improves the performance of role-based operations.
nswcalCALID	X			Used by Calendar Server.
owner	X			Improves server performance. This index is also used by the referential integrity plug-in.
pipstatus	X			Used by other servers.
pipuid		X		Used by other servers.
seeAlso	X			Improves server performance. This index is used by the referential integrity plug-in.
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 server performance.
uniquemember	X			Improves server performance. This index is also used by the referential integrity plug-in.

Types of Index

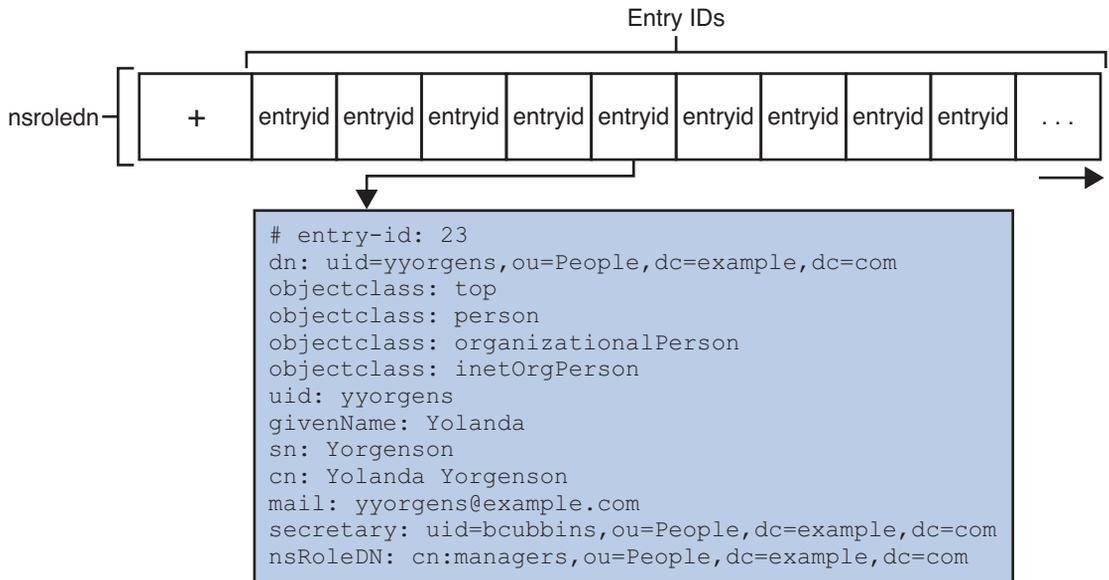
With the exception of the approximate index, the indexes in this section are used by Directory Server to speed up basic matching rules. This section covers the following index types:

- “Presence Index” on page 156
- “Equality Index” on page 157
- “Substring Index” on page 159
- “Browsing Index” on page 160
- “Approximate Index” on page 161
- “International Index” on page 162

Presence Index

The presence index includes all entries in the database that have a value for a specified attribute, irrespective of that value. The following figure shows a presence index for the `nsRoleDN` attribute. For information about this attribute, see [nsRoleDN\(5dsat\)](#).

FIGURE 9-1 Presence Index



Directory Server uses the value of the `entryid` attribute to store a reference to the entry. Directory Server retrieves the entry by using the `instance-path/db/dbinstance/dbinstance_id2entry.db3` index file, where `dbinstance` depends on the database identifier.

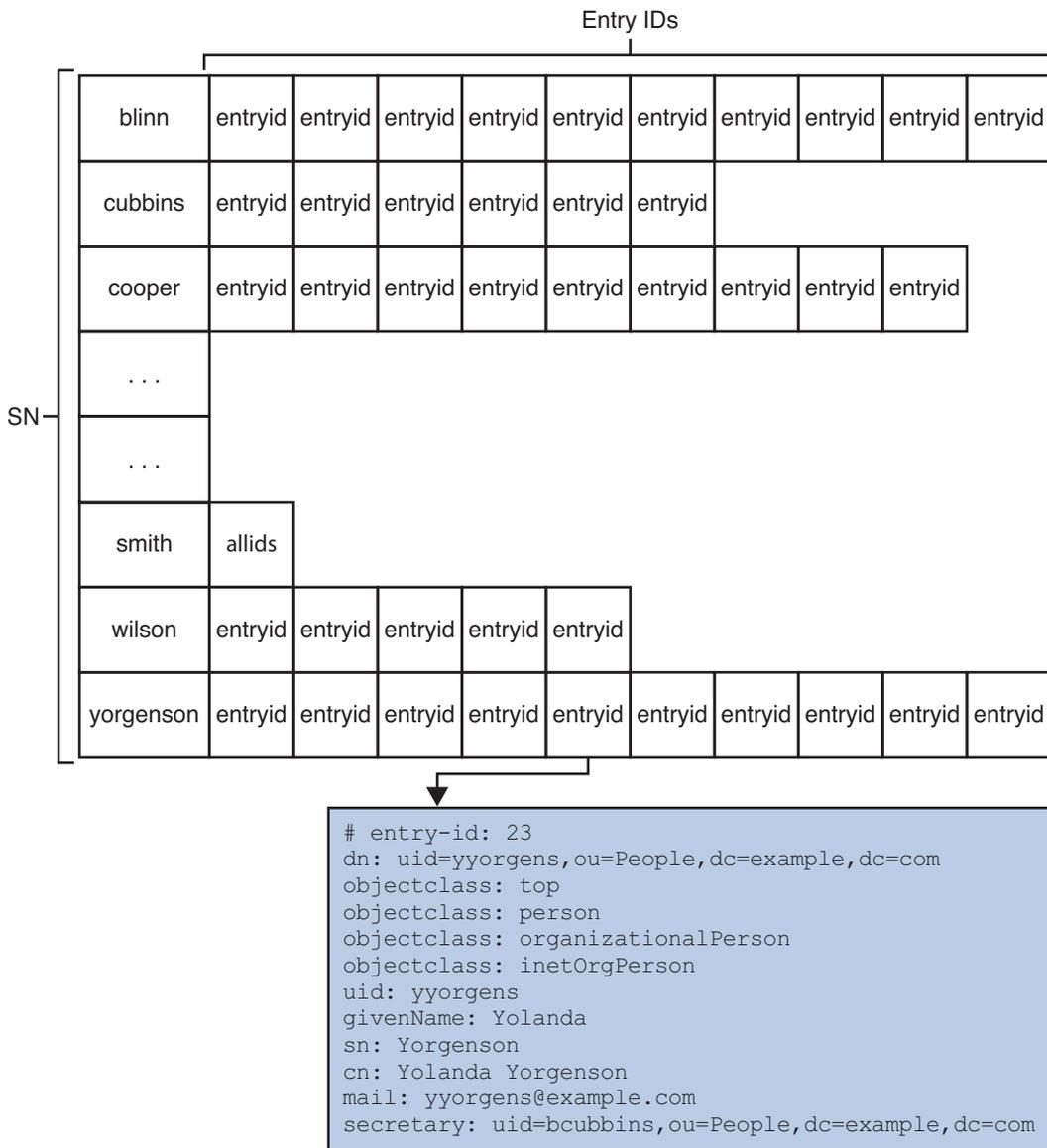
When Directory Server receives a request to remove an attribute value indexed for presence, it must remove the entry from the presence index for that attribute before acknowledging the update to the client application.

The cost of presence indexes is generally low, although the list of entries maintained for a presence index may be long. When the index list length is small, presence indexes are useful for attributes in a relatively small percentage of directory entries.

Equality Index

The equality index includes all entries in the database that have a specified value for a given attribute. This index requires a value to be specified in the search filter. The following figure shows an equality index for the `sn`, surname, attribute. The index maintains a list of values for the `sn` attribute. For information about this attribute, see [sn\(5dsat\)](#).

FIGURE 9-2 Equality Index



When Directory Server receives a request to update an entry indexed for equality, it must do the following tasks before performing the update and acknowledging the update to the client:

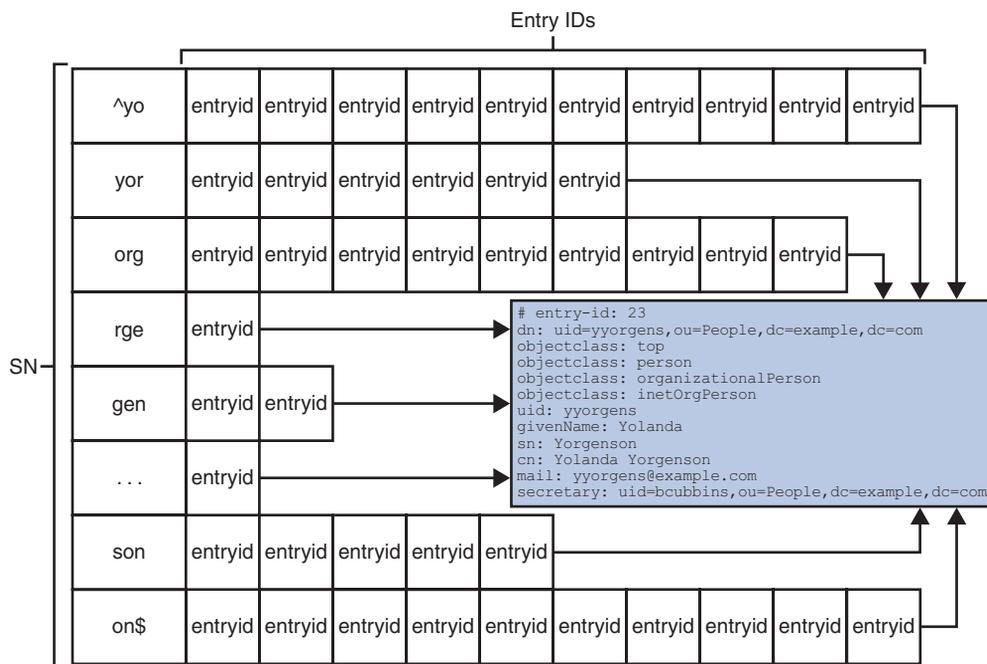
- Determine whether the entry must be removed from the index
- Determine whether a list must be added to or removed from the index

The cost of equality indexes is generally lower than for substring indexes, but equality indexes require more space than presence indexes. Some client applications such as messaging servers might rely on equality indexes for search performance. Avoid using equality indexes for large binary attributes such as photos and hashed passwords.

Substring Index

Substring indexes are used for searches on three-character groups, for example, `sn=*abc*`. The three-character groups are stored in the index. Substring indexes cannot be applied to binary attributes such as photos. The following figure shows a substring index for the SN attribute.

FIGURE 9-3 Substring Index for the SN Attribute



The Directory Server search algorithm includes optimizations for the following searches, however, these searches are more likely to reach the index list threshold:

- Searches on two-character substrings with this format `sn=*ab*`
- Searches on one-character group with this format `sn=a*`. Searches cannot be performed on one-character groups with this format `sn=*a` and `sn=*a*`

Directory Server builds an index of substrings according to its own built-in rules. Substring indexes cannot be configured by the system administrator.

When Directory Server receives a request to update an entry that has an attribute indexed for substrings, it must do the following tasks before performing the update and acknowledging the update to the client:

- Determine whether the entry must be removed from the index
- Determine whether and how modifications to the entry affect the index
- Determine whether the entry IDs or lists of entry IDs must be added to or removed from the index

Maintaining substring indexes is relatively costly; the cost is a function of the length of the string indexed. To minimize cost, avoid unnecessary substring indexes, especially for attributes that have potentially long string values such as a description.

Browsing Index

Browsing indexes are also called *virtual list view indexes*. Browsing indexes are used for search operations that request server-side sorting or virtual list view, VLV, results. By using browsing indexes, you 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.

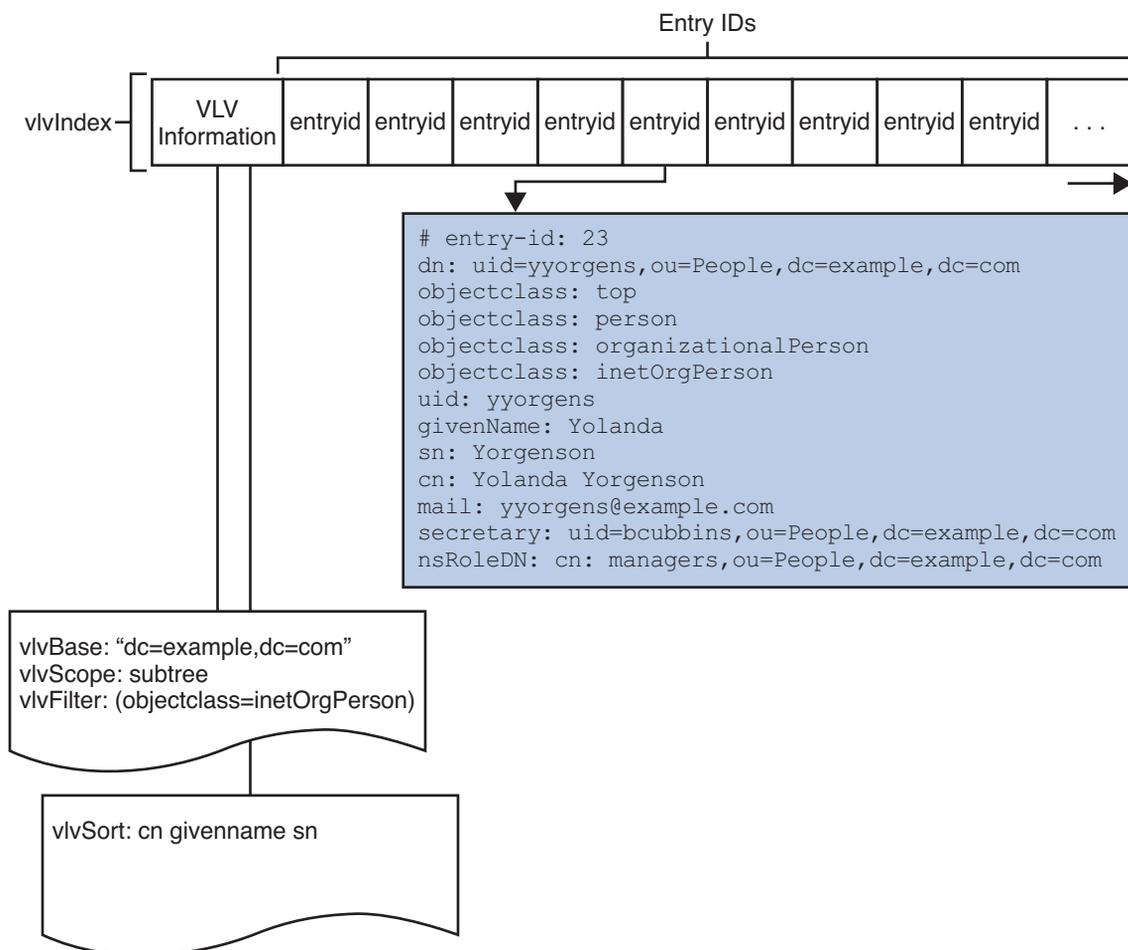
Browsing indexes are configured with the following parameters in the `vlvSearch(5dsoc)` object class, `vlvBase(5dsat)`, `vlvScope(5dsat)`, `vlvScope(5dsat)`, and `vlvFilter(5dsat)`. Browsing index are sorted by the following parameter in the `vlvIndex(5dsoc)` object class, `vlvSort(5dsat)`.

Browsing indexes are configured in two steps.

1. The base of the search, the scope of the search, and a filter for the search are configured by the `vlvBase`, `vlvScope`, and `vlvFilter` attributes in the `vlvSearch` object class.
2. The name of the attributes that sort the index are configured by the `vlvSort` attribute in the `vlvIndex` object class.

The following figure shows a browsing index.

FIGURE 9-4 Representation of a Browsing Index



When Directory Server receives a request to update an entry with a `vlvFilter` value, it must do the following tasks before performing the update and acknowledging the update to the client:

- Determine whether the entry must be removed from the index
- Determine the correct position of the entry in the list

Approximate Index

Approximate indexes work with the English language only to provide efficient “sounds-like” searches. 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. Because the algorithm is based loosely on syllables, it is not effective for attributes that contain numbers, such as telephone numbers.

International Index

International indexes are also called matching rule indexes. International indexes associate language-specific matching rules with attributes. This index type enables attributes to be sorted and searched for in accordance with the language rules. International indexes use matching rules for particular locales to maintain indexes.

Standard support for international and other types of indexing can be extended by using a custom matching rule server plug-in.

Directory Server Logging

For information about the types of logs used in Directory Server and for a description of the server logs, see the following sections:

- [“Introduction to Logs” on page 163](#)
- [“Transaction Log” on page 164](#)
- [“Access, Error, and Audit Logs” on page 164](#)

Introduction to Logs

The following table summarizes the different logs used by the Directory Server.

TABLE 10-1 Logs Used by Directory Server

Log	Type	Description
Transaction log	Database	Ensuring data integrity by committing each update operation to the transaction log on disk before the result code for the update operation is returned to the client application. When Directory Server accepts an update operation, it writes a log message about the operation to the transaction log. If the system crashes, Directory Server uses the transaction log to recover the database.
Access log	Flat file	Evaluating directory use patterns, verifying configuration settings, diagnosing access problems. For information about access logs, see “Access Logs” on page 165 .
Error log	Flat file	Debugging directory deployments. For information about error logs, see “Error Logs” on page 165 .
Audit log	Flat file	Providing audit trails for security and data integrity. For information about audit logs, see “Audit Logs” on page 165 .

Transaction Log

The following server properties configure the transaction log.

`db-checkpoint-interval`

How often Directory Server checkpoints the transaction log, ensures the entire database system is synchronized to disk, and cleans up transaction logs

`db-durable-transaction-enabled`

Whether update operations are committed to the transaction log on disk before result codes are sent to clients

`db-log-buf-size`

The buffer size for log information stored in memory until the buffer fills or the transaction commit forces the buffer to be written to disk

`db-log-path`

The path of the transaction log

`db-batched-transaction-count`

How many updates are accumulated before being committed to the directory database

See `server(5dsconf)` for details.

Access, Error, and Audit Logs

Access logs, error logs and audit logs are flat files that contain information about operations. For information about how to view and configure logs, see [Chapter 14, “Directory Server Logging,”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

By default, the logs are stored in the directory `instance-path/logs/`.

Log files can be rotated on demand, or can be scheduled to be rotated on a specific day-of-the-week and time of day, or when the log file exceeds a specified minimum size.

Old log files are stored in the same path with the same name and an extension that contains the date that the file was created, in the format `filename.YYYYMMDD-hhmmss`. The server also maintains a file with the same name and the `.rotationinfo` extension to record the creation dates of all log files.

For information about access logs, error logs and audit logs, see the following sections:

- “Access Logs” on page 165
- “Error Logs” on page 165
- “Audit Logs” on page 165
- “Content of Access, Error, and Audit Logs” on page 166

- [“Connection Codes in Log Files” on page 170](#)
- [“Result Codes in Log Files” on page 171](#)

Access Logs

Access logs contain information about connections between an LDAP client and a directory server. A connection is a sequence of requests from the same client, and can contain the following components:

- Connection index and the IP address of the client
- Bind record
- Bind result record
- Sequence of operation request/result pairs, or individual records in the case of connection, closed, and abandon records
- Unbind record
- Closed record

Error Logs

Error logs contain a unique identifier of the error, warning or information message, and a human readable message. Errors are defined according to the following severity.

Error	The error is severe. Immediate action should be taken to avoid the loss or corruption of directory data.
Warning	The error is important. Action should be taken at some stage to prevent a severe error occurring in the future.
Info	An informative message, usually describing server activity. No action is necessary.

Audit Logs

Audit logs contain records of all modifications to configuration or suffix entries. The modifications are written in LDIF format.

Audit logging is not enabled by default. To enable audit logging, use the procedure [“To Enable the Audit Log”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Content of Access, Error, and Audit Logs

The remainder of this chapter describes each of the parts of the log files.

Time Stamp

Each line of an access log file begins with a timestamp of this format: [20/Dec/2006:11:39:51-0700]. The time stamp, -0700 indicates the time difference in relation to GMT.

The format of the time stamp can vary according to your platform. The connection, closed, and abandon records appear individually. All other records appear in pairs, consisting of a request for service record followed by a result record. The record pairs usually, but not exclusively, appear on adjacent lines.

Connection Number

The connection number is represented by `conn=value`. Every external request is listed with an incremental connection number.

When `conn=Internal` the operation is an internal operation. To log internal access operations, specify an access logging level of `acc-internal` in the `dsconf` configuration attribute.

File Descriptor

The file descriptor is represented by `fd=value`.

Every connection from an external LDAP client to a directory server requires a file descriptor from the operating system. The file descriptor is taken from a pool of available file descriptors.

Slot Number

The slot number has the same meaning as file descriptor. Slot number is a legacy section of the access log and can be ignored.

Operation Number

The operation number is represented by `op=value`.

For a connection, all operation request and result pairs are given incremental operation numbers beginning with `op=0`. The operation number identifies the operation being performed.

When `op=-1`, the LDAP request for the connection was not issued by an external LDAP client, but was initiated internally.

Method Type

The method type is represented by `method=value`.

The method type indicates which bind method was used by the client. The method type can have one of the following values.

0	No authentication
128	Simple bind with user password
sasl	SASL bind using external authentication mechanism

LDAP Version

The LDAP version can be LDAPv2 or LDAPv3. The LDAP version gives the LDAP version number that the LDAP client used to communicate with the LDAP server.

Error Number

The error number is represented by `err=number`.

The error number provides the LDAP result code returned from the LDAP operation. The LDAP error number 0 means that the operation was successful. For a list of LDAP result codes refer to [“Result Codes in Log Files” on page 171](#).

Tag Number

The tag number is represented by `tag=value`.

The tags are used internally for message decoding and are not intended for use outside. The following tags are used most often.

tag=97	A client bind operation
tag=100	The entry for which you were searching
tag=101	The result from a search operation
tag=103	The result from a modify operation
tag=105	The result from an add operation
tag=107	The result from a delete operation
tag=109	The result from a modify DN operation
tag=111	The result from a compare operation
tag=115	A search reference when the entry you perform your search on holds a referral to the entry you require. Search references are expressed in terms of a referral.

`tag=120` A result from an extended operation

Number of Entries

The number of entries is represented by `number=value`.

The number of entries indicates the number of entries that matched an LDAP search request.

Elapsed Time

The elapsed time is represented by `etime=value`.

Elapsed time indicates the time that it took to perform the LDAP operation. An `etime` value of 0 means that the operation took milliseconds to perform.

To log the time in microseconds, specify an access logging level of `acc-timing` in the `dsconf` configuration attribute.

LDAP Request Type

The LDAP request type indicates the type of LDAP request made by the client. The following types of LDAP requests can be made:

SRCH	Search
MOD	Modify
DEL	Delete
ADD	Add
MODDN	Modify DN
EXT	Extended operation
ABANDON	Abandon operation
COMPARE	Compare operation

LDAP Response Type

The LDAP response type indicates the LDAP response being returned by the server. The following LDAP responses can be returned:

RESULT	Result
ENTRY	Entry
REFERRAL	Referral or search reference

Unindexed Search Indicator

The unindexed search indicator is represented by `notes=U`.

In an unindexed search, the database is searched instead of the index file. Unindexed searches occur for the following reasons:

- The all IDs threshold was reached in the index file used for the search
- An index file does not exist
- The index file is not configured in the way required by the search

An unindexed search indicator is often accompanied by a large `etime` value because unindexed searches are usually more time consuming than indexed searches.

Extended Operation OID

An extended operation OID is represented by `EXT oid="OID number"`. See [extended-operations\(5dsconf\)](#) for a list of supported extended operations.

Change Sequence Number in Log Files

The replication change sequence number is represented in log files by `csn=value`.

The presence of a change sequence number indicates that replication is enabled for this naming context.

Abandon Message

The abandon message is represented by `ABANDON`.

The presence of the abandon message indicates that an operation has been aborted. If the message ID succeeds in locating the operation that has been aborted, the log message reads as follows:

```
conn=12 op=2 ABANDON targetop=1 msgid=2 nentries=0 etime=0
```

However, if the message ID does not succeed in locating the operation, or if the operation had already finished prior to the `ABANDON` request being sent, then the log message reads as follows:

```
conn=12 op=2 ABANDON targetop=NOTFOUND msgid=2
```

The abandon message uses the following parameters:

- | | |
|-----------------------|---|
| <code>nentries</code> | Gives the number of entries sent before the operation was aborted |
| <code>etime</code> | Gives the number of seconds that elapsed before the operation was aborted |

`targetop` Identifies the operation to be aborted. If the value is `NOTFOUND`, the operation to be aborted was either an unknown operation or already complete

Message ID

The message ID is represented by `msgId=value`.

The message ID is the LDAP operation identifier generated by the client. The message ID can have a different value to the operation number, but identifies the same operation. The message ID in an `ABANDON` operation specifies which client operation is being abandoned.

The operation number starts counting at 0. However, in many client implementations the message ID number starts counting at 1. This explains why the message ID is frequently equal to the operation number plus 1.

SASL Multi-Stage Bind Logging

Directory Server logs each stage in the multi stage bind process and, where appropriate, the progress statement `SASL bind in progress` is included.

The DN used for access control decisions is logged in the `BIND` result line and not in the bind request line.

```
conn=14 op=1 RESULT err=0 tag=97 nentries=0 etime=0 dn="uid=myname,dc=example,dc=com"
```

For SASL binds, the DN value displayed in the `BIND` request line is not used by the server and is, therefore, not relevant. However, for SASL binds, the authenticated DN must be used for audit purposes. Therefore, the authenticated DN must be clearly logged. Having the authenticated DN logged in the `BIND` result line avoids any confusion as to which DN is which.

Options Description

The options description, `options=persistent`, indicates that a persistent search is being performed. Persistent searches can be used as a form of monitoring and can be configured to return changes to given configurations. The access log distinguishes between persistent and regular searches.

Connection Codes in Log Files

A connection code is included in the `closing` message of a log file. The connection code provides additional information about why the connection was closed. The following table describes the common connection codes.

TABLE 10-2 Summary of Connection Codes

Connection Code	Description
A1	The client has closed the connection without performing an UNBIND.
B1	This connection code can have one of the following causes: <ul style="list-style-type: none"> ■ The client has closed the connection without performing an UNBIND. ■ The BER element was corrupt. If BER elements, which encapsulate data being sent over the wire, are corrupt when they are received, a B1 connection code is logged to the access log. BER elements can be corrupted by physical layer network problems or bad LDAP client operations, such as an LDAP client aborting before receiving all request results.
B2	The BER element is longer than the <code>nsslapd-maxbersize</code> attribute value.
B3	A corrupt BER tag was encountered.
B4	The server failed to flush data response back to client. This code can occur when the client closes the connection to the server, before the server finished sending data to the client.
P1	The client connection was closed by a custom plug-in. None of the plug-ins provided by Directory Server close a connection.
P2	A closed connection or corrupt connection has been detected.
T1	The server closed the client connection because it was idle for longer than the <code>idle-timeout</code> server property.
T2	The server closed the client connection because it was stalled for longer than the <code>nsslapd-ioblocktimeout</code> attribute value. This code can occur for the following reasons: <ul style="list-style-type: none"> ■ There is a network problem. ■ The server sends a lot of data to the client but the client does not read the data. As a result, the server's transmit buffer becomes full.
U1	The server closed the client connection because client sent an UNBIND request.

Result Codes in Log Files

The following tables summarizes the LDAP result codes generated by an LDAP server and an LDAP client.

TABLE 10-3 Summary of Result Codes for LDAP Servers

Result Code	Description
0	Success
1	Operations error

TABLE 10-3 Summary of Result Codes for LDAP Servers (Continued)

Result Code	Description
2	Protocol error
3	Time limit exceeded
4	Size limit exceeded
5	Compare false
6	Compare true
7	Authentication method not supported
8	Strong authentication required
9	Partial results and referral received
10	Referral received
11	Administrative limit exceeded
12	Unavailable critical extension
13	Confidentiality required
14	SASL bind in progress
16	No such attribute
17	Undefined attribute type
18	Inappropriate matching
19	Constraint violation
20	Type or value exists
21	Invalid syntax
32	No such object
33	Alias problem
34	Invalid DN syntax
35	Object is a leaf
36	Alias de-referencing problem
48	Inappropriate authentication
49	Invalid credentials
50	Insufficient access
51	Server is busy

TABLE 10-3 Summary of Result Codes for LDAP Servers (Continued)

Result Code	Description
52	Server is unavailable
53	Server is unwilling to perform
54	Loop detected
64	Naming violation
65	Object class violation
66	Operation not permitted on a non-leaf entry
67	Operation not permitted on a RDN
68	Entry already exists
69	Cannot modify object class
70	Results too large
71	Affects multiple servers
76	Virtual list view error

TABLE 10-4 Summary of Result Codes for LDAP Clients

Result Code	Description
80	Unknown error
81	Cannot contact LDAP server
82	Local error
83	Encoding error
84	Decoding error
85	Timed out
86	Unknown authentication method
87	Bad search filter
88	User cancelled operation
89	Bad parameter to an LDAP routine
90	Out of memory
91	Cannot connect to the LDAP server
92	Not supported by this version of LDAP

TABLE 10-4 Summary of Result Codes for LDAP Clients *(Continued)*

Result Code	Description
93	Requested LDAP control not found
94	No results returned
95	Additional results to return
96	Client detected loop
97	Referral hop limit exceeded

Directory Server Groups and Roles

The directory information tree organizes entries hierarchically. This hierarchy is a type of grouping mechanism. The hierarchy is not well suited for associations between dispersed entries, for organizations that change frequently, or for data that is repeated in many entries. Directory Server groups and roles offer more flexible associations between entries.

This chapter describes how groups and roles are used by Directory Server to associate entries with each other. This chapter covers the following topics:

- [“Directory Server Groups” on page 175](#)
- [“Directory Server Roles” on page 178](#)
- [“Deciding Between Groups and Roles” on page 180](#)

Directory Server Groups

A group is an entry that identifies the other entries that are in the group. The group mechanism makes it easy to retrieve a list of entries that are members of a given group.

Although groups may identify members anywhere in the directory, the group definitions themselves should be located under an appropriately named node such as `ou=Groups`. This makes them easy to find, for example, when defining access control instructions (ACIs) that grant or restrict access when the bind credentials are members of a group.

Static Groups

Static groups explicitly name their member entries. For example, a group of directory administrators would name the specific people who formed part of that group, as shown in the following illustration.



The following LDIF extract shows how the members of this static group would be defined.

```
dn: cn=Directory Administrators, ou=Groups, dc=example,dc=com
...
member: uid=kvaughan, ou=People, dc=example,dc=com
member: uid=rdaugherty, ou=People, dc=example,dc=com
member: uid=hmilller, ou=People, dc=example,dc=com
```

Static groups specify the DN of each member of the group. Static groups use one of the following object class and attribute pairs:

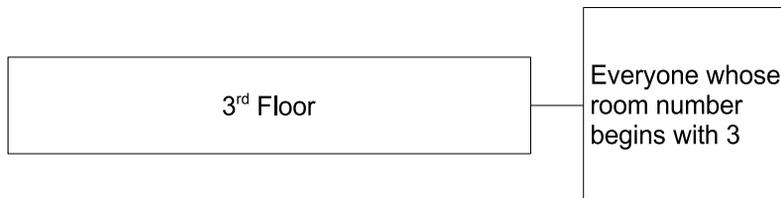
- The `groupOfNames` object class, with a multi-valued `member` attribute
- The `groupOfUniqueNames` object class, with a multi-valued `uniqueMember` attribute

The `member` attribute and `uniqueMember` attribute contain the DN for every entry that is a member of the group. The `uniqueMember` attribute value for the DN is optionally followed by a hash, #, and a unique identifier label to guarantee uniqueness.

Dynamic Groups

Dynamic groups specify a filter and all entries that match the filter are members of the group. These groups are dynamic because membership is defined each time the filter is evaluated.

Imagine, for example, that all management employees and their assistants were situated on the 3rd floor of your building, and that the room number of each employee commenced with the number of the floor. If you wanted to create a group containing just the employees on the third floor, you could use the room number to define just these employees, as shown in the following illustration.



The following LDIF extract shows how the members of this dynamic group would be defined.

```
dn: cn=3rd Floor, ou=Groups, dc=example,dc=com
...
memberURL: ldap:///dc=example,dc=com??sub?(roomnumber=3*)
```

Dynamic groups use one of the following object class and attribute pairs:

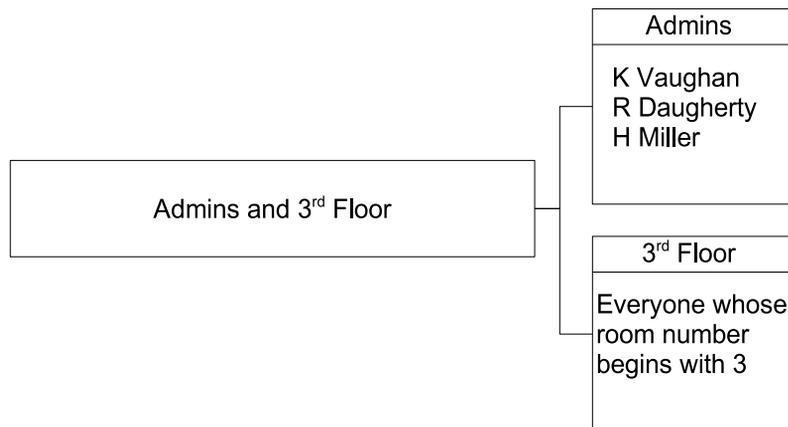
- The `groupOfURLs` object class, with the `memberURL` attribute
- The `groupOfUniqueNames` object class, with the `uniqueMember` attribute

The group members are listed either by one or more filters represented as LDAP URL values of the `memberURL` attribute or by one or more DN values of the `uniqueMember` attribute.

Nested Groups

Static and dynamic groups can be nested by specifying the DN of another group as a value for the `member` attribute or `uniqueMember` attribute. The depth to which nested groups are supported by ACIs is controlled by the `nsslapd-groupevalnestlevel` configuration parameter. Directory Server also supports mixed groups, that is groups that reference individual entries, static groups, and dynamic groups.

Imagine for example that you wanted a group containing all directory administrators, and all management employees and their assistants. You could use a combination of the two groups defined earlier to create one nested group, as shown in the following illustration.



The following LDIF extract shows how the members of this nested group would be defined.

```
dn: cn=Admins and 3rd Floor, ou=Groups, dc=example,dc=com
...
member: cn=Directory Administrators, ou=Groups, dc=example,dc=com
member: cn=3rd Floor, ou=Groups, dc=example,dc=com
```



Caution – Nested groups are not the most efficient grouping mechanism. Dynamic nested groups incur an even greater performance cost. To avoid these performance problems, consider using roles instead.

Directory Server Roles

Roles are similar to groups but work in the opposite way — where a group entry lists the DN of the member entries, the DN of a role entry is listed on each member entry. The role mechanism makes it is easy to retrieve a list of roles that are assigned to an entry.

Each role has *members*, or entries that possess the role. The role mechanism is managed by the `nsRoleDN` attribute and the `nsRole` attribute. The `nsRoleDN` attribute is used to add an entry to a role. The `nsRole` attribute is a read-only attribute, maintained by the directory server, that lists the roles to which an entry belongs. The `nsRole` attribute can be read or searched by clients to enumerate all roles to which an entry belongs. If you do not want to expose role membership, define access controls to read-protect the `nsRole` attribute.

By default, the scope of a role is limited to the subtree where it is defined. The scope of a role can be extended to other subtrees on the same server instance.

Managed Roles

Managed roles are functionally very similar to static groups. Managed roles explicitly assign a role to each member entry by adding the `nsRoleDN` attribute to the entry. The value of this attribute is the DN of the role definition entry.

The role definition entry only defines the scope of the role in the directory. Members of the role are entries that lie within the scope of the role definition, and that identify the role definition entry with their `nsRoleDN` attributes.

Filtered Roles

Filtered roles are equivalent to dynamic groups. Entries are assigned a role if they match a specified search filter. The value of the search filter is defined by the `nsRoleFilter` attribute. When the server returns an entry in the scope of a filtered role, that entry contains the generated `nsRole` attribute that identifies the role.

Nested Roles

Nested roles are equivalent to nested groups. Nested roles enable you to create roles that contain other roles and to extend the scope of existing roles. A nested role can itself contain another nested role. Up to 30 levels of nesting are supported.

A nested role lists the definition entries of other roles and combines all the members of their roles. If an entry is a member of a role that is listed in a nested role, then the entry is also a member of the nested role.

Limitations on Using Roles

When you use roles to support your directory service, be aware of the following limitations.

Filtered Roles cannot use CoS generated attributes

The filter string of a filtered role cannot be based on the values of a CoS virtual attribute. However, the specifier attribute in a CoS definition may reference the `nsRole` attribute generated by a role definition. For information about CoS, see [Chapter 12, “Directory Server Class of Service.”](#)

Extending the scope of roles

You can extend the scope of roles to different subtrees but they must be on the same server instance. You cannot extend the scope of roles to other servers.

Searches on the `nsRole` attribute

The `nsRole` attribute can be used in any search filter with any of the comparison operators. When you search on `nsRole` attribute, consider the following points:

- Searches on the `nsRole` attribute can take a long time because all roles must be evaluated before the entries can be filtered.
- Directory Server is optimized for equality searches on membership in managed roles. For example, this search will be nearly as fast as a search on real attributes.

```
((&(nsRole=cn=managersRole,ou=People,dc=example,dc=com)  
(objectclass=person))
```
- The `nsRoleDN` attribute is indexed by default in all suffixes. Optimizations for searching the membership of managed roles are lost if indexing is disabled for the `nsRoleDN` attribute.
- Searches for entries that contain a filtered role involve an internal search with 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.

Deciding Between Groups and Roles

The functionality of the groups and roles mechanisms overlap somewhat. Both mechanisms have advantages and disadvantages. Generally, the roles mechanism is designed to provide frequently required functionality more efficiently. Because the choice of a grouping mechanism influences server complexity and determines how clients process membership information, you must plan your grouping mechanism carefully. To decide which mechanism is more suitable, you need to understand the typical membership queries and management operations that are performed.

Advantages of the Groups Mechanism

Groups have the following advantages:

- Static groups are the only standards-based grouping mechanism. Static groups are therefore interoperable with most client applications and LDAP servers.
- Static groups are preferable to roles for enumerating members.

If you *only* need to enumerate members of a given set, static groups are less costly. Enumerating members of a static group by retrieving the member attribute is easier than recovering all entries that share a role. In Directory Server, significant performance improvements have been made for large multi-valued attributes. Equality matching and modify operations on these attributes are greatly improved, specifically in relation to static groups. Membership testing for group entries has also been improved. These improvements remove some of the previous restrictions on static groups, specifically the restriction on group size.

Directory Server also provides group membership directly in user entries, with the `isMemberOf` operational attribute. This feature applies to static groups only but includes nested groups. For more information, see [“Managing Groups” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*](#).

- Static groups are preferable to roles for management operations such as assigning and removing members.

Static groups are the simplest mechanism for assigning a user to a set or removing a user from a set. Special access rights are not required to add the user to the group.

The right to create the group entry automatically gives you the right to assign members to that group. This is not the case for managed and filtered roles. In these roles, the administrator must also have the right to write the `nsroledn` attribute to the user entry. The same access right restrictions also apply indirectly to nested roles. The ability to create a nested role implies the ability to pull together other roles that have already been defined.

- Dynamic groups are preferable to roles for use in filter-based ACIs.

If you *only* need to find all members based on a filter, such as for designating bind rules in ACIs, use dynamic groups. Although filtered roles are similar to dynamic groups, filtered roles trigger the roles mechanism and generate the virtual `nsRole` attribute. If your client does not need the `nsRole` value, use dynamic groups to avoid the overhead of this computation.

- Groups are preferable to roles for adding or removing sets into or from existing sets.
If you want to add a set to an existing set, or remove a set from an existing set, the groups mechanism is simplest. The groups mechanism presents no nesting restrictions. The roles mechanism only allows nested roles to receive other roles.
- Groups are preferable to roles if flexibility of scope for grouping entries is critical.
Groups are flexible in terms of scope because the scope for possible members is the entire directory, regardless of where the group definition entries are located. Although roles can also extend their scope beyond a given subtree, they can only do so by adding the scope-extending attribute `nsRoleScopeDN` to a nested role.

Advantages of the Roles Mechanism

Roles have the following advantages:

- Roles are preferable to dynamic groups if you want to enumerate members of a set *and* find all sets of which a given entry is a member. Static groups also provide this functionality with the `isMemberOf` attribute.
Roles push membership information out to the user entry where this information can be cached to make subsequent membership tests more efficient. The server performs all computations, and the client only needs to read the values of the `nsRole` attribute. In addition, all types of roles appear in this attribute, allowing the client to process all roles uniformly. Roles can perform both operations more efficiently and with simpler clients than is possible with dynamic groups.
- Roles are preferable to groups if you want to integrate your grouping mechanism with existing Directory Server functionality such as CoS, Password Policy, Account Inactivation, and ACIs.
If you want to use the membership of a set “naturally” in the server, roles are a better option. This implies that you use the membership computations that the server does automatically. Roles can be used in resource-oriented ACIs, as a basis for CoS, as part of more complex search filters, and with Password Policy, Account Inactivation, and so forth. Groups do not allow this kind of integration.

Restricting Permissions on Roles

Be aware of the following issues when using roles:

- The `nsRole` attribute can only be assigned by the roles mechanism. While this attribute cannot be assigned or modified by any directory user, it is potentially *readable* by any directory user. Define access controls to keep this attribute from being read by unauthorized users.
- The `nsRoleDN` attribute defines managed role membership. You need to decide whether users can add or remove themselves from the role. To keep from modifying their own roles, you must define an ACI to that effect.
- Filtered roles determine membership through filters that are based on the existence or the values of attributes in user entries. Assign the user permissions of these attributes carefully to control who can define membership in the filtered role.

Directory Server Class of Service

The Class of Service (CoS) mechanism allows attributes to be shared between entries. CoS values are calculated dynamically when they are requested. For information about CoS, see the following sections:

- “About CoS” on page 183
- “CoS Definition Entries and CoS Template Entries” on page 184
- “Pointer CoS, Indirect CoS, and Classic CoS” on page 186
- “Managing Attributes With Class of Service” on page 190
- “CoS Priorities” on page 195
- “CoS Limitations” on page 195

About CoS

Imagine a directory containing thousands of entries that all have the same value for the `facsimileTelephoneNumber` attribute. Traditionally, to change the fax number, you would update each entry individually, a time consuming job for administrators. Using CoS, the fax number is stored in a single place, and the `facsimileTelephoneNumber` attribute is automatically generated on every entry as it is returned.

To client applications, a CoS attribute is generated in the same ways as any other attribute. However, directory administrators now have only a single fax value to manage. Also, because there are fewer values stored in the directory, the database uses less disk space. The CoS mechanism also allows entries to override a generated value or to generate multiple values for the same attribute.

Note – Because CoS virtual attributes are not indexed, referencing them in an LDAP search filter may have an impact on performance.

Generated CoS attributes can be multivalued. Specifiers can designate several template entries, or there can be several CoS definitions for the same attribute. Alternatively, you can specify template priorities so that only one value is generated from all templates.

Roles and classic CoS can be used together to provide role-based attributes. These attributes appear on an entry because it possesses a particular role with an associated CoS template. You could use a role-based attribute to set the server look through limit on a role-by-role basis, for example.

CoS functionality can be used recursively; you can generate attributes through CoS that depend on other attributes generated through CoS. Complex CoS schemes can simplify client access to information and ease administration of repeated attributes, but they also increase management complexity and degrade server performance. Avoid overly complex CoS schemes; many indirect CoS schemes can be redefined as classic or pointer CoS, for example.

You should also avoid changing CoS definitions more often than necessary. Modifications to CoS definitions do not take effect immediately, because the server caches CoS information. Although caching accelerates read access to generated attributes, when changes to CoS information occur, the server must reconstruct the cache. This task can take some time, usually in the order of seconds. During cache reconstruction, read operations may still access the old cached information, rather than the newly modified information, which means that if you change CoS definitions too frequently, you are likely to be accessing outdated data.

CoS Definition Entries and CoS Template Entries

The CoS mechanism relies on two types of entries, the CoS definition entry and the CoS template entry. This section describes the CoS definition entry and the CoS template entry.

CoS Definition Entry

The CoS definition entry identifies the type of CoS and the names of the CoS attributes that will be generated. Like the role definition entry, the CoS definition entry inherits from the `LDAPsubentry` object class. Multiple definitions may exist for the same CoS attribute, which, as a result, may be multivalued.

The CoS definition entry is an instance of the `cosSuperDefinition` object class. The CoS definition entry 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. By default,

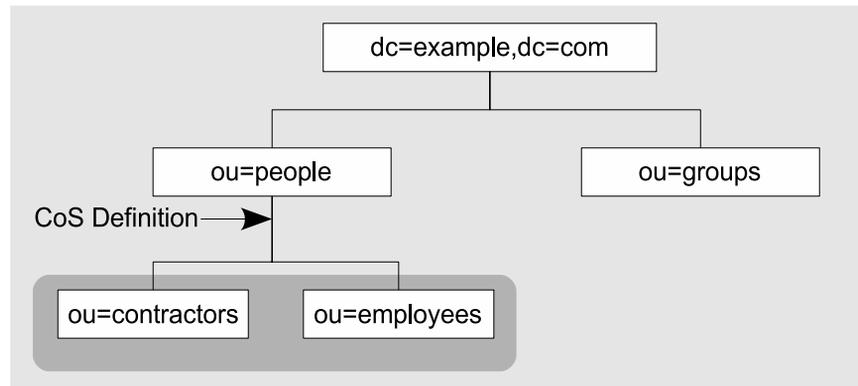
the CoS mechanism will not override the value of an existing attribute with the same name as the CoS attribute. However, the syntax of the CoS definition entry allows you to control this behavior.

When schema checking is turned on, the CoS attribute will be generated on all target entries that allow that attribute. When schema checking is turned off, the CoS attribute will be generated on all target entries.

The location of the definition entry determines the scope of the CoS, which is the entire subtree below the parent of the CoS definition entry. All entries in the branch of the definition entry's parent are called *target entries* for the CoS definition.

The following figure shows a CoS definition entry at the root of the `ou=people` subtree. The scope of the CoS is only the two subtrees beneath the root. The CoS does not extend above this root, or to other subtrees in the DIT.

FIGURE 12-1 CoS Scope



CoS Template Entry

The CoS template entry contains the value that is generated for the CoS attribute. All entries within the scope of the CoS use the values defined here. There may be several templates, each with a different value, in which case the generated attribute may be multivalued. The CoS mechanism selects one of these values based on the contents of both the definition entry and the target entry.

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. You should also name them in a way that suggests the functionality they provide. For example, a definition entry DN such as `"cn=classicCosGenEmployeeType,ou=People,dc=example,dc=com"` is more descriptive than `"cn=ClassicCos1,ou=People,dc=example,dc=com"`. For more information about the object classes and attributes associated with each type of CoS, see [“Class of Service” in Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition](#).

Pointer CoS, Indirect CoS, and Classic CoS

The following types of CoS differ in how the template, and therefore the generated value, is selected:

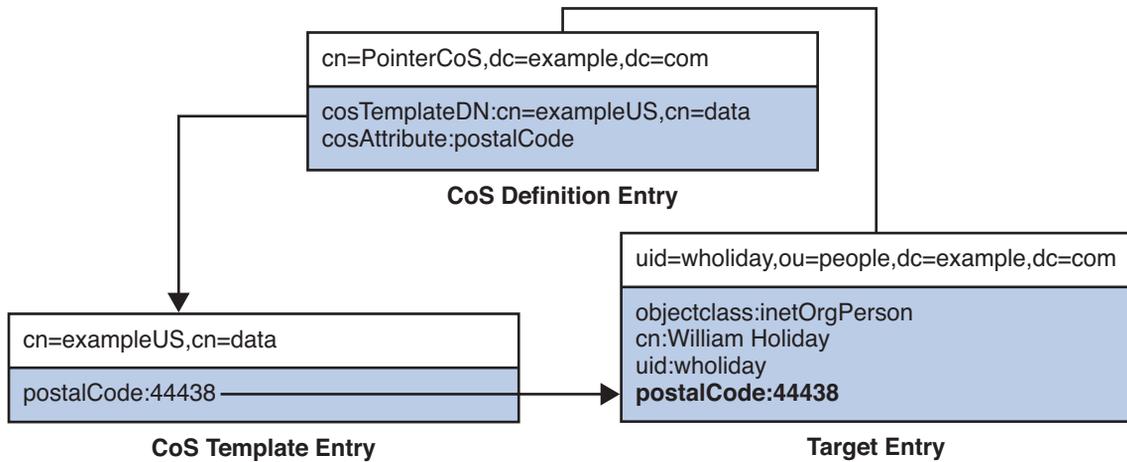
- [“Pointer CoS” on page 186](#)
- [“Indirect CoS” on page 187](#)
- [“Classic CoS” on page 189](#)

Pointer CoS

Pointer CoS is the simplest type of CoS. The pointer CoS definition entry provides the DN of a specific template entry of the `cosTemplate` object class. All target entries have the same CoS attribute value, as defined by this template.

The following figure shows a pointer CoS that defines a common postal code for all of the entries stored under `dc=example,dc=com`. The CoS definition entry, CoS template entry and target entry are indicated.

FIGURE 12-2 Example of a Pointer CoS Definition and Template



The template entry is identified by its DN, `cn=exampleUS,cn=data`, in the CoS definition entry. Each time the `postalCode` attribute is queried on entries under `dc=example,dc=com`, Directory Server returns the value available in the template entry `cn=exampleUS,cn=data`. Therefore, the postal code will appear with the entry `uid=wholiday,ou=people,dc=example,dc=com`, but it is not stored there.

In a scenario where several shared attributes are generated by CoS for thousands or millions of entries, instead of existing as real attributes in each entry, the storage space savings and performance gains provided by CoS are considerable.

Indirect CoS

Indirect CoS allows any entry in the directory to be a template and provide the CoS value. The indirect CoS definition entry identifies an attribute, called the indirect specifier, whose value in a target entry determines the template used for that entry. The indirect specifier attribute in the target entry must contain a DN. With indirect CoS, each target entry may use a different template and thus have a different value for the CoS attribute.

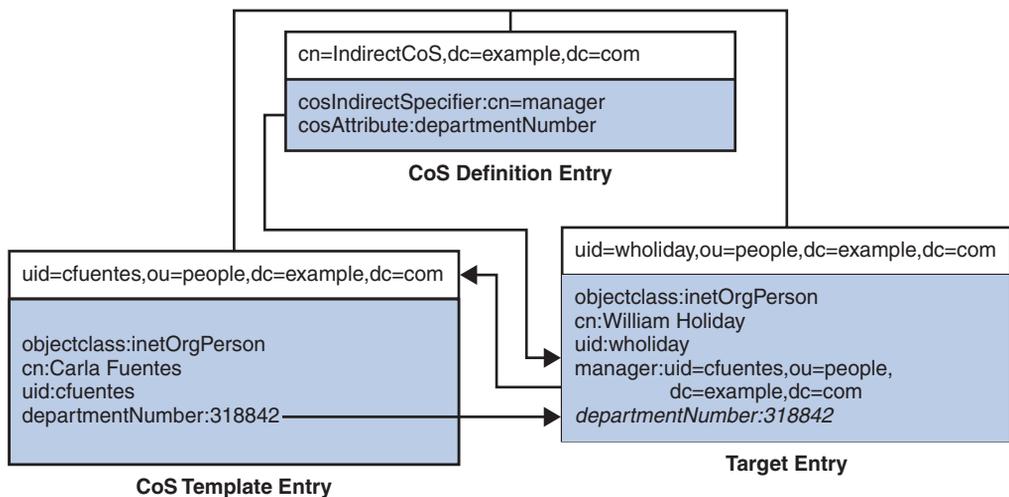
For example, an indirect CoS that generates the `departmentNumber` attribute may use an employee's manager as the specifier. When retrieving a target entry, the CoS mechanism will use the DN value of the manager attribute as the template. It will then generate the `departmentNumber` attribute for the employee using the same value as the manager's department number.

Note – Because templates may be arbitrary entries anywhere in the directory tree, implementing access control for indirect CoS can become extremely complex. In deployments where performance is critical, you should also avoid overusing indirect CoS due to its resource intensive nature.

In many cases, results that are similar to those made possible by indirect CoS can be achieved by limiting the location of the target entries with classic CoS or using the less flexible pointer CoS mechanism.

The following figure shows an indirect CoS that uses the manager attribute of the target entry to identify the template entry. In this way, the CoS mechanism can generate the `departmentNumber` attribute of all employees to be the same as their manager's, ensuring that it is always up to date.

FIGURE 12-3 Example of an Indirect CoS Definition and Template



The indirect CoS definition entry names the specifier attribute, which in this example, is the manager attribute. William Holiday's entry is one of the target entries of this CoS, and his manager attribute contains the DN of `uid=cfuentes,ou=people,dc=example,dc=com`. Therefore, Carla Fuentes's entry is the template, which in turn provides the `departmentNumber` attribute value of 318842.

Classic CoS

Classic CoS combines the pointer and indirect CoS behavior. The classic CoS definition entry identifies the base DN of the template and a specifier attribute. The value of the specifier attribute in the target entries is then used to construct the DN of the template entry as follows:

```
cn=specifierValue, baseDN
```

The template containing the CoS values is determined by the combination of the RDN (relative distinguished name) value of the specifier attribute in the target entry and the template's base DN.

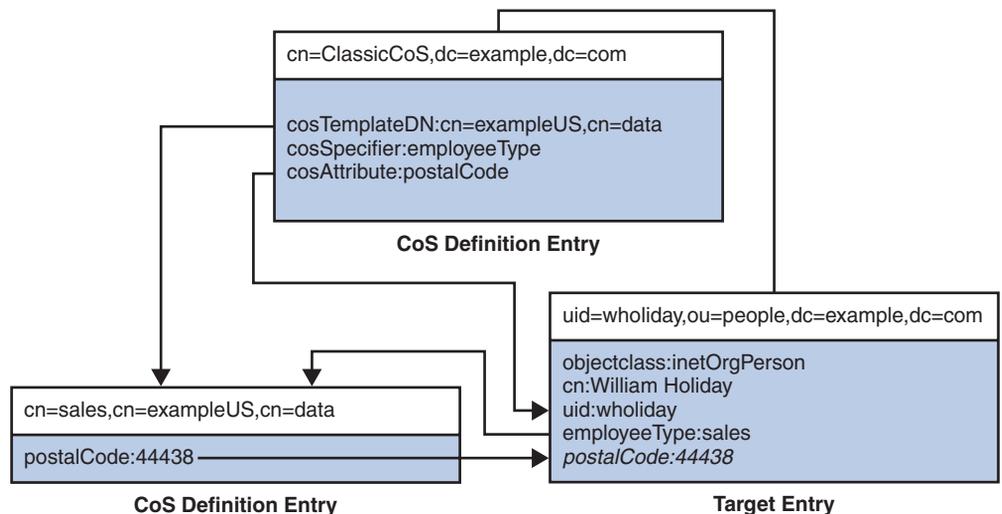
Classic CoS templates are entries of the `cosTemplate` object class to avoid the performance issue associated with arbitrary indirect CoS templates.

The classic CoS mechanism determines the DN of the template from the base DN given in the definition entry and the specifier attribute in the target entry. The value of the specifier attribute is taken as the `cn` value in the template DN. Template DNs for classic CoS must therefore have the following structure:

```
cn=specifierValue, baseDN
```

The following figure shows a classic CoS definition that generates a value for the postal code attribute.

FIGURE 12-4 Example of a Classic CoS Definition and Template



In this example, the `cosSpecifier` attribute names the `employeeType` attribute. The combination of the `cosSpecifier` attribute and the template DN identifies the template entry as `cn=sales, cn=exampleUS, cn=data`. The template entry then provides the value of the `postalCode` attribute to the target entry.

Managing Attributes With Class of Service

The Class of Service (CoS) mechanism allows attributes to be shared between entries. Like the role mechanism, CoS generates virtual attributes on the entries as the entries are retrieved. CoS does not define membership, but it does allow related entries to share data for coherency and space considerations. CoS values are calculated dynamically when the values are requested. CoS functionality and the various types of CoS are described in detail in the [Oracle Fusion Middleware Reference for Oracle Directory Server Enterprise Edition](#).

The following sections examine the ways in which you can use the CoS functionality as intended, while avoiding performance pitfalls:

- “Using CoS When Many Entries Share the Same Value” on page 190
- “Using CoS When Entries Have Natural Relationships” on page 191
- “Avoiding Excessive CoS Definitions” on page 195

Note – CoS generation always impacts performance. Client applications that search for more attributes than they actually need can compound the problem.

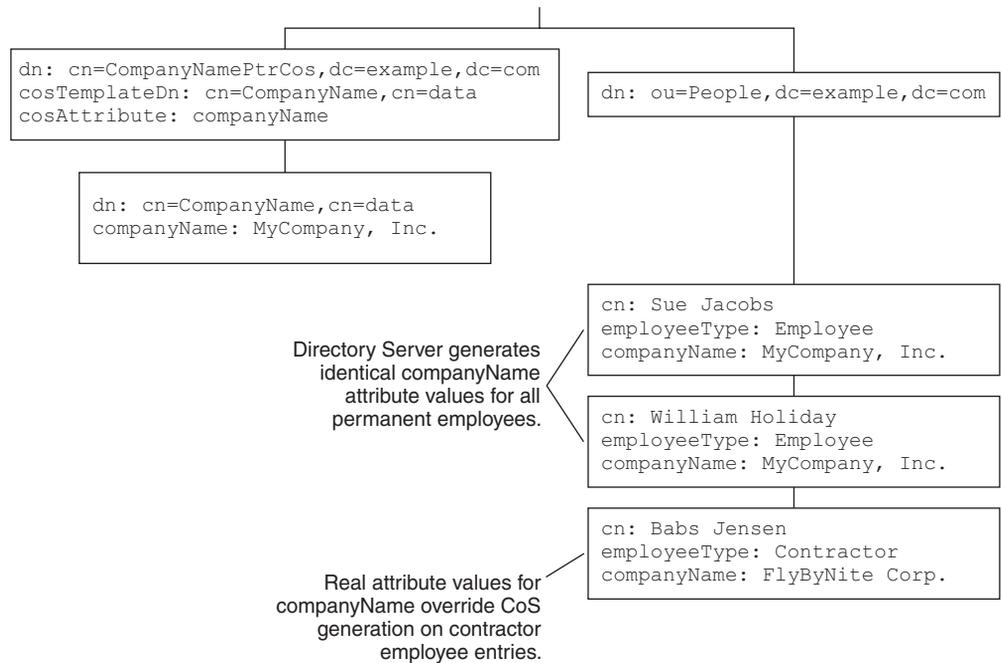
If you can influence how client applications are written, remind developers that client applications perform much better when looking up only those attribute values that they actually need.

Using CoS When Many Entries Share the Same Value

CoS provides substantial benefits for relatively low cost when you need the same attribute value to appear on numerous entries in a subtree.

Imagine, for example, a directory for MyCompany, Inc. in which every user entry under `ou=People` has a `companyName` attribute. Contractors have real values for `companyName` attributes on their entries, but all regular employees have a single CoS-generated value, `MyCompany, Inc.`, for `companyName`. The following figure demonstrates this example with pointer CoS. Notice that CoS generates `companyName` values for all permanent employees without overriding real, not CoS-generated, `companyName` values stored for contractor employees. The company name is generated only for those entries for which `companyName` is an allowed attribute.

FIGURE 12-5 Generating CompanyName With Pointer CoS



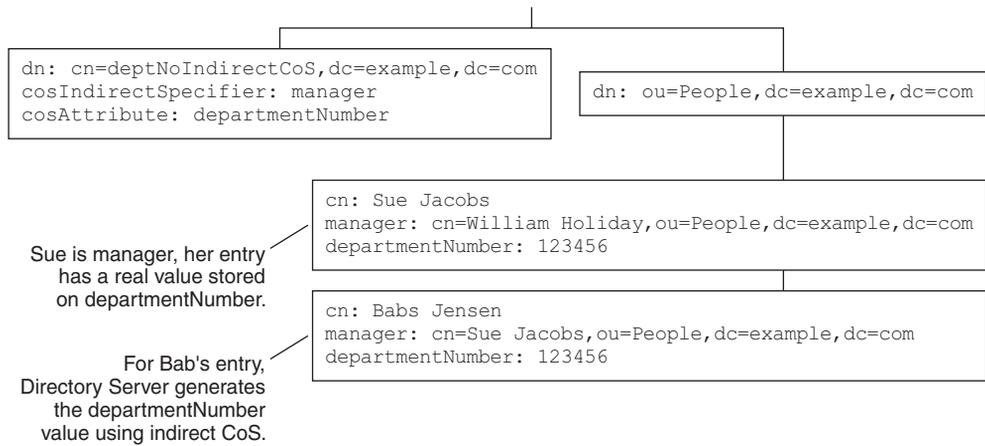
In cases where many entries share the same value, pointer CoS works particularly well. The ease of maintaining `companyName` for permanent employees offsets the additional processing cost of generating attribute values. Deep directory information trees (DITs) tend to bring together entries that share common characteristics. Pointer CoS can be used in deep DITs to generate common attribute values by placing CoS definitions at appropriate branches in the tree.

Using CoS When Entries Have Natural Relationships

CoS also provides substantial data administration benefits when directory data has natural relationships.

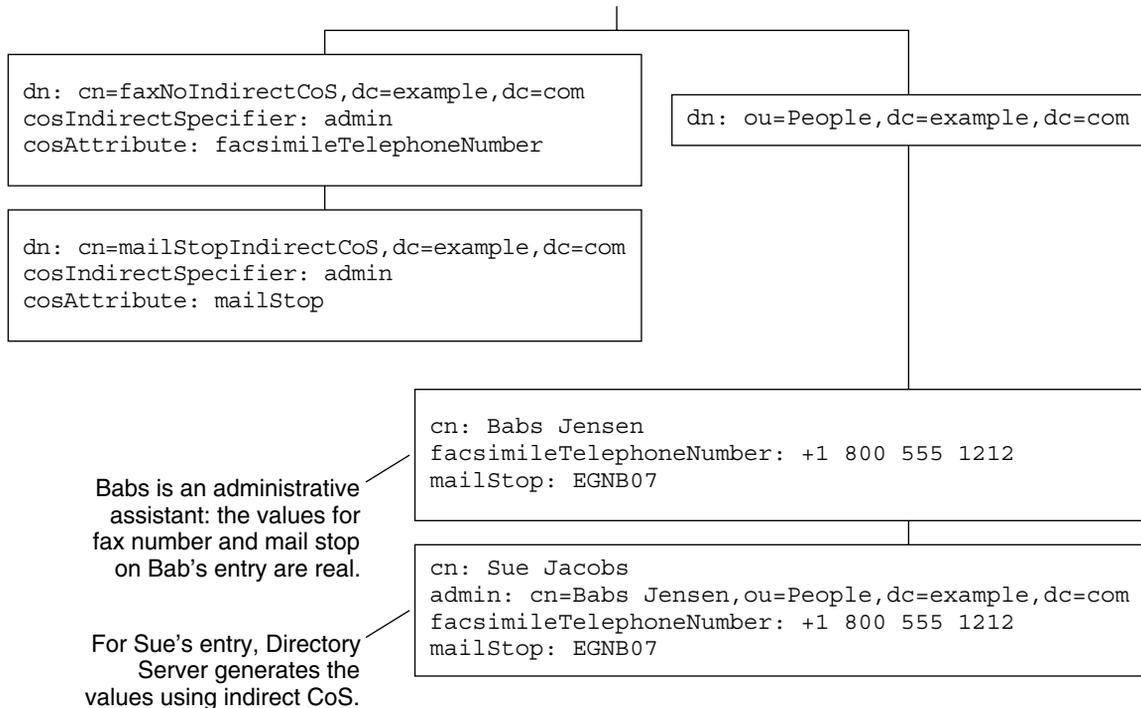
Consider an enterprise directory in which every employee has a manager. Every employee shares a mail stop and fax number with the nearest administrative assistant. [Figure 12-6](#) demonstrates the use of indirect CoS to retrieve the department number from the manager entry. In [Figure 12-7](#), the mail stop and fax number are retrieved from the administrative assistant entry.

FIGURE 12-6 Generating DepartmentNumber With Indirect CoS



In this implementation, the manager's entry has a real value for departmentNumber, and this real value overrides any generated value. Directory Server does not generate attribute values from CoS-generated attribute values. Thus, in the [Figure 12-6](#) example, the department number attribute value needs to be managed only on the manager's entry. Likewise, for the example shown in [Figure 12-7](#), mail stop and fax number attributes need to be managed only on the administrative assistant's entry.

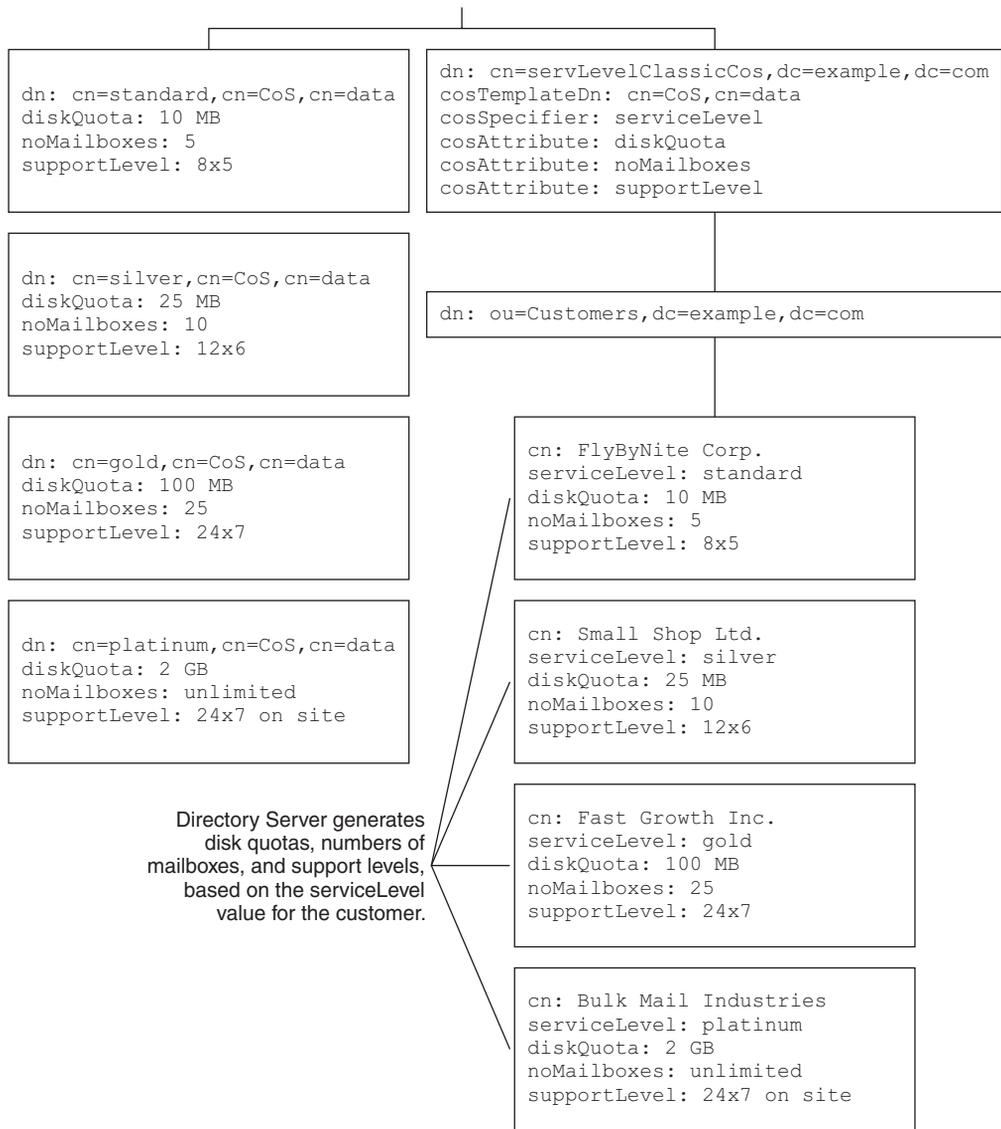
FIGURE 12-7 Generating Mail Stop and Fax Number With Indirect CoS



A single CoS definition entry can be used to exploit relationships such as these for many different entries in the directory.

Another natural relationship is service level. Consider an Internet service provider that offers customers standard, silver, gold, and platinum packages. A customer's disk quota, number of mailboxes, and rights to prepaid support levels depend on the service level purchased. The following figure demonstrates how a classic CoS scheme enables this functionality.

FIGURE 12-8 Generating Service-Level Data With Classic CoS



One CoS definition might be associated with multiple CoS template entries.

Avoiding Excessive CoS Definitions

Directory Server optimizes CoS when one classic CoS definition entry is associated with multiple CoS template entries. Directory Server does not optimize CoS if many CoS definitions potentially apply. Instead, Directory Server checks each CoS definition to determine whether the definition applies. This behavior leads to performance problems if you have thousands of CoS definitions.

This situation can arise in a modified version of the example shown in [Figure 12–8](#). Consider an Internet service provider that offers customers delegated administration of their customers' service level. Each customer provides definition entries for standard, silver, gold, and platinum service levels. Ramping up to 1000 customers means creating 1000 classic CoS definitions. Directory Server performance would be affected as it runs through the list of 1000 CoS definitions to determine which apply. If you must use CoS in this sort of situation, consider indirect CoS. In indirect CoS, customers' entries identify the entries that define their class of service allotments.

When you start approaching the limit of having different CoS schemes for every target entry or two, you are better off updating the real values. You then achieve better performance by reading real, not CoS-generated values.

CoS Priorities

It is possible to create CoS schemes that compete with each other to provide an attribute value. For example, you might have a multivalued `cosSpecifier` in your CoS definition entry. In such a case, you can specify a template priority on each template entry to determine which template provides the attribute value. Set the template priority using the `cosPriority` attribute. This attribute represents the global priority of a particular template numerically. A priority of zero is the highest possible priority.

Templates that contain no `cosPriority` attribute are considered the lowest possible priority. In the case where two or more templates are considered to supply an attribute value and they have the same (or no) priority, a value is chosen arbitrarily. Directory Server can be configured to log messages when it is forced to choose a template arbitrarily.

CoS Limitations

The CoS functionality is a complex mechanism which, for performance and security reasons, is subject to the following limitations:

- Restricted subtrees
You cannot create CoS definitions in either the `cn=config` or `cn=schema` subtrees.
- Unindexed searches

Searches in suffixes where an attribute is declared as a CoS-generated attribute will result in an unindexed search. This may have a significant impact on performance. In suffixes where the same attribute is NOT declared as a CoS attribute, the search will be indexed.

- Restricted attribute types

The following attributes should not be generated by CoS because they do not have the same behavior as real attributes of the same name.

- `userPassword` - A CoS-generated password value cannot be used to bind to Directory Server.
- `aci` - Directory Server will not apply any access control based on the contents of a virtual ACI value defined by CoS.
- `objectClass` - 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.

- 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. Templates and the values they contain cannot be retrieved through directory chaining or referrals.

- CoS virtual values cannot be combined with real values

The values of a CoS attribute are never a combination of real values from the entry and virtual values from the templates. When the CoS overrides a real attribute value, it replaces all real values with those from the templates. However, the CoS mechanism can combine virtual values from several CoS definition entries. For more information, see “CoS Limitations” in the *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

- Filtered roles cannot use CoS-generated attributes

The filter string of a filtered role cannot be based on the values of a CoS virtual attribute. However, the specifier attribute in a CoS definition may reference the `nsRole` attribute generated by a role definition. For more information, see “Creating Role-Based Attributes” in the *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

- Access Control Instructions (ACIs)

The server controls access to attributes generated by a CoS in exactly the same way as regular, stored attributes. However, access control rules that depend on the value of attributes generated by CoS are subject to the conditions described in “CoS Limitations” on [page 195](#).

- CoS cache latency

The CoS cache is an internal structure that keeps all CoS data in memory to improve performance. This cache is optimized for retrieving CoS data to be used in computing virtual attributes, even while CoS definition and template entries are being updated. Therefore, once definition and template entries have been added or modified, there may be a slight delay before they are taken into account. This delay depends on the number and complexity of CoS definitions, as well as the current server load, but it is usually in the order of a few seconds. Consider this latency before designing overly complex CoS configurations.

Directory Server DSMLv2

For information about DSMLv2 in Directory Server, see the following sections:

- “Introduction to DSML” on page 199
- “Implementation of the DSMLv2 Standard” on page 201
- “DSML Security” on page 201
- “DSML Identity Mapping” on page 201
- “Content of the HTTP Header” on page 204
- “Accessing the Directory Using DSMLv2” on page 204

Introduction to DSML

Directory Services Markup Language version 2, DSMLv2, is a markup language that describes directory operations in an eXtensible Markup Language (XML) document. For information about the DSMLv2 standard, see *Directory Services Markup Language (DSML) v2.0 [OASIS 200201]* at <http://www.oasis-open.org/specs>.

The complete DSMLv2 specification and supporting documentation can be found at the following locations:

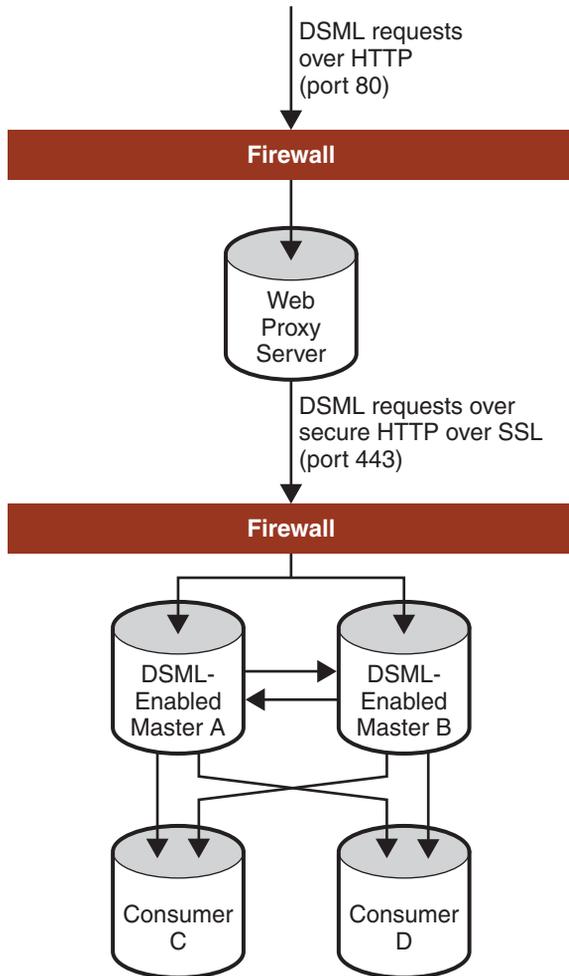
- <http://www.oasis-open.org/committees/dsml/docs/DSMLv2.xsd>
- <http://www.oasis-open.org/committees/dsml/docs/DSMLv2.doc>

Directory Server supports DSMLv2 SOAP over HTTP binding. DSML requests and responses are embedded in the body of SOAP v1.1, and transported in an HTTP/1.1 payload.

The Directory Server Resource Kit contains tools for searching and modifying directories using DSMLv2. See `dsmlsearch(1)` and `dsmlmodify(1)`.

By using DSML, non-LDAP clients can perform directory operations. The following figure shows an example deployment where a non-LDAP client makes a requests to modify data on DSML-enabled directory servers.

FIGURE 13-1 Sample DSML-Enabled Directory Deployment



In the example deployment, update requests in DSML arrive from non-LDAP client applications cross a firewall over HTTP port 80. The web proxy server enforces the use of secure HTTP over port 443 for the requests to cross a second firewall and enter the intranet domain. The requests are then processed by the two master replicas on Master A and Master B, before being replicated to the non-DSML enabled Consumers C and D.

Implementation of the DSMLv2 Standard

The Directory Server implementation of the DSMLv2 specification has the following restrictions:

Bindings	DSMLv2 defines two normative bindings: a SOAP request/response binding and a file binding that serves as the DSMLv2 analog of LDIF. Directory Server supports the SOAP request/response binding.
Modify DN	Directory Server supports the DSML <code>modDNRequest</code> and <code>modDNResponse</code> operations.
Abandon request	Directory Server does not support the <code>abandonRequest</code> operation, because this operation is of no use over HTTP.
Search operations	Some DSML clients incorrectly send an equality match with value * when a presence match is intended. Directory Server will return zero results from these badly formatted queries. You can detect these incorrect clients by searching for the characters <code>=\2a</code> in the access log.

DSML Security

The DSML front end constitutes a restricted HTTP server; it accepts only DSML post operations, it rejects requests that do not conform to the DSMLv2 SOAP binding specifications.

The security of DSML is configured by the following server properties `dsml-client-auth-mode`, `dsml-port`, `dsml-secure-port`, and `dsml-relative-root-url`. For information about these properties, see [server\(5dsconf\)](#).

For additional security, consider the following.

- Protect DSML-enabled directory servers by implementing a firewall.
- If you do not impose the use of HTTP over SSL on your clients, implement a demilitarized zone.

DSML Identity Mapping

Identity mapping is required for the following mechanisms: DSML over HTTP, DIGEST-MD5, and GSSAPI SASL. Identity mapping is used 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 the following containers for the protocols that 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 how to extract credentials about the protocol to use them in a search operation. If a search returns a single user entry, the mapping has succeeded and the connection uses the mapping entry as the bind DN for all operations. If the search returns zero or more than one entry, the mapping fails and the connection does not use the mapping entry as the bind DN.

The protocols that perform identity mapping must have a default mapping. Additionally, The protocols can have 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. If the default mapping fails, authentication of the client fails.

A mapping entry must contain the object classes `top`, `container`, and `dsIdentityMapping`.

The entry can 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, including all naming contexts, but excluding `cn=config`, `cn=monitor`, and `cn=schema`.

`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 4515 on <http://www.ietf.org/rfc/rfc4515.txt>.

Additionally, a mapping entry may also contain the `dsPatternMatching` object class which allows it to use the following attributes:

`dsMatching-pattern`: *patternString*

A string on which to perform pattern matching.

`dsMatching-regexp`: *regularExpression*

A regular expression to apply to the pattern string.

All of the attribute values above, except for `dsSearchScope` may contain placeholders of the format `${keyword}`, where *keyword* is the name of an element in the protocol-specific credentials. During mapping, the placeholder is substituted for the actual value of the element provided by the client.

After all of the placeholders have been substituted, the pattern matching is performed. The matching pattern is compared to the regular expression, as follows.

- If the regular expression does not match the pattern string, the mapping fails.
- If the regular expression does match the pattern string, the matching values of the regular expression terms in parentheses are available as numbered placeholders 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 following 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` by using the POSIX `regexexec(3C)` and `regcomp(3C)` function calls. Directory Server uses extended regular expressions and all comparisons are case insensitive. For more information, refer to the man pages for these functions.

The attribute values that can contain placeholders must encode any `$`, `{`, and `}` characters that are not part of a placeholder, even if no placeholder is used. You must encode these characters with the following values: `$` as `\\24`, `{` as `\\7B`, and `}` as `\\7D`.

The use of placeholders and substitutions allows you to create mappings that extract a username or any other value from the protocol-specific credentials. The credential can be used to define a mapped DN or perform a search for a corresponding DN anywhere in the directory.



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. Always try to map client connections to specific users according to the client credentials.

Content of the HTTP Header

Directory Server supports the HTTP POST operation only. The following example shows the minimum fields required to send a DSML request to the server over HTTP:

```
POST /dsml HTTP/1.1
content-length: 450
HOST: hostname
SOAPAction: ""
Content-Type: text/xml
Connection: close
```

The `Connection` field is optional. In HTTP 1.0, the default value of this field is `close`. In HTTP 1.1, however, the default value is `keep-alive`. It is therefore recommended that you include this field with a value of `close` in your last request if you are using HTTP 1.1, to accelerate the dialog.

Additional fields may be included in the HTTP header. If they are supported by Directory Server, their values will override the defaults. If the fields are not supported, the request is not rejected by the server but the fields are ignored.

Accessing the Directory Using DSMLv2

The following examples indicate how to use DSML requests to access and search the directory.

- [“An Empty Anonymous DSML Ping Request” on page 204](#)
- [“Issuing a DSML Request to Bind as a Particular User” on page 207](#)
- [“A DSML Search Request” on page 208](#)

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 [“Configuring DSML” in *Oracle Fusion Middleware Administration Guide for Oracle Directory*](#)

Server Enterprise Edition. To check whether the DSML front end is enabled, send an empty DSML batch request, as shown in [Example 13-1](#).

EXAMPLE 13-1 Empty Anonymous DSML Request

```
POST /dsml HTTP/1.1
content-length: 451
HOST: hostname
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: hostname` 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 prologue 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 name spaces.

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, as shown in [Example 13-2](#).

EXAMPLE 13-2 Empty Anonymous DSML Response

```
HTTP/1.1 200 OK
Cache-control: no-cache
Connection: close
Date: Mon, 11 Dec 2006 13:56:49 GMT
Accept-Ranges: none
Server: Directory Server Enterprise Edition/11g Release 1 (11.1.1)
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 `dsml-max-parser-count` and `dsml-min-parser-count` server properties and the request size limit by the server property `dsml-request-max-size`. See [server\(5dsconf\)](#).

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, as shown in [Example 13-3](#).

EXAMPLE 13-3 DSML Extended Operation: Bind as a Particular User

```
POST /dsml HTTP/1.1
content-length: 578
content-type: text/xml; charset="utf-8"
HOST: hostname
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 user ID `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.

The response to the DSML extended operation shows the DN of the user that made the bind request. In [Example 13-4](#), the `whoami` response, which contains the DN, is shown in the response line.

```
<response>dn:uid=easter,ou=people,dc=example,dc=com</response>
```

EXAMPLE 13-4 Response to DSML Extended Operation

```
HTTP/1.1 200 OK
Cache-control: no-cache
Connection: close
Date: Fri, 15 Dec 2006 09:15:09 GMT
Accept-Ranges: none
Server: Directory Server Enterprise Edition/11g Release 1 (11.1.1)
```

EXAMPLE 13-4 Response to DSML Extended Operation *(Continued)*

```

Content-Type: text/xml; charset="utf-8"
Content-Length: 697

<?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'
  \>
  <extendedResponse\>
    <resultCode code='0' descr='success'/\>
    <responseName\>1.3.6.1.4.1.4203.1.11.3</responseName\>
    <response\>dn:uid=easter,ou=people,dc=example,dc=com</response\>
  </extendedResponse\>
</batchResponse\>
</soap-env:Body\>
</soap-env:Envelope\>

```

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

[Example 13-5](#) shows a DSML base object search request on the root DSE entry.

EXAMPLE 13-5 DSML Search Request

```

POST /dsml HTTP/1.1
HOST: hostname
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\>

```

EXAMPLE 13-5 DSML Search Request (Continued)

```

<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\>

```

- `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\>

```

EXAMPLE 13-6 DSML Search Response

```

HTTP/1.1 200 OK
Cache-control: no-cache
Connection: close
Date: Fri, 15 Dec 2006 09:21:43 GMT
Accept-Ranges: none
Server: Directory Server Enterprise Edition/11g Release 1 (11.1.1)
Content-Type: text/xml; charset="utf-8"
Content-Length: 1287

<?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='Batch of search requests'
  \>
  <searchResponse requestID='search on Root DSE'\>
    <searchResultEntry\>
      <attr name='namingContexts'\>
        <value\>dc=example,dc=com</value\>
      </attr\>
      <attr name='supportedLDAPVersion'\>
        <value\>2</value\>
        <value\>3</value\>
      </attr\>
      <attr name='vendorName'\>
        <value\>Sun Microsystems, Inc.</value\>
      </attr\>
      <attr name='vendorVersion'\>
        <value\>Directory Server Enterprise Edition/11g Release 1 (11.1.1)</value\>
      </attr\>
      <attr name='supportedSASLMechanisms'\>
        <value\>EXTERNAL</value\>
        <value\>GSSAPI</value\>
        <value\>DIGEST-MD5</value\>
      </attr\>
    </searchResultEntry\>
    <searchResultDone\>
      <resultCode code='0' descr='success'/\>
    </searchResultDone\>
  </searchResponse\>
</batchResponse\>
</soap-env:Body\>
</soap-env:Envelope\>

```

Directory Server Internationalization Support

Directory Server provides support for storing, managing, and searching for entries and their associated attributes in different languages.

Data inside the internationalized directory is stored in UTF-8 format. Therefore, Directory Server supports all international characters by default. The internationalized directory can be used to specify matching rules and collation orders based on language preferences in search operations. For information about the internationalized directory, see the following sections:

- [“About Locales” on page 211](#)
- [“Identifying Supported Locales” on page 212](#)
- [“Supported Language Subtypes” on page 218](#)

About Locales

A locale identifies language-specific information about how users in a specific region, culture, or custom expect data to be presented. Locales define how data in different languages is interpreted, sorted, and collated. Directory Server supports multiple languages through the use of locales.

A locale specifies the following information.

Code page

The code page is an internal table used by an operating system to relate keyboard keys to character fonts displayed on a screen. A locale can indicate what code page an application should select for interaction with an end user.

Collation order

The collation order provides information about how the characters of a given language should be sorted. The collation order specifies the following information:

- The sequence of the letters in the alphabet
- How to compare letters with accents to letters without accents

- Whether there are characters that can be ignored when comparing strings
- The direction, left to right, right to left, or up and down, in which the language is read

Character type

The character type distinguishes alphabetic characters from numeric or other characters. It defines the mapping of uppercase letters to lowercase letters. For example, in some languages, the pipe character (|) is considered punctuation, while in other languages it is considered as alphabetic.

Monetary format

The monetary format specifies the following information: the monetary symbol used in a region, whether the symbol goes before or after its value, and how monetary units are represented.

Time and date formats

The time and date formats determine the appearance of times and dates in a region. The time format indicates whether the locale uses a 12-hour clock or 24-hour clock. The date format includes both the short date order and the long date format, and include the names of months and days of the week in each language.

Identifying Supported Locales

When you perform directory operations that require you to specify a locale, such as a search operation, you can use a language tag or a collation order object identifier, OID.

A language tag is a string that begins with the two-character lowercase language code that identifies the language, as defined in ISO standard 639. If necessary to distinguish regional differences in language, the language tag may also contain a country code, which is a two-character string, as defined in ISO standard 3166. The language code and country code are separated by a hyphen. For example, the language tag used to identify the American English locale is en-US.

An OID is a decimal number that uniquely identifies an object, such as an attribute or object class.

When you perform an international search in a directory, use either the language tag or the OID to identify the collation order you want to use. When you set up an international index, use the OIDs.

The following table lists the locales supported by Directory Server. It identifies the associated language tags and OIDs.

TABLE 14-1 Supported Locales

Locale	Tag	Collation Order OID	Backward Compatible OID
Afrikaans	af	1.3.6.1.4.1.42.2.27.9.4.1.1	
Amharic Ethiopia	am	1.3.6.1.4.1.42.2.27.9.4.2.1	
Arabic	ar	1.3.6.1.4.1.42.2.27.9.4.3.1	2.16.840.1.113730.3.3.2.1.1
Arabic United Arab Emirates	ar-AE	1.3.6.1.4.1.42.2.27.9.4.4.1	
Arabic Bahrain	ar-BH	1.3.6.1.4.1.42.2.27.9.4.5.1	
Arabic Algeria	ar-DZ	1.3.6.1.4.1.42.2.27.9.4.6.1	
Arabic Egypt	ar-EG	1.3.6.1.4.1.42.2.27.9.4.7.1	
Arabic India	ar-IN	1.3.6.1.4.1.42.2.27.9.4.8.1	
Arabic Iraq	ar-IQ	1.3.6.1.4.1.42.2.27.9.4.9.1	
Arabic Jordan	ar-JO	1.3.6.1.4.1.42.2.27.9.4.10.1	
Arabic Kuwait	ar-KW	1.3.6.1.4.1.42.2.27.9.4.11.1	
Arabic Lebanon	ar-LB	1.3.6.1.4.1.42.2.27.9.4.12.1	
Arabic Libya	ar-LY	1.3.6.1.4.1.42.2.27.9.4.13.1	
Arabic Morocco	ar-MA	1.3.6.1.4.1.42.2.27.9.4.14.1	
Arabic Oman	ar-OM	1.3.6.1.4.1.42.2.27.9.4.15.1	
Arabic Qatar	ar-QA	1.3.6.1.4.1.42.2.27.9.4.16.1	
Arabic Saudi Arabia	ar-SA	1.3.6.1.4.1.42.2.27.9.4.17.1	
Arabic Sudan	ar-SD	1.3.6.1.4.1.42.2.27.9.4.18.1	
Arabic Syria	ar-SY	1.3.6.1.4.1.42.2.27.9.4.19.1	
Arabic Tunisia	ar-TN	1.3.6.1.4.1.42.2.27.9.4.20.1	
Arabic Yemen	ar-YE	1.3.6.1.4.1.42.2.27.9.4.21.1	
Byelorussian	be	1.3.6.1.4.1.42.2.27.9.4.22.1	2.16.840.1.113730.3.3.2.2.1
Bulgarian	bg	1.3.6.1.4.1.42.2.27.9.4.23.1	2.16.840.1.113730.3.3.2.3.1
Bengali India	bn	1.3.6.1.4.1.42.2.27.9.4.24.1	
Catalan	ca	1.3.6.1.4.1.42.2.27.9.4.25.1	2.16.840.1.113730.3.3.2.4.1
Czech	cs	1.3.6.1.4.1.42.2.27.9.4.26.1	2.16.840.1.113730.3.3.2.5.1
Danish	da	1.3.6.1.4.1.42.2.27.9.4.27.1	2.16.840.1.113730.3.3.2.6.1

TABLE 14-1 Supported Locales (Continued)

Locale	Tag	Collation Order OID	Backward Compatible OID
German	de or de-DE	1.3.6.1.4.1.42.2.27.9.4.28.1	2.16.840.1.113730.3.3.2.7.1
German Austria	de-AT	1.3.6.1.4.1.42.2.27.9.4.29.1	2.16.840.1.113730.3.3.2.8.1
German Belgium	de-BE	1.3.6.1.4.1.42.2.27.9.4.30.1	
German Swiss	de-CH	1.3.6.1.4.1.42.2.27.9.4.31.1	2.16.840.1.113730.3.3.2.9.1
German Luxembourg	de-LU	1.3.6.1.4.1.42.2.27.9.4.32.1	
Greek	el	1.3.6.1.4.1.42.2.27.9.4.33.1	2.16.840.1.113730.3.3.2.10.1
English (US)	en-US	1.3.6.1.4.1.42.2.27.9.4.34.1	2.16.840.1.113730.3.3.2.11.1
English Australian	en-AU	1.3.6.1.4.1.42.2.27.9.4.35.1	
English Canada	en-CA	1.3.6.1.4.1.42.2.27.9.4.36.1	2.16.840.1.113730.3.3.2.12.1
English Great Britain	en-GB	1.3.6.1.4.1.42.2.27.9.4.37.1	2.16.840.1.113730.3.3.2.13.1
English Hong Kong	en-HK	1.3.6.1.4.1.42.2.27.9.4.38.1	
English Ireland	en-IE	1.3.6.1.4.1.42.2.27.9.4.39.1	2.16.840.1.113730.3.3.2.14.1
English India	en-IN	1.3.6.1.4.1.42.2.27.9.4.40.1	
English Malta	en-MT	1.3.6.1.4.1.42.2.27.9.4.41.1	
English New Zealand	en-NZ	1.3.6.1.4.1.42.2.27.9.4.42.1	
English Philippines	en-PH	1.3.6.1.4.1.42.2.27.9.4.43.1	
English Singapore	en-SG	1.3.6.1.4.1.42.2.27.9.4.44.1	
English Virgin Island	en-VI	1.3.6.1.4.1.42.2.27.9.4.45.1	
English South Africa	en-ZA	1.3.6.1.4.1.42.2.27.9.4.46.1	
English Zimbabwe	en-ZW	1.3.6.1.4.1.42.2.27.9.4.47.1	
Esperanto	eo	1.3.6.1.4.1.42.2.27.9.4.48.1	
Spanish	es or es-ES	1.3.6.1.4.1.42.2.27.9.4.49.1	2.16.840.1.113730.3.3.2.15.1
Spanish Argentina	es-AR	1.3.6.1.4.1.42.2.27.9.4.50.1	
Spanish Bolivia	es-BO	1.3.6.1.4.1.42.2.27.9.4.51.1	
Spanish Chile	es-CL	1.3.6.1.4.1.42.2.27.9.4.52.1	
Spanish Colombia	es-CO	1.3.6.1.4.1.42.2.27.9.4.53.1	

TABLE 14-1 Supported Locales (Continued)

Locale	Tag	Collation Order OID	Backward Compatible OID
Spanish Costa Rica	es-CR	1.3.6.1.4.1.42.2.27.9.4.54.1	
Spanish Dominican Rep.	es-DO	1.3.6.1.4.1.42.2.27.9.4.55.1	
Spanish Ecuador	es-EC	1.3.6.1.4.1.42.2.27.9.4.56.1	
Spanish Guatemala	es-GT	1.3.6.1.4.1.42.2.27.9.4.57.1	
Spanish Honduras	es-HN	1.3.6.1.4.1.42.2.27.9.4.58.1	
Spanish Mexico	es-MX	1.3.6.1.4.1.42.2.27.9.4.59.1	
Spanish Nicaragua	es-NI	1.3.6.1.4.1.42.2.27.9.4.60.1	
Spanish Panama	es-PA	1.3.6.1.4.1.42.2.27.9.4.61.1	
Spanish Peru	es-PE	1.3.6.1.4.1.42.2.27.9.4.62.1	
Spanish Puerto Rico	es-PR	1.3.6.1.4.1.42.2.27.9.4.63.1	
Spanish Paraguay	es-PY	1.3.6.1.4.1.42.2.27.9.4.64.1	
Spanish El Salvador	es-SV	1.3.6.1.4.1.42.2.27.9.4.65.1	
Spanish US	es-US	1.3.6.1.4.1.42.2.27.9.4.66.1	
Spanish Uruguay	es-UY	1.3.6.1.4.1.42.2.27.9.4.67.1	
Spanish Venezuela	es-VE	1.3.6.1.4.1.42.2.27.9.4.68.1	
Estonian	et	1.3.6.1.4.1.42.2.27.9.4.69.1	2.16.840.1.113730.3.3.2.16.1
Basque	eu	1.3.6.1.4.1.42.2.27.9.4.70.1	
Persian	fa	1.3.6.1.4.1.42.2.27.9.4.71.1	
Persian India	fa-IN	1.3.6.1.4.1.42.2.27.9.4.72.1	
Persian Iran	fa-IR	1.3.6.1.4.1.42.2.27.9.4.73.1	
Finnish	fi	1.3.6.1.4.1.42.2.27.9.4.74.1	2.16.840.1.113730.3.3.2.17.1
Faeroese	fo	1.3.6.1.4.1.42.2.27.9.4.75.1	
French	fr or fr-FR	1.3.6.1.4.1.42.2.27.9.4.76.1	2.16.840.1.113730.3.3.2.18.1
French Belgium	fr-BE	1.3.6.1.4.1.42.2.27.9.4.77.1	2.16.840.1.113730.3.3.2.19.1
French Canada	fr-CA	1.3.6.1.4.1.42.2.27.9.4.78.1	2.16.840.1.113730.3.3.2.20.1
French Swiss	fr-CH	1.3.6.1.4.1.42.2.27.9.4.79.1	2.16.840.1.113730.3.3.2.21.1
French Luxembourg	fr-LU	1.3.6.1.4.1.42.2.27.9.4.80.1	
Irish	ga	1.3.6.1.4.1.42.2.27.9.4.81.1	

TABLE 14-1 Supported Locales (Continued)

Locale	Tag	Collation Order OID	Backward Compatible OID
Galician	gl	1.3.6.1.4.1.42.2.27.9.4.82.1	
Gujarati	gu	1.3.6.1.4.1.42.2.27.9.4.83.1	
Manx Gaelic (Isle of Man)	gv	1.3.6.1.4.1.42.2.27.9.4.84.1	
Hebrew	he or iw	1.3.6.1.4.1.42.2.27.9.4.85.1	2.16.840.1.113730.3.3.2.27.1
Hindi	hi	1.3.6.1.4.1.42.2.27.9.4.86.1	
Croatian	hr	1.3.6.1.4.1.42.2.27.9.4.87.1	2.16.840.1.113730.3.3.2.22.1
Hungarian	hu	1.3.6.1.4.1.42.2.27.9.4.88.1	2.16.840.1.113730.3.3.2.23.1
Armenian	hy	1.3.6.1.4.1.42.2.27.9.4.89.1	
Indonesian	id	1.3.6.1.4.1.42.2.27.9.4.90.1	
Icelandic	is	1.3.6.1.4.1.42.2.27.9.4.91.1	2.16.840.1.113730.3.3.2.24.1
Italian	it	1.3.6.1.4.1.42.2.27.9.4.92.1	2.16.840.1.113730.3.3.2.25.1
Italian Swiss	it-CH	1.3.6.1.4.1.42.2.27.9.4.93.1	2.16.840.1.113730.3.3.2.26.1
Japanese	ja	1.3.6.1.4.1.42.2.27.9.4.94.1	2.16.840.1.113730.3.3.2.28.1
Greenlandic	kl	1.3.6.1.4.1.42.2.27.9.4.95.1	
Kannada	kn	1.3.6.1.4.1.42.2.27.9.4.96.1	
Korean	ko	1.3.6.1.4.1.42.2.27.9.4.97.1	2.16.840.1.113730.3.3.2.29.1
Konkani	kok	1.3.6.1.4.1.42.2.27.9.4.98.1	
Cornish	kw	1.3.6.1.4.1.42.2.27.9.4.99.1	
Lithuanian	lt	1.3.6.1.4.1.42.2.27.9.4.100.1	2.16.840.1.113730.3.3.2.30.1
Latvian or Lettish	lv	1.3.6.1.4.1.42.2.27.9.4.101.1	2.16.840.1.113730.3.3.2.31.1
Macedonian	mk	1.3.6.1.4.1.42.2.27.9.4.102.1	2.16.840.1.113730.3.3.2.32.1
Marathi	mr	1.3.6.1.4.1.42.2.27.9.4.103.1	
Maltese	mt	1.3.6.1.4.1.42.2.27.9.4.104.1	
Dutch	nl or nl-NL	1.3.6.1.4.1.42.2.27.9.4.105.1	2.16.840.1.113730.3.3.2.33.1
Dutch Belgium	nl-BE	1.3.6.1.4.1.42.2.27.9.4.106.1	2.16.840.1.113730.3.3.2.34.1
Norwegian	no or no-NO	1.3.6.1.4.1.42.2.27.9.4.107.1	2.16.840.1.113730.3.3.2.35.1

TABLE 14-1 Supported Locales (Continued)

Locale	Tag	Collation Order OID	Backward Compatible OID
Norwegian Nynorsk	no-NO-NY	1.3.6.1.4.1.42.2.27.9.4.108.1	2.16.840.1.113730.3.3.2.37.1
Norwegian Nynorsk	nn	1.3.6.1.4.1.42.2.27.9.4.109.1	
Norwegian Bokmål	nb or no-NO-B	1.3.6.1.4.1.42.2.27.9.4.110.1	2.16.840.1.113730.3.3.2.36.1
Oromo (Afan)	om	1.3.6.1.4.1.42.2.27.9.4.111.1	
Oromo Ethiopia	om-ET	1.3.6.1.4.1.42.2.27.9.4.112.1	
Oromo Kenya	om-KE	1.3.6.1.4.1.42.2.27.9.4.113.1	
Polish	pl	1.3.6.1.4.1.42.2.27.9.4.114.1	2.16.840.1.113730.3.3.2.38.1
Portuguese	pt or pt-PT	1.3.6.1.4.1.42.2.27.9.4.115.1	
Portuguese Brazil	pt-BR	1.3.6.1.4.1.42.2.27.9.4.116.1	
Romanian	ro	1.3.6.1.4.1.42.2.27.9.4.117.1	2.16.840.1.113730.3.3.2.39.1
Russian	ru or ru-RU	1.3.6.1.4.1.42.2.27.9.4.118.1	2.16.840.1.113730.3.3.2.40.1
Russian Ukraine	ru-UA	1.3.6.1.4.1.42.2.27.9.4.119.1	
Serbo-Croatian	sh	1.3.6.1.4.1.42.2.27.9.4.120.1	2.16.840.1.113730.3.3.2.41.1
Slovak	sk	1.3.6.1.4.1.42.2.27.9.4.121.1	2.16.840.1.113730.3.3.2.42.1
Slovenian	sl	1.3.6.1.4.1.42.2.27.9.4.122.1	2.16.840.1.113730.3.3.2.43.1
Somali	so or so-SO	1.3.6.1.4.1.42.2.27.9.4.123.1	
Somali Djibouti	so-DJ	1.3.6.1.4.1.42.2.27.9.4.124.1	
Somali Ethiopia	so-ET	1.3.6.1.4.1.42.2.27.9.4.125.1	
Somali Kenya	so-KE	1.3.6.1.4.1.42.2.27.9.4.126.1	
Albanian	sq	1.3.6.1.4.1.42.2.27.9.4.127.1	2.16.840.1.113730.3.3.2.44.1
Serbian	sr	1.3.6.1.4.1.42.2.27.9.4.128.1	2.16.840.1.113730.3.3.2.45.1
Swedish	sv-SE	1.3.6.1.4.1.42.2.27.9.4.129.1	2.16.840.1.113730.3.3.2.46.1
Swedish Finland	sv-FI	1.3.6.1.4.1.42.2.27.9.4.130.1	
Swahili	sw	1.3.6.1.4.1.42.2.27.9.4.131.1	
Swahili Kenya	sw-KE	1.3.6.1.4.1.42.2.27.9.4.132.1	

TABLE 14-1 Supported Locales (Continued)

Locale	Tag	Collation Order OID	Backward Compatible OID
Swahili Tanzania	sw-TZ	1.3.6.1.4.1.42.2.27.9.4.133.1	
Tamil	ta	1.3.6.1.4.1.42.2.27.9.4.134.1	
Telugu	te	1.3.6.1.4.1.42.2.27.9.4.135.1	
Thai	th	1.3.6.1.4.1.42.2.27.9.4.136.1	
Tigrinya	ti	1.3.6.1.4.1.42.2.27.9.4.137.1	
Tigrinya Eritrea	ti-ER	1.3.6.1.4.1.42.2.27.9.4.138.1	
Tigrinya Ethiopia	ti-ET	1.3.6.1.4.1.42.2.27.9.4.139.1	
Turkish	tr	1.3.6.1.4.1.42.2.27.9.4.140.1	2.16.840.1.113730.3.3.2.47.1
Ukrainian	uk	1.3.6.1.4.1.42.2.27.9.4.141.1	2.16.840.1.113730.3.3.2.48.1
Vietnamese	vi	1.3.6.1.4.1.42.2.27.9.4.142.1	
Chinese	zh	1.3.6.1.4.1.42.2.27.9.4.143.1	2.16.840.1.113730.3.3.2.49.1
Chinese China	zh-CN	1.3.6.1.4.1.42.2.27.9.4.144.1	
Chinese Hong Kong	zh-HK	1.3.6.1.4.1.42.2.27.9.4.145.1	
Chinese Mongolia	zh-MO	1.3.6.1.4.1.42.2.27.9.4.146.1	
Chinese Singapore	zh-SG	1.3.6.1.4.1.42.2.27.9.4.147.1	
Chinese Taiwan	zh-TW	1.3.6.1.4.1.42.2.27.9.4.148.1	2.16.840.1.113730.3.3.2.50.1

Supported Language Subtypes

Language subtypes can be used by clients to indicate specific attributes in characters of a language other than the default language of a deployment. For example, German users may prefer to see addresses in German when possible. In this case, you can select German as a language subtype for the `streetAddress` attribute so that users can search for either the English or the German representation of the address. If you specify a language subtype for an attribute, the subtype is added to the attribute name as follows: `attribute;lang-subtype`.

The following listing shows an English language and German language subtype for the `streetAddress` attribute:

```
streetAddress;lang-en: 10 Schlossplatz, 76113, Karlsruhe, Germany
streetAddress;lang-de: Schloßplatz 10, 76113, Karlsruhe, Deutschland
```

The following table contains the list of supported language subtypes.

TABLE 14-2 Supported Language Subtypes

Language	Language Tag
Afrikaans	af
Albanian	sq
Amharic Ethiopia	am
Arabic	ar
Armenian	hy
Basque	eu
Bengali India	bn
Bulgarian	bg
Byelorussian	be
Catalan	ca
Chinese	zh
Cornish	kw
Croatian	hr
Czech	cs
Danish	da
Dutch	nl
English	en
Esperanto	eo
Estonian	et
Faeroese	fo
Finnish	fi
French	fr
Galician	gl
German	de
Greek	el
Greenlandic	kl
Gujarati	gu

TABLE 14–2 Supported Language Subtypes (Continued)

Language	Language Tag
Hebrew	he or iw
Hindi	hi
Hungarian	hu
Icelandic	is
Indonesian	id
Irish	ga
Italian	it
Japanese	ja
Kannada	kn
Konkani	kok
Korean	ko
Latvian or Lettish	lv
Lithuanian	lt
Macedonian	mk
Maltese	mt
Manx (Isle of Man)	gv
Marathi	mr
Norwegian	no
Oromo	om
Persian	fa
Polish	pl
Portuguese	pt
Romanian	ro
Russian	ru
Serbian	sr
Serbo-Croatian	sh
Slovak	sk
Slovenian	sl

TABLE 14–2 Supported Language Subtypes (Continued)

Language	Language Tag
Somali	so
Spanish	es
Swahili	sw
Swedish	sv
Tamil	ta
Telugu	te
Thai	th
Tigrinya	ti
Turkish	tr
Ukrainian	uk
Vietnamese	vi

PART II

Directory Proxy Server Reference

This part explains how Directory Proxy Server works. The information here is primarily descriptive. For instructions, try [Part II, “Directory Proxy Server Administration,”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition* instead.

This part includes the following chapters:

- [Chapter 15, “Directory Proxy Server Overview,”](#) outlines the architecture of Directory Proxy Server and describes, at a high level, the most important features of this release.
- [Chapter 16, “Directory Proxy Server Load Balancing and Client Affinity,”](#) describes how Directory Proxy Server can be configured for load balancing, and how client affinity can be used to reduce the risk of propagation delay in load balanced deployments.
- [Chapter 17, “Directory Proxy Server Distribution,”](#) describes how data in an LDAP server is exposed to a client request.
- [Chapter 18, “Directory Proxy Server Virtualization,”](#) explains how virtual data views enable you to display physical data in a different way, and describes the kinds of virtual data views that are available in Directory Proxy Server.
- [Chapter 19, “Connections Between Directory Proxy Server and Backend LDAP Servers,”](#) describes the connections between Directory Proxy Server and backend LDAP servers.

- [Chapter 20, “Connections Between Clients and Directory Proxy Server,”](#) describes how connection handlers are used to apply limits and filters to a connection, and to restrict the data to which clients are exposed.
- [Chapter 21, “Directory Proxy Server Client Authentication,”](#) describes the client authentication mechanisms available in Directory Proxy Server.
- [Chapter 22, “Security in Directory Proxy Server,”](#) describes the mechanisms that can be used to secure data that passes through Directory Proxy Server.
- [Chapter 23, “Directory Proxy Server Logging,”](#) provides an overview of the Directory Proxy Server logging interface.
- [Chapter 24, “Directory Proxy Server Alerts and Monitoring,”](#) describes the mechanisms that can be used to monitor both Directory Proxy Server and the availability of backend LDAP servers.

Directory Proxy Server Overview

This chapter outlines the architecture of Directory Proxy Server, and describes at a high level, the most important features of this release.

The chapter covers the following topics:

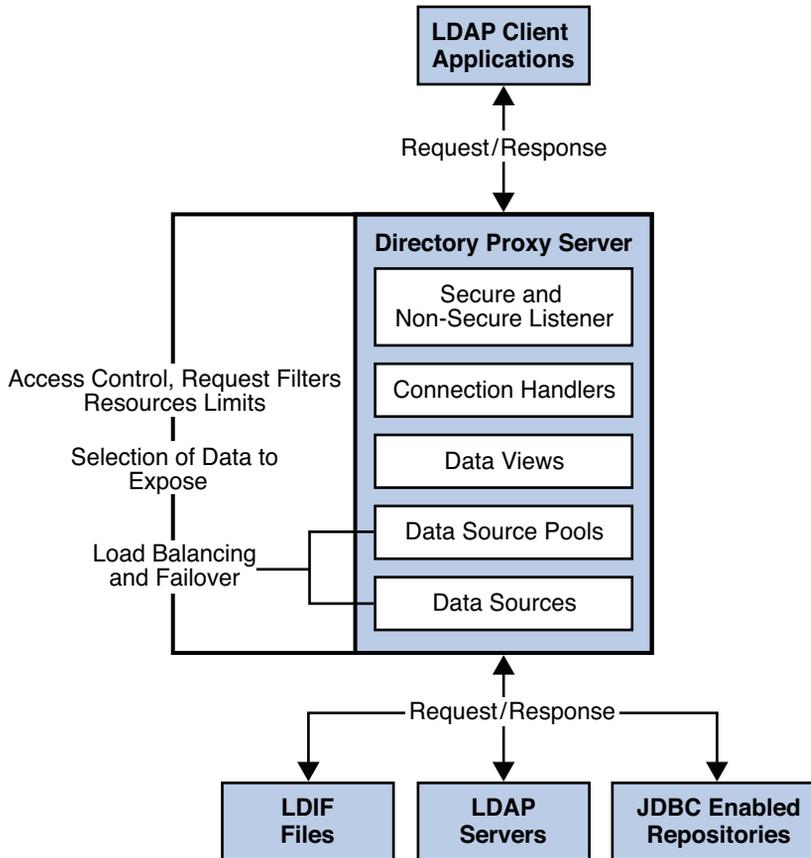
- [“Introduction to Directory Proxy Server” on page 225](#)
- [“Directory Proxy Server Architecture” on page 226](#)
- [“Overview of Directory Proxy Server Features” on page 228](#)

Introduction to Directory Proxy Server

Directory Proxy Server is an LDAP application-layer protocol gateway. Directory Proxy Server delivers enhanced directory access control, schema compatibility, and high availability.

The Directory Proxy Server architecture enables you to configure several objects that control how client requests are routed to backend data sources. These configuration objects are illustrated at a high level in the following simplified schematic of the Directory Proxy Server architecture. This illustration will help you to understand the architectural concepts presented in the remainder of this book.

FIGURE 15-1 Simplified Architecture of Directory Proxy Server



Directory Proxy Server Architecture

This section briefly presents the new Directory Proxy Server architecture and what is new compared to 5.2. Its aim is to help you understand why literal translation of some 5.2 configuration attributes is not possible.

A Directory Proxy Server instance proxies client application requests to *data sources* through *data views*. Data sources and pools of data sources correspond to load balanced groups from 5.2.

Data views, however, are new. They do not correspond to anything present in 5.2. Fundamentally Directory Proxy Server handles incoming connections individually, assigning a *connection handler* when the connection is opened, and reassigning a connection handler upon rebind when the bind identity changes.

The connection handler gives Directory Proxy Server a set of policy rules for making decisions about what to do with operations requested through a given connection. Connection handlers correspond roughly to network groups in 5.2, yet whereas network groups are configured to use load balanced groups directly.

Directory Proxy Server uses connection handlers mainly to determine policies about a connection, so it can take appropriate decisions about operations performed on that connection. For example, if a connection handler is configured to prevent write operations on a certain connection, Directory Proxy Server can use that property of the policy to short circuit evaluations concerning write operation requests on that connection. In this case, the appropriate errors are returned to the client as soon as Directory Proxy Server has decoded the operation.

LDAP operations on a connection are handled in Directory Proxy Server first through data views. Data views enable Directory Proxy Server to perform DN-based routing. In other words, operations concerning one set of data can be sent to one set of data sources, and operations concerning another set of data can be sent elsewhere. This new architectural form seems unnecessary when you look at it from the point of view of reproducing a 5.2 configuration. Yet data views become indispensable when you want to distribute different directory data across various directories, or when you want to recover different data from disparate data sources to present a virtual directory view of those sources to a client application.

Data views therefore enable Directory Proxy Server to select the data sources via a data source pool to handle the LDAP operation. Data source pools, which correspond to 5.2 load balanced groups, represent sets of data sources each holding equivalent data. A pool defines the load balancing and failover management that Directory Proxy Server performs to spread load across different data sources. As load balancing is performed per operation, the balancing itself is by nature operation based.

Data sources can be understood as sources of data for reads, and sinks of data for writes. Directory Proxy Server handles the following kinds of data sources:

- LDAP directories
- LDIF files
- JDBC-enabled data repositories

Directory Proxy Server 5.2 was essentially a connection based router. In Directory Proxy Server 5.2, a client connection was routed to a directory server. All requests from that client connection were sent to the same directory server until the connection was broken. For compatibility, Directory Proxy Server can be configured to behave in a similar way to Directory Proxy Server 5.2. For information about how to configure this, see [“Configuring Directory Proxy Server as a Connection Based Router”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*. For information about how to migrate to this version of Directory Proxy Server, see the *Oracle Fusion Middleware Upgrade and Migration Guide for Oracle Directory Server Enterprise Edition*.

Overview of Directory Proxy Server Features

Directory Proxy Server provides the following features:

- Manageability
 - Single point of access to directory data stored on multiple directory servers
 - Automatic referral following
 - Reactive and proactive monitoring of directory servers
 - Configuration on the command line or with a GUI
 - All connections have a normal listener port and a secure listener port
- Authentication and authorization
 - Certificate-based authentication with certificate mapping
 - Secure LDAP reverse proxy
 - LDAP control filtering
 - Proxy authorization
 - Identity mapping
 - Access control
- Distribution
 - Single point of access to a directory service spread over multiple directory servers
 - Extensible and customizable distribution algorithm
 - Server affinity to address propagation delay problem
 - Connection pooling and partial BER-decoding for performance and scalability
- Load-balancing/Fail-over
 - Routing based on the operation or the connection
 - Automatic load balancing and automatic fail over and fail back among a set of replicated LDAP directory servers
 - Three load-balancing algorithms
- Virtualization
 - Multiple virtual views for client applications
 - Aggregation of multiple heterogeneous data sources
 - Mapping of attribute names and values
 - Access to JDBC-compliant data repositories
 - Access to flat LDIF file resources

Directory Proxy Server Load Balancing and Client Affinity

Deployments that use more than one data source to respond to client requests use load balancing to distribute work load. Client affinity can be used to reduce the risk of propagation delay in load balanced deployments.

For information about how to configure load balancing and client affinity, see [Chapter 20, “Directory Proxy Server Load Balancing and Client Affinity,”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

For information about how the Directory Proxy Server performs load balancing and client affinity, see the following sections:

- “LDAP Data Source Pools” on page 229
- “Load Balancing” on page 230
- “Client Affinity” on page 236

LDAP Data Source Pools

Requests from clients are distributed to an LDAP data source pool. One or more data sources are attached to the data source pool. The properties of a data source pool determine how client requests are routed to the different LDAP data sources that are attached to the pool. The following properties can be configured for an LDAP data source pool:

<code>client-affinity-policy</code>	The algorithm used to determine when client requests should exhibit affinity to a single LDAP data source
<code>client-affinity-timeout</code>	The client affinity time-out duration
<code>description</code>	A description of the LDAP data source pool
<code>enable-client-affinity</code>	A flag indicating whether or not consecutive requests from the same client should be directed to the same LDAP data source

`load-balancing-algorithm` The algorithm used to distribute operations over load-balanced LDAP data sources

For information about how to create and configure an LDAP data source pool, see [“Creating and Configuring LDAP Data Source Pools”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Load Balancing

When more than one data source is attached to a pool, load balancing determines which data source in the pool responds to the request.

For information about load balancing, see the following sections:

- [“Introduction to Load Balancing”](#) on page 230
- [“Proportional Algorithm for Load Balancing”](#) on page 231
- [“Saturation Algorithm for Load Balancing”](#) on page 232
- [“Operational Affinity Algorithm for Load Balancing”](#) on page 233
- [“Failover Algorithm for Load Balancing”](#) on page 235

Introduction to Load Balancing

Directory Proxy Server distributes requests according to a load balancing algorithm. The following load balancing algorithms can be configured:

Proportional algorithm

Requests are distributed according to the weight of the data source and the cumulative load of the data source since the last startup of Directory Proxy Server.

Saturation algorithm

Requests are distributed according to the weight of the data source and the number of available connections on the data source.

Operational affinity algorithm

Requests are distributed according to the hash value. The number of hash values that are allocated to an attached data source is proportional to the weight of that data source.

Failover algorithm

Requests are distributed exclusively to the attached data source with the highest weight for that operation.

In all load balancing algorithms, each attached data source can be configured with an independent weight for each of the following types of operation:

- Add
- Bind
- Compare
- Delete
- Modify DN
- Modify
- Search

If multiple attached data sources are configured with the same weight for a given type of operation, Directory Proxy Server distributes the requests evenly between the data sources. If a data source has a weight of disabled for a particular type of operation, Directory Proxy Server never distributes requests of that type to the data source. If a data source has a weight of 0 (zero) no requests are distributed to that data source.

An attached data source cannot be selected by the load balancing algorithm in the following circumstances:

- The data source is unavailable because an error occurred.
- All connections between the Directory Proxy Server and the data source are in use.

If a data source is configured as read-only, the data source cannot receive add, delete, or modify requests. The data source can receive search requests.

The load balancing algorithm works on a best-effort basis. If there are not sufficient resources for the load balancing algorithm to distribute requests by respecting weights, the weights are overruled. For example, if the number of simultaneous requests to a data source exceeds the maximum number of connections to that data source, requests are distributed to other data sources.

When the client affinity feature is active, Directory Proxy Server distributes requests by using the client affinity feature instead of using the load balancing algorithm. For information about client affinity, see [“Client Affinity” on page 236](#).

Proportional Algorithm for Load Balancing

In the proportional algorithm, requests are distributed to attached data sources according to the following criteria:

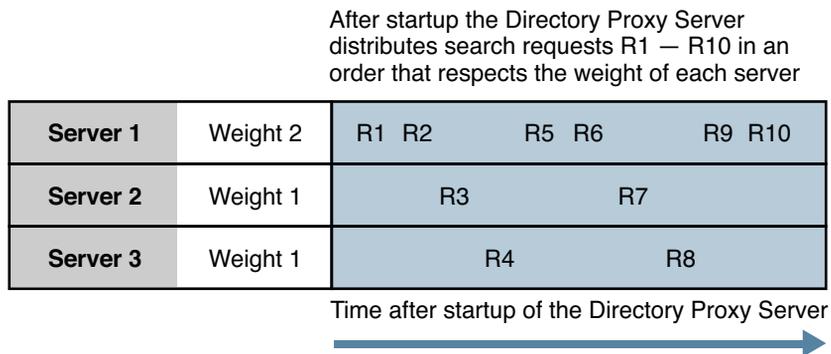
- The type of request
- The weight of the data source as a ratio of the total weights of the other data sources in the pool
- The cumulative load since the last startup of Directory Proxy Server

After startup, the first request of a given type is distributed to the data source with the highest weight for that type of request. Directory Proxy Server continues to distribute the requests in proportion to the weight of each data source for that type of request.

If a data source becomes unavailable, Directory Proxy Server distributes the requests to remaining data sources in proportion to their weight.

The following figure illustrates how Directory Proxy Server distributes the first eight search requests to a pool of data sources with different weights. The data source with a weight of 2 processes twice as many requests as the data sources with a weight of 1.

FIGURE 16-1 Distribution of Requests According to the Proportional Algorithm for Load Balancing



For an example of how configure the proportional algorithm, see [“To Configure the Proportional Algorithm for Load Balancing”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Saturation Algorithm for Load Balancing

In the saturation algorithm, requests are distributed to data sources according to a combination of the weight of the data source and the number of available connections.

All requests of a certain type are distributed to the data source with the highest weight, until its *saturation level* is reached. Once this level is reached, requests are distributed between this data source and the data source with the next highest weight. The saturation level is obtained by multiplying the weight of the data source by the total number of connections.

The following figure illustrates how Directory Proxy Server distributes requests to a pool of data sources with 10 connections and different weights. The number of available connections multiplied by the weight is shown in brackets.

FIGURE 16–2 Distribution of Requests According to the Saturation Algorithm for Load Balancing

After startup the Directory Proxy Server distributes search requests R1 — R16 in order of the number of remaining connections multiplied by the weight

Server 1 Weight 3x Connections 10	R1 R2 R3 R4 R7 R9 R12 R16 *(30)*(27)*(24)*(21) *(18) *(15) *(12) *(9)
Server 2 Weight 2x Connections 10	R5 R6 R8 R10 R11 R13 *(20)*(18) *(16) *(14)*(12) *(10)
Server 3 Weight 1x Connections 10	R14 R15 *(10)*(9)

Time after startup of the Directory Proxy Server



*The number of remaining connections multiplied by the weight

If your deployment includes data sources with greatly different capacity, you can use the saturation algorithm to distribute requests according to the capacity of the data source.

For an example of how configure the saturation algorithm, see “[To Configure the Saturation Algorithm for Load Balancing](#)” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Operational Affinity Algorithm for Load Balancing

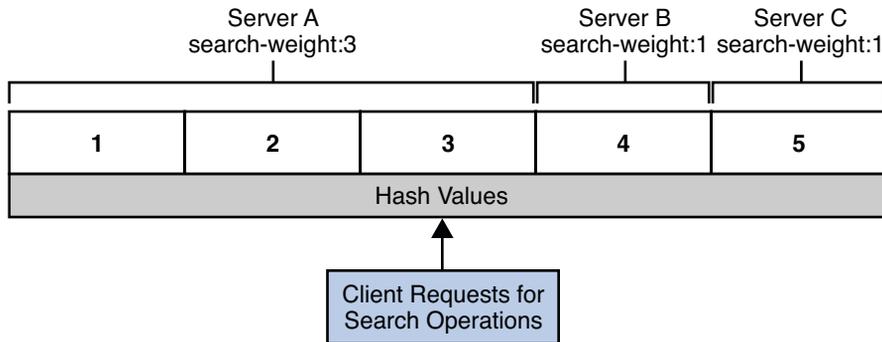
In the operational affinity algorithm for load balancing, all requests are allocated a hash value according to the request type and request properties. Each hash value is allocated to an attached data source. The number of hash values that are allocated to a data source is proportional to the weight of the data source.

When a request is received, Directory Proxy Server examines the hash table to determine whether a request with that hash value has already been distributed. If the hash value already exists in the hash table, Directory Proxy Server sends the request to the data source with that hash value. If the hash value does not exist in the hash table, the request is distributed by using the proportional algorithm for load balancing.

Figure 16–3 shows an example with three attached data sources. Data source A has a weight of 3 for search operations, the other data sources have a weight of 1 for search operations. The hash table allocates $3/5_{\text{ths}}$ of the hash values to data source A, $1/5_{\text{th}}$ to data source B, and $1/5_{\text{th}}$ to data source C.

If requests have a normal range of diversity, data source A would receive three times more requests than data source B or data source C. If there is a disproportionate number of requests with identical properties, the ratio of requests between the three data sources is disturbed. For example, if a client make repeated BIND requests on the same DN, the BIND must always be serviced by the same data source.

FIGURE 16-3 Distribution of Requests According to the Operational Affinity Algorithm for Load Balancing



The use of the operational affinity algorithm for load balancing is beneficial for the following features:

- Global account lockout
- Cache optimization in Directory Server

Disadvantage of Using the Operational Affinity Algorithm for Load Balancing

The operational affinity algorithm for load balancing does not ensure an evenly distributed work load across data sources.

A hash value is allocated to a request according to the type of request and the properties of the request. A range of hash values represents an arbitrary group of unrelated requests. It is possible for one range of hash values to represent many more operations than another range of hash values. A given range of hash values might represent requests that are made frequently, another range of hash values might represents requests that are almost never made.

Operational Affinity Algorithm for Global Account Lockout

By using the operational affinity algorithm for load balancing, you can ensure that the same data source always responds to bind requests from a given client. In this way, you can ensure that a client is locked out after the maximum number of failed bind attempts. If the same data source does not respond to bind requests from a given client, the client can exceed the maximum number of failed bind attempts.

When a client binds, a hash value for the request is allocated according to the bind credentials. Directory Proxy Server consults the hash table and distributes the request to the data source for that hash value. No matter how many times the client binds, the hash value is always the same. The request is always distributed to the same data source.

If a client requests a bind without the appropriate credentials, the data source rejects the bind request. If the client makes a second or third bind request, the same data source rejects the bind request. When the client exceeds the maximum number of allowed bind attempts, Directory Server locks the client out.

For an example of how configure the operational affinity algorithm for global account lockout, see [“To Configure the Operational Affinity Algorithm for Global Account Lockout”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Operational Affinity Algorithm for Cache Optimization

By using the operational affinity algorithm for load balancing, searches from the same client to the same entry can always be distributed to the same data source. When a data source responds to a request, the targeted entry is stored in the cache. If the same data source responds repeatedly to the same request, the data source can benefit from using the cached data.

For an example of how configure the operational affinity algorithm for cache optimization, see [“To Configure Operational Affinity Algorithm for Cache Optimization”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Failover Algorithm for Load Balancing

In the failover algorithm, requests of a given type are distributed exclusively to the attached data source with the highest weight for that operation. If that attached data source fails, requests are distributed exclusively to the attached data source with the next highest weight for that operation. If the data source with the highest weight comes back on line, requests are distributed to that data source.

For an example of how configure the failover algorithm, see [“To Configure the Failover Algorithm for Load Balancing”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Client Affinity

Client affinity is defined between a client connection and a data source. When client affinity is defined, requests from a specified client connection are distributed to a specified data source in a data source pool.

The client affinity feature reduces the risk of propagation delay in deployments that use load balancing. Propagation delays can occur when a client makes consecutive requests that target the same entry if those requests are not treated by the same data source. For example, a client might make one request to change an entry and a second request to use the changed entry. If the second request is treated by a data source that has not been updated by the first request, an error occurs.

Client affinity can be configured in the following ways:

- Enabled or disabled
- Configured for all write requests after the first write request
- Configured for all requests after the first write request
- Configured for all requests after the first read request or write request
- Configured for first read request after a write request
- Configured to expire after a specified time

Client affinity takes precedence over the load balancing algorithm. Directory Proxy Server distributes a request from the specified connection to the specified data source, irrespective of the load balancing algorithm.

If client affinity is defined and enabled, the load balancing algorithm takes precedence in the following circumstances:

- The request that starts client affinity has not occurred
- The request that ends client affinity has occurred
- The client affinity time-out has expired
- The specified data source cannot be used for a request, or an error has occurred on the specified data source

A data source cannot be used for a request in the following circumstances:

- It is offline.
- It is not configured to perform the operation being requested. For example, a data source that is configured for read requests cannot respond to write requests.

For information about how to configure client affinity, see [“Configuring Client Affinity”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

The client affinity feature must be used to configure Directory Proxy Server as a simple, connection based router. For information, see “[Configuring Directory Proxy Server as a Connection Based Router](#)” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Directory Proxy Server Distribution

Directory Proxy Server enables distribution through the definition of data views. Data views are defined with a view base, which determines the base DN of the entries in that data view. Based on the distribution algorithms provided in Directory Proxy Server, you can specify how entries are divided among the different data views.

This chapter covers the following topics:

- “LDAP Data Views” on page 239
- “Distributing Entries In a Subtree to Different Data Views” on page 242
- “Use Cases for Data Views” on page 244

LDAP Data Views

An LDAP data view exposes data in an LDAP server to a client request and specifies the data source pool that responds to the request. By defining LDAP data views, you can perform the following tasks:

- Expose a whole database in a single view
- Provide different views for different subtrees in a database
- Provide a unified view of different databases

There are additional types of data views but distribution can only be done with LDAP data views. For more information about other types of data views, see [Chapter 18, “Directory Proxy Server Virtualization.”](#)

LDAP Data View Features

A simple LDAP data view is defined primarily by the base DN of the data view. In a simple data view all of the entries in the subtree are encompassed by the data view. Data views can exist in hierarchy, with a *superior data view* and a *subordinate data view*. A subordinate data view is a

data view whose base DN is inferior to the base DN of a superior data view. The entries in a subordinate data view are excluded from the superior data view.

For information about the features of a data view, see the following sections.

- [“Excluding a Subtree From a Data View” on page 240](#)
- [“Performing a Search Directed at a Superior Data View on an Excluded, Subordinate Data View” on page 240](#)
- [“Distributing Entries In a Subtree to Different Data Views” on page 242](#)
- [“Attribute Renaming and DN Renaming” on page 240](#)

Excluding a Subtree From a Data View

When a subordinate data view is created, Directory Proxy Server automatically excludes the subordinate data view from the superior data view. When a request targets the subordinate data view, the request is sent to the subordinate data view instead of the superior data view.

By default, Directory Proxy Server automatically configures the `excluded-subtrees` parameter in the superior data view to exclude subordinate data views. For information about how to disable the automatic configuration, see [“To Manually Configure the excluded-subtrees and alternate-search-base-dn Properties” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*](#).

The following subtrees are excluded by default from all data views: `cn=config`, `cn=monitor`, and `cn=proxy manager`.

Performing a Search Directed at a Superior Data View on an Excluded, Subordinate Data View

When an alternate search base is specified in a subordinate data view, search operations targeted at the superior data view are also performed in the subordinate data view.

By default, Directory Proxy Server automatically configures the `alternateSearchBase` parameter in the subordinate data view. For information about how to disable the automatic configuration, see [“To Manually Configure the excluded-subtrees and alternate-search-base-dn Properties” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*](#).

Attribute Renaming and DN Renaming

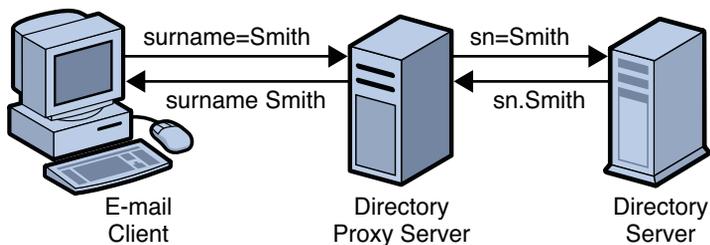
Each entry in a directory is identified by a DN and a set of attributes and their values. Often, the DN and the attributes defined on the client side do not map to the DN and the attributes defined on the server side.

Data views can be defined to rename DNs and attributes to values that match the server side. When a client makes a request, the DNs and attributes are renamed to match the server side. When the result is returned to a client, the DN and attributes are changed back to match the client side.

Attribute Renaming

The following figure illustrates how attribute renaming is performed by Directory Proxy Server.

FIGURE 17-1 Attribute Renaming



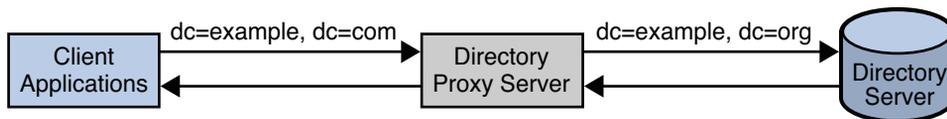
In [Figure 17-1](#), the email client expects the last names to be specified by the attribute `surname`. However, in the LDAP server, last names are specified by the attribute `sn`. When attributes are renamed, only the name of the attribute is affected — the value of the attribute is not changed. However, when attributes are renamed all entries with that name are renamed.

For information about how to configure attribute renaming, see “[To Configure Attribute Renaming](#)” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

DN Renaming

The following figure illustrates how DN renaming is performed by Directory Proxy Server.

FIGURE 17-2 DN Renaming



```

ou:groups,dc=example,dc=com
member: uid=kvaughan, ou=People, dc=example, dc=com
member: uid=rdaugherty, ou=People, dc=example, dc=com
member: uid=hmilller, ou=People, dc=example, dc=com
  
```

In [Figure 17-2](#), the client contains the `dc=example, dc=com` database. The LDAP server contains the `dc=example, dc=org` database. The Directory Proxy Server renames the DNs.

Attributes that contain DNs must also be renamed if those DNs are in the portion of the DIT that is affected by the original DN renaming. In [Figure 17-2](#), the group attribute contains a list

of the DNs of group members. When `dc=example`, `dc=com` is renamed to `dc=example`, `dc=org`, the DNs in the group attribute must also be renamed.

For information about how to configure DN renaming, see “To Configure DN Renaming” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Distributing Entries In a Subtree to Different Data Views

A distribution algorithm distributes operations across data views that have the same base DN. The type of distribution algorithm is defined by the `distribution-algorithm` parameter.

To determine how to distribute operations, the distribution algorithm considers the value of the attribute *directly below* the base DN of the data view. For example, consider a data view with a base DN of `ou=people,dc=example,dc=com`. If a search operation contains the base DN `uid=23,ou=people,dc=example,dc=com`, the distribution algorithm considers `uid` to be the routing attribute, because `uid` is directly below the base DN of the data view. The algorithm then attempts to match the value `23` to determine how to route the operation.

However, if the search operation contains the base DN `uid=23,ou=managers,ou=people,dc=example,dc=com`, the distribution algorithm considers `ou` to be the routing attribute, because `ou` is directly below the base DN of the data view. Because `ou` does not match the `uid` specified in the search query, the distribution algorithm cannot distribute the search correctly. For distribution to work in this case, the base DN of the data view should be `ou=managers,ou=people,dc=example,dc=com`.

You must therefore ensure that the base DN of the data view is appropriate to the distribution algorithm.

The following distribution algorithms are provided with Directory Proxy Server:

Pattern matching

Requests are distributed to data views based on the match between the parameters of the requests and one or more patterns. Patterns are defined by the following parameters:

- `pattern-matching-base-dn-regular-expression`
- `pattern-matching-base-object-search-filter`
- `pattern-matching-dn-regular-expression`
- `pattern-matching-one-level-search-filter`
- `pattern-matching-subtree-search-filter`

The syntax supported by the pattern matching algorithm is specified by the Java Pattern class (documented at <http://java.sun.com/j2se/1.4.2/docs/api/java/util/regex/Pattern.html> (<http://java.sun.com/j2se/1.4.2/docs/api/java/util/regex/Pattern.html>)). This syntax is not the same as the usual regex syntax.

Numeric

Requests are distributed to data views according to the numeric value of the RDN in the request. The numeric value is taken from the value of the first RDN beneath the base DN of the data view. Numeric bounds are defined by these parameters:

- `numeric-attrs`
- `numeric-default-data-view`
- `numeric-lower-bound`
- `numeric-upper-bound`

Lexicographic

Requests are distributed to data views according to the lexicographic value of the RDN in the request. Lexico bounds are taken from the value of the first RDN beneath the base DN of the data view. Lexico bounds are defined by these parameters:

- `lexicographic-attrs`
- `lexicographic-lower-bound`
- `lexicographic-upper-bound`

Replication

Requests are distributed to data views according to the role of the data view in replication. The algorithm distributes write operations to all data sources in the data source pool and read operations to a single data source. The replication role is defined by the `replication-role` parameter. A data view can have a master role or a consumer role.

You can also configure Directory Proxy Server to support your custom distribution algorithms. For more information about configuring custom distribution algorithms, see “[To Configure Custom Distribution Algorithm](#)” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

For information about how to configure a distribution algorithm, see “[Data Views With Hierarchy and a Distribution Algorithm](#)” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*. For information about the parameters used with the distribution algorithms, see `distribution-algorithm(5dpconf)`.

Limitations of Distribution Algorithms

The distribution algorithms provided with Directory Proxy Server have certain limitations in specific request scenarios.

The following list outlines the situations in which requests do not respect the distribution algorithm. The examples in this list assume that the routing attribute is `uid` and the view base of the data view is `dc=example,dc=com`.

- When the search base ends with the view base and the scope is `base`, requests are always distributed to the first data view. For example:

```
$ ldapsearch -b "ou=people,dc=example,dc=com" -s base "uid=116352"
```

- When the search base ends with the view base and the scope is `one level` or `subtree`, requests are always distributed to the first data view. For example:

```
$ ldapsearch -b "ou=people,dc=example,dc=com" -s sub "uid=116352"
```

- When the search base ends with the view base and starts with the routing attribute, but the search filter does not contain the routing attribute, requests are distributed to all data views. For example:

```
$ ldapsearch -b "uid=116352",ou=people,dc=example,dc=com" -s base "objectclass=*"

```

In this example, requests are distributed correctly if the RDN value matches the data view criteria.

- When the search base ends with the view base and contains the routing attribute, but the search filter does not contain the routing attribute, requests are distributed to all data views. For example:

```
$ ldapsearch -b "cn=myAccount,uid=116352,ou=people,dc=example,dc=com" -s base "objectclass=*"

```

In this example, requests are distributed correctly if the RDN value matches the data view criteria.

Use Cases for Data Views

This section describes use cases for LDAP data views. All of the examples assume that the connection handler allows all client connections to be processed by Directory Proxy Server.

For examples of data views in different deployments, see the following sections:

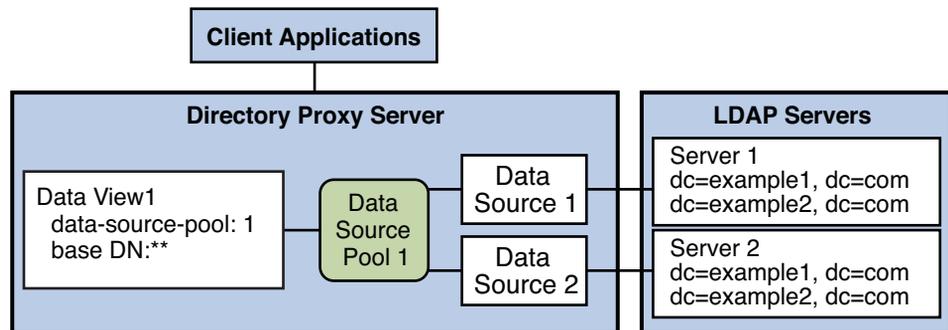
- “Data Views to Route All Requests, Irrespective of the Target DN of the Request” on page 245
- “Data Views to Route Requests When a List of Subtrees Are Stored on Multiple, Data-Equivalent Data Sources” on page 245
- “Data Views to Provide a Single Point of Access When Different Subtrees Are Stored on Different Data Sources” on page 246
- “Data Views to Route Requests When Different Parts of a Subtree Are Stored in Different Data Sources” on page 247
- “Data Views to Route Requests When Superior and Subordinate Subtrees Are Stored in Different Data Sources” on page 249
- “Data Views With Hierarchy and a Distribution Algorithm” on page 251

Data Views to Route All Requests, Irrespective of the Target DN of the Request

This section describes a data view that routes all requests to a data source pool, irrespective of the target DN of the request. This data view is called the *root data view*. The root data view is created by default when an instance of Directory Proxy Server is created.

The example in this section has multiple data sources that contain the same set of subtrees. The data sources are data-equivalent and pooled into one data source pool for load balancing. A data view is configured with a base DN at the rootDSE, represented as “*”. [Figure 17–3](#) shows an example deployment.

FIGURE 17–3 Example Deployment That Routes All Requests to a Data Source Pool, Irrespective of the Target DN



Because the base DN of the data view is the rootDSE, the data view encompasses the base DN of all possible requests. *All* requests are forwarded to the data source pool, irrespective of the target DN or whether the data source contains an entry for the request.

If Directory Proxy Server receives a request with a target DN that does not exist in the data source, the request is forwarded to the data source pool. The data source that responds to the request returns an error.

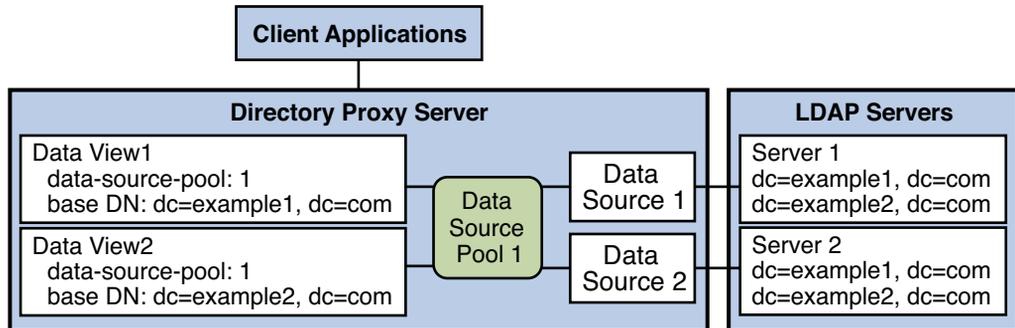
For information about how to configure the data view in [Figure 17–3](#), see “Data Views That Route All Requests, Irrespective of the Target DN of the Request” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Data Views to Route Requests When a List of Subtrees Are Stored on Multiple, Data-Equivalent Data Sources

This section describes data views that route requests targeted at a list of subtrees to a set of data-equivalent data sources.

The example in this section has multiple data sources that each contain the same set of subtrees. The data sources are data-equivalent and pooled into one data source pool for load balancing. A data view is configured for each subtree to expose that subtree to client requests. [Figure 17-3](#) shows the example deployment.

FIGURE 17-4 Example Deployment That Routes Requests When a List of Subtrees Is Stored on Multiple, Data-Equivalent Data Sources



A request is exposed to a data view only if the target DN is subordinate to the base DN of the data view. When a request is exposed to a data view, the request is forwarded to the data source pool specified by the data view.

If the target DN of a request is not subordinate to the base DN of any data view, Directory Proxy Server returns an error.

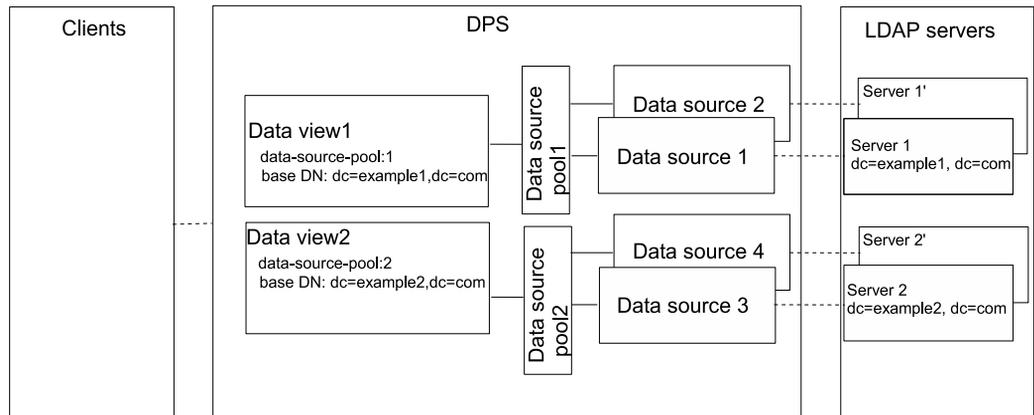
In [Figure 17-4](#), requests that target `dc=example1, dc=com` or `dc=example2, dc=com` are forwarded to the data source pool. Directory Proxy Server returns an error for requests that target neither `dc=example1, dc=com` nor `dc=example2, dc=com`.

For information about how to configure the data views in this section, see [“Data Views That Route Requests When a List of Subtrees Is Stored on Multiple, Data-Equivalent Data Sources”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Data Views to Provide a Single Point of Access When Different Subtrees Are Stored on Different Data Sources

This section describes how Directory Proxy Server provides a single point of access to different subtrees of data on multiple data sources. The example in this section contains a data view for each subtree, to expose that subtree to client requests. A data source pool is configured for each set of data-equivalent data sources. [Figure 17-5](#) shows the example deployment.

FIGURE 17-5 Example Deployment That Provides a Single Point of Access When Different Subtrees Are Stored on Different Data Sources



The Directory Proxy Server exposes a request to a data view if the DN targeted by the request is subordinate to the base DN of the data view. When a request is exposed to a data view, the request is forwarded to the data source pool specified by the data view.

If a request has a target DN that is not subordinate to the base DN of a data view, Directory Proxy Server returns an error.

In [Figure 17-5](#), client requests that target `dc=example1,dc=com` are forwarded to the data source pool 1 and are treated by data source 1 or data source 1'. Client requests that target `dc=example2,dc=com` are forwarded to the data source pool 2 and are treated by data source 2 or data source 2'. The Directory Proxy Server returns an error for client requests that target neither `dc=example1,dc=com` nor `dc=example2,dc=com`.

For information about how to configure a data view to provide a single point of access to different subtrees stored in multiple data sources, see [“Data Views That Provide a Single Point of Access When Different Subtrees Are Stored in Different Data Sources”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

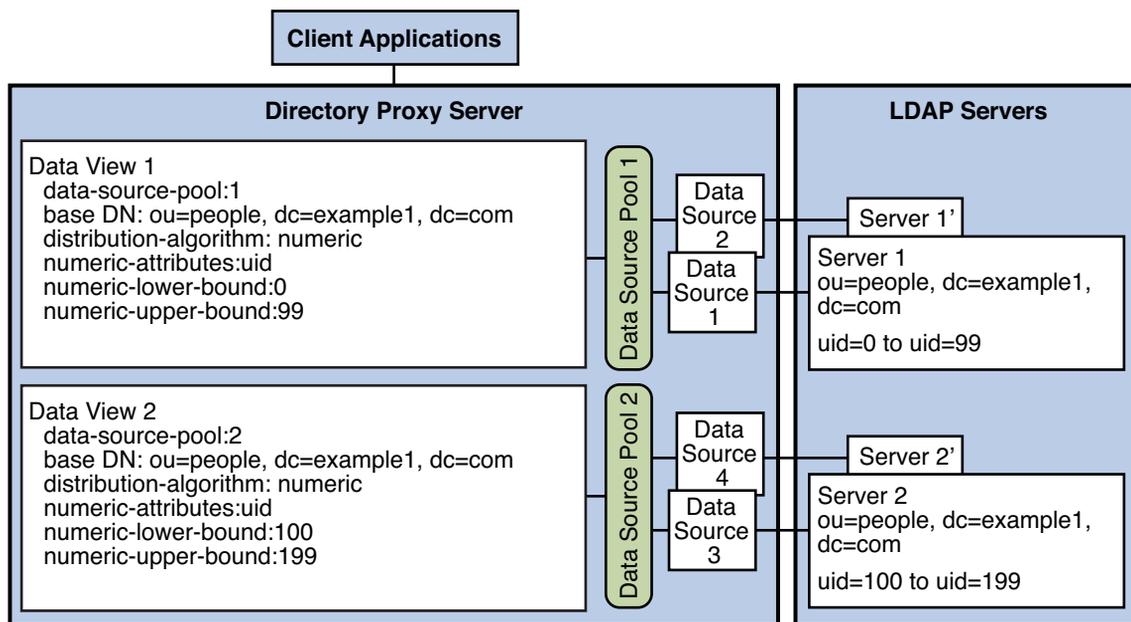
Data Views to Route Requests When Different Parts of a Subtree Are Stored in Different Data Sources

This section describes how Directory Proxy Server provides a single point of access to different parts of a subtree stored in multiple data sources. To route requests for different parts of a subtree, Directory Proxy Server uses a distribution algorithm. In the example in this section,

Directory Proxy Server uses the numeric distribution algorithm. For more information about distribution algorithms, see [“Distributing Entries In a Subtree to Different Data Views”](#) on page 242.

The example in this section contains two data views with the same base DN. A numeric distribution algorithm is used to separate entries into different data views. A data source pool is configured for each set of data-equivalent data sources. [Figure 17–6](#) shows the example deployment.

FIGURE 17–6 Example Deployment That Routes Requests When Different Parts of a Subtree Are Stored in Different Data Sources



Directory Proxy Server exposes a request to the data view which satisfies the following conditions:

- The DN targeted by the request is subordinate to the base DN of the data view
- The parameters of the requests match the pattern specified by the distribution algorithm in the data view

When a request is exposed to a data view, the request is forwarded to the data source pool specified by the data view.

If a request that does not match the conditions of any data view, Directory Proxy Server returns an error.

For information about how to configure a data view to provide a single point of access to different parts of subtree on multiple data sources, see [“Data Views That Provide a Single Point of Access When Different Parts of a Subtree Are Stored in Different Data Sources”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Data Views to Route Requests When Superior and Subordinate Subtrees Are Stored in Different Data Sources

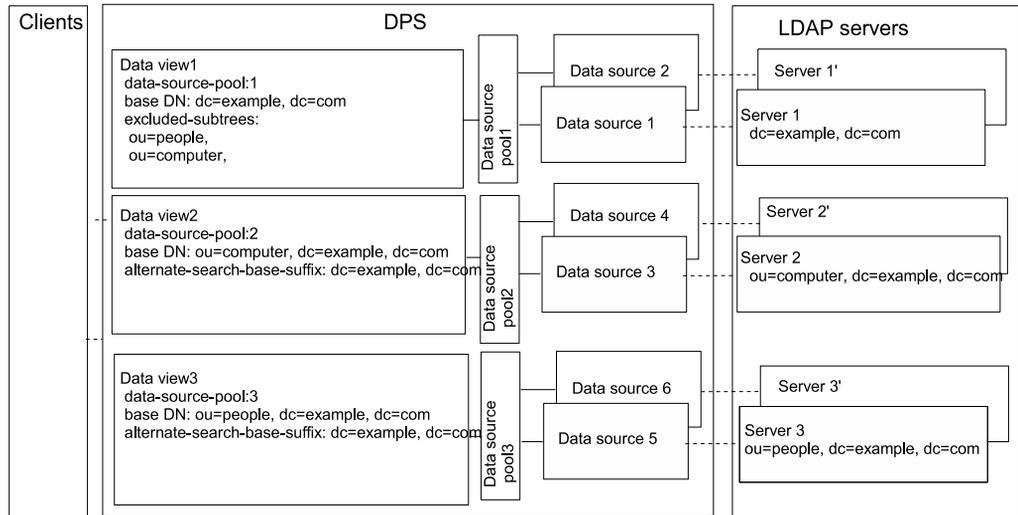
This section describes how Directory Proxy Server provides a single point of access when a superior branch of a subtree is stored in a different data source to a subordinate branch.

By default, Directory Proxy Server automatically sets the `excluded-subtrees` property and the `alternate-search-base-dn` property. However, the automatic management of the `excluded-subtrees` property and the `alternate-search-base-dn` property can be disabled. For information about how to manually configure the `excluded-subtrees` property and the `alternate-search-base-dn` property, see [“To Manually Configure the excluded-subtrees and alternate-search-base-dn Properties”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

The example in [Figure 17–7](#) contains three data views. The base DN of `dataview-1` is superior to the base DNs of `dataview-2` and `dataview-3`.

The `excluded-subtrees` property on `dataview-1` excludes `dataview-2` and `dataview-3` from `dataview-1`. The `alternate-search-base-dn` properties on `dataview-2` and `dataview-3` include `dataview-2` and `dataview-3` in search operations targeted at `dataview-1`. [Figure 17–7](#) shows the example deployment.

FIGURE 17-7 Example Deployment to Route Requests When Superior and Subordinate Subtrees Are Stored in Different Data Sources



Directory Proxy Server exposes a request to the data view which satisfies the following conditions:

- The DN targeted by the request is subordinate to the base DN of the data view
- The DN targeted by the request is not excluded from the data view by the excluded - subtrees parameter

When a request is exposed to a data view, the request is forwarded to the data source pool specified by the data view.

If a request does not match the conditions of any data view, the request cannot be exposed to a data view and Directory Proxy Server returns an error.

In [Figure 17-7](#), client requests that target dc=example, dc=com but do not target ou=computer, dc=example, dc=com or ou=people, dc=example, dc=com are forwarded to the data source pool 1. Such requests are treated by data source 1 or data source 1'. Client requests that target ou=computer, dc=example, dc=com or ou=people, dc=example, dc=com are forwarded to data source pool 2 and data source 3, respectively. Directory Proxy Server returns an error for client requests that do not target dc=example, dc=com.

All three data views are candidates for search operations that are targeted at dc=example, dc=com.

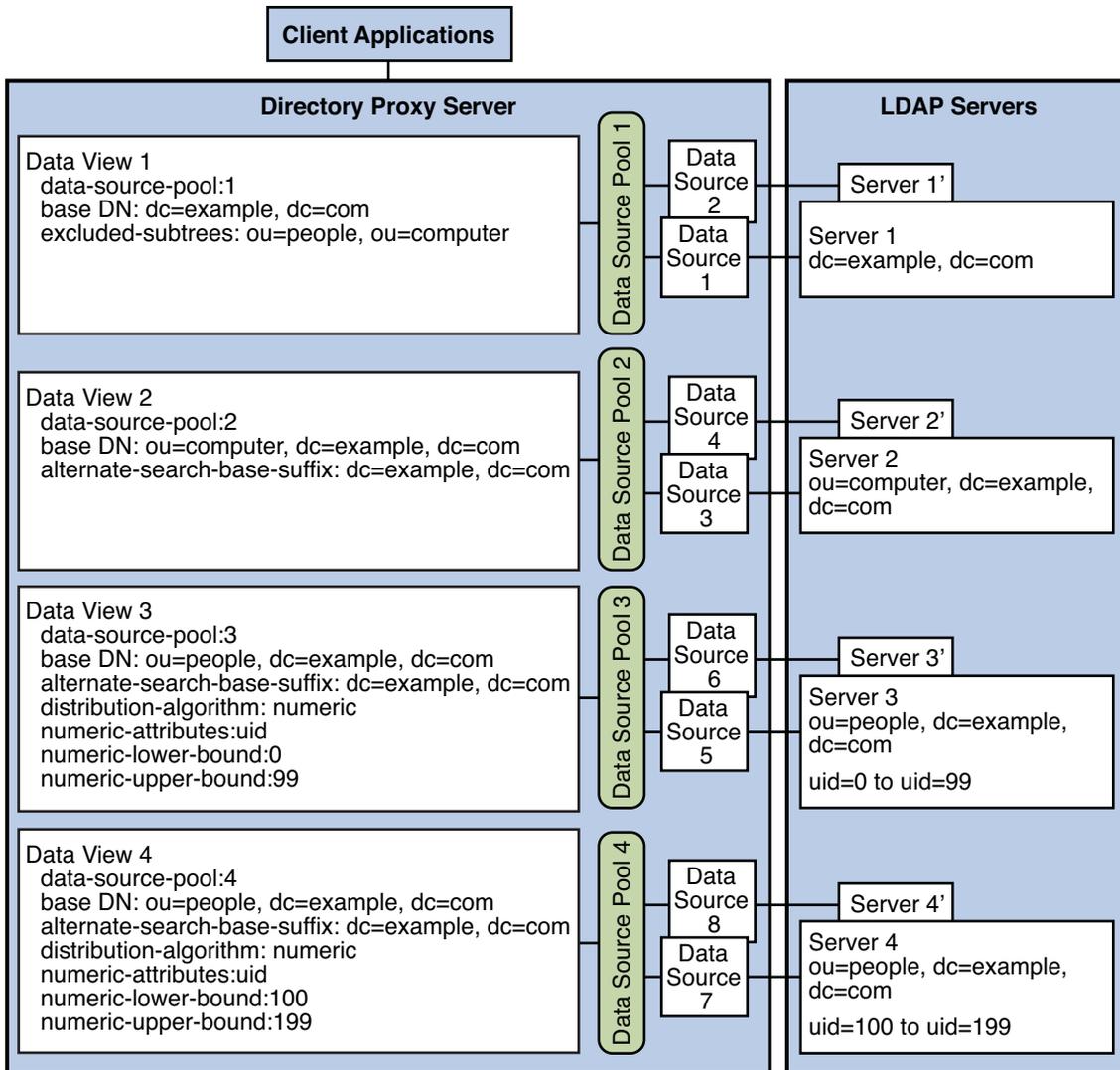
For information about how to configure a data view to provide a single point of access to different parts of subtree in multiple data sources, see “Data Views That Provide a Single Point of Access When Superior and Subordinate Subtrees Are Stored in Different Data Sources” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Data Views With Hierarchy and a Distribution Algorithm

Different data views can be used in the same topology to expose or hide parts of a subtree. [Figure 17–8](#) shows an example with data views that combine the hierarchy shown in [Figure 17–7](#) with the distribution algorithms shown in [Figure 17–6](#).

The example in [Figure 17–8](#) contains four data views. The base DN of data view 1 is superior to the base DNs of the other data views. Data view 3 and data view 4 have the same base DN, but a numeric distribution algorithm separates entries into the different data views. [Figure 17–8](#) shows the example deployment.

FIGURE 17-8 Data View With Hierarchy and a Distribution Algorithm



The `excluded-subtrees` property on `dataview-1` excludes the other data views from `dataview-1`. The `alternate-search-base-dn` property on `dataview-2`, `dataview-3`, and `dataview-4` includes these data views in search operations targeted at `dataview-1`.

Directory Proxy Server exposes a request to the data view which satisfies the following conditions:

- The DN targeted by the request is subordinate to the base DN of the data view

- The DN targeted by the request is not excluded from the data view by the `excluded-subtrees` parameter
- The parameters of the requests match the pattern specified by the distribution algorithm

When a request is exposed to a data view, the request is forwarded to the data source pool specified by the data view.

If a request does not match the conditions of any data view, Directory Proxy Server returns an error.

For information about how to configure a complex data view, see [“Data Views With Hierarchy and a Distribution Algorithm”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Directory Proxy Server Virtualization

Directory Proxy Server enables virtualization through the definition of virtual data views. Virtual data views enable you to display physical data in a different way. This chapter describes how virtual data views are created, and the kinds of virtual data views that are available in Directory Proxy Server.

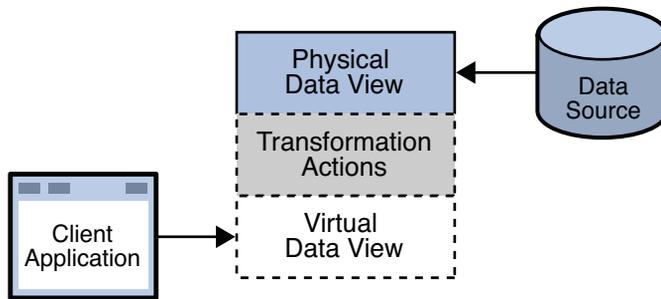
The chapter covers the following topics:

- “Construction of Virtual Data Views” on page 255
- “Virtual Data Transformations” on page 256
- “Additional Virtual Data View Properties” on page 266
- “Join Data Views” on page 267
- “Coordinator Data Views” on page 270
- “LDIF Data Views” on page 271
- “JDBC Data Views” on page 271
- “Access Control On Virtual Data Views” on page 275
- “Virtual Schema Checking” on page 277
- “Virtual Data Views and LDAP Groups” on page 277

Construction of Virtual Data Views

A virtual data view is essentially a physical data view on which certain transformation actions have been defined. The transformation actions take place in real time, to create the virtual data view. The following figure shows how transformation actions are defined on a physical data view to create a virtual data view.

FIGURE 18-1 Virtual Data View



In addition to the transformation actions, certain properties can be defined on a data view, which restrict the way in which data can be managed through that data view. The additional virtual data view properties are described in “[Additional Virtual Data View Properties](#)” on [page 266](#).



Caution – Virtual data views imply a performance impact. The significance of the performance impact depends on several factors including the size of the physical data source, the complexity of the transformation, and the complexity of any virtual ACIs you might use.

Virtual Data Transformations

Virtual data transformations create a virtual data view from a physical data view. Practically, you never define a virtual data view. Instead, you specify the transformations that you require and define these on an existing physical data view. A transformation performs a specific *action* in a certain *direction*. The direction of a transformation determines the transformation model. When you define a virtual data transformation, you create a virtual attribute that exists only in the context of the virtual data view.

A transformation is defined on a data view, by using the `dpconf` command as follows:

```
$ dpconf add-virtual-transformation -h host -p port -D bindDN /
view-name model action attr-name [parameters...]
```

The *view-name* refers to the data view on which the transformation is defined. The *attr-name* refers to the virtual attribute that is created. The model, action, and additional parameters are described in the following sections.

The name of the virtual transformation can be set by using the following command:

```
$ dpconf set-virtual-transformation-prop -h host -p port -D bindDN /
view-name transformation-name property:value [property:value]
```

Transformation Models

The transformation model is determined by the direction of a transformation, in other words, whether the transformation is applied during the request, during the response, or both.

In this sense, transformations can be categorized into the following types:

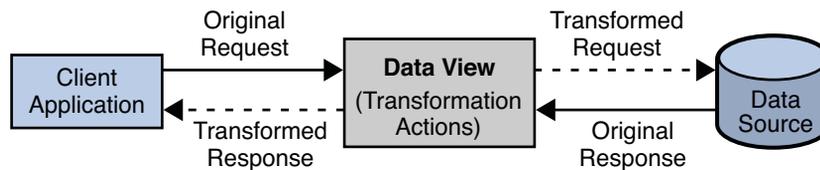
- Mapping transformations (bidirectional transformations)
- Write transformations (inbound transformations)
- Read transformations (outbound transformations)

Mapping Transformations

The most common transformation is a bidirectional (mapping) transformation. A mapping transformation is applied during the request, and its inverse is applied during the response. These transformations are called *mappings* because in effect, an attribute or entry in the physical data view maps to an attribute or entry in the virtual data view. Mapping transformations enable you to process existing values before assigning them to a DN component, an attribute type or value, or an object class.

The following diagram illustrates the principals of a mapping transformation.

FIGURE 18-2 Mapping Transformation



A mapping transformation is defined on a data view, by running the `dpconf` command as follows:

```
$ dpconf add-virtual-transformation -h host -p port -D bindDN /
view-name mapping action attr-name [parameters]
```

EXAMPLE 18-1 When Would You Use a Mapping Transformation?

Imagine, for example, an organization has a physical data source that contains entries with the attributes `surname` and `givenname`. The organization has a client application that requires entries to have a `cn` (common name) attribute of the form `givenname surname`.

The client application sends a search request for an entry of the form `cn=Carlos Fuentes`. A transformation is defined that extracts the name and surname during this request and transforms the request to one of the form `surname=Fuentes, givenname=Carlos`. The

EXAMPLE 18-1 When Would You Use a Mapping Transformation? *(Continued)*

corresponding entry is located in the data source. Before returning this entry to the client application, the inverse transformation is performed. The client application receives the entry as `cn=Carlos Fuentes`, which it understands.

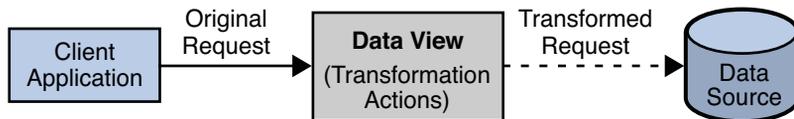
This request is transformed to be of the form `surname=Fuentes, givenname=Carlos`. Similarly, the client application sends a modify request to change the `cn` attribute of an entry to `Lisa Davis`. The request is transformed so that the `givenname` attribute of the physical entry is modified to `Lisa` and the `surname` attribute is modified to `Davis`.

Write Transformations

A write transformation is applied during the request, but not during the response. A write transformation *changes the physical data in storage*.

The following diagram illustrates the principals of a write transformation.

FIGURE 18-3 Write Transformation



A write transformation is defined on a data view, by using the `dpconf` command as follows:

```
$ dpconf add-virtual-transformation -h host -p port -D bindDN /
view-name write action attr-name [parameters]
```

EXAMPLE 18-2 When Would You Use a Write Transformation

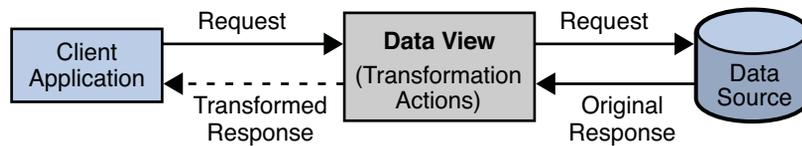
Imagine an organization has a legacy application whose function is to add person entries to a data source. The application adds the entries without the `telephoneNumber` attribute. The physical data source has been upgraded and the `telephoneNumber` is now a mandatory attribute for person entries. The transformation required here is to add the `telephoneNumber` attribute during the add request. This transformation changes the entry that is written to the database. No reverse transformation is required.

Read Transformations

A read transformation is applied only during the response to a request. No transformation is applied during the request and the physical data is not changed.

The following diagram illustrates the principals of a read transformation.

FIGURE 18-4 Read Transformation



A read transformation is defined on a data view, by using the `dpconf` command as follows:

```
$ dpconf add-virtual-transformation -h host -p port -D bindDN /
view-name read action attr-name parameters
```

EXAMPLE 18-3 When Would You Use a Read Transformation

Imagine an organization has a legacy application whose function is to display person entries. The application does not support entries that do not contain a `mail` attribute. The physical data source has been upgraded and the `email` attribute no longer exists for person entries (e-mail addresses are constructed using other attributes).

The transformation required here is to add the `mail` attribute during the search response. This transformation changes the entry that is read from the database and adds a `mail` attribute whose value is `givenname.surname@example.com`. No reverse transformation is required and the physical data is not changed.

Note that with the above transformation, the `mail` attribute makes no sense in a search request filter. Search request filters must contain physical attributes.

Transformation Actions

Transformation actions describe what a transformation does to its target entry or entries. The following transformation actions are possible:

- **Construct an attribute.** This action enables you to construct a virtual attribute that does not actually exist in the physical data source but is required by a client application. The action can also be used to alter an add or modify request to construct an attribute that is required by the physical data source.

To construct the attribute, use the `add-attr` transformation action.

- **Remove an attribute.** This action enables you to delete an attribute from a client request if that attribute is not permitted by the schema on the physical data source. The action can also be used to remove an attribute from the response sent to a client application if the client application does not require that attribute.

To remove an attribute, use the `remove-attr` transformation action.

- **Construct an attribute value.** This action enables you to create an attribute value from other attribute values.

To create an attribute value, use the `add-attr-value` transformation action.

- **Delete an attribute value.** This action enables you to remove the value from an attribute. It is usually used to remove one or more values from a multi-valued attribute if either the client application or the data source schema does not permit multi-valued attributes.

To remove an attribute value, use the `remove-attr-value` transformation action.

- **Add a default value to an attribute.** This action enables you to add a default value to an attribute, if no value exists.

To add a default value to an attribute, use the `def-value` transformation action.

- **Map one attribute value to another.** This action enables you to have two different values for an attribute, depending on whether the attribute is being written to a data source or returned to a client application.

To map attribute values, use the `attr-value-mapping` transformation action, with the `internal-value` and `view-value` parameters.

Note – Directory Proxy Server supports two ways of mapping attribute values — simple attribute mapping and mapping through a virtual transformation. In general, attribute mapping is simpler to configure and slightly better in terms of performance. For more information, see “[Renaming Attributes and DNSs](#)” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

The results of a transformation action depend on the transformation model.

Transformation Parameters

Transformation parameters provide the value of a virtual attribute. This value can either be a default value, or rule that creates the value from other attribute values.

The following transformation parameters are accepted:

- `value`. This parameter is applied to all transformation actions that add an attribute value, other than the `attr-value-mapping` action.
- `internal-value:value`. This parameter applies only to the `attr-value-mapping` action, and to the `remove-attr-value` action when used with the mapping model. It describes the value of the attribute that is written to or read from the physical data source.
- `view-value:value`. This parameter applies only to the `attr-value-mapping` action, and to the `remove-attr-value` action when used with the mapping model. It describes the value of the attribute that is returned to or sent by the client application.

Transformation parameters take the following syntaxes:

- **Constant.** Used to generate an attribute with a static default value.
For example, the parameter `0800-5994654` might be used to provide a default telephone number.
- **Attribute value.** Used to create a new attribute from an existing attribute in the entry that is being processed.
For example, the parameter `\${cn}` specifies that the value of the new attribute must be taken from the value of the `cn` attribute. The escape character is required before the `$`.
- **Constant and attribute value.** Used to create a new attribute by combining an existing attribute and a static value.
For example, the parameter `\${cn}@example.com` specifies that the value of the new attribute must be taken from the value of the `cn` attribute and a static domain name.
- **Macro.** Used to create an attribute by manipulating the value of an existing attribute. The macro is a Java regular expression. For more information about Java regular expressions, see http://download.oracle.com/docs/cd/E17476_01/javase/1.4.2/docs/api/java/util/regex/Pattern.html.

The following macros are supported:

- Increase the value of an attribute by a consistent amount:

`increment (source-attribute-value, increment)`

For example, the macro `increment (\$(uid), 10)` specifies that the value of the new attribute is obtained by adding 10 to the value of the `uid` attribute present in the entry.

- Decrease the value of an attribute by a consistent amount:

`decrement (source-attribute-value, decrement)`

For example, the macro `decrement (\$(uid), 10)` specifies that the value of the new attribute is obtained by subtracting 10 from the value of the `uid` attribute present in the entry.

- Use part of an existing attribute value.

`substring (source-attribute-value, begin-index[, end-index])`

The `begin-index` is inclusive and the `end-index` is exclusive. That is, the substring begins on the character specified by the `begin-index` and ends on the character just before the `end-index`.

For example, to create a new attribute whose value is the value of the `cn` attribute minus the first two characters, you would define the following macro:

`substring (\${cn}, 2)`

To create a new attribute whose value contains only the first two characters of the value of the `cn` attribute, you would define the following macro:

```
substring(\${cn}, 0, 2)
```

- Use part of an existing attribute value by splitting that value at a certain point.

```
split(source-attribute-value, token-index, regular-expression)
```

For example, the macro `split\(\${mail}, 1, "@\`) returns the domain.

Note – The transformation parameter syntax is slightly different when used in the context of a join data view. For more information, see [“Virtual Data Transformations on Join Data Views” on page 270](#).

Transformation Examples

The following sections provide use cases in which virtual data views are required, and the combination of transformation models and actions required to implement the use cases.

EXAMPLE 18-4 Adapting an ADAM Object Class For LDAP Compliance

An organization, Example A, stores its users in an LDAP directory. Example A acquires another company, Example B, which stores its users in an ADAM directory.

In Example A's LDAP directory, a user is stored as an `inetOrgPerson`. In Example B's directory, a user is stored as a `user`. A transformation is required that maps the ADAM user object class to the LDAP `inetOrgPerson` object class.

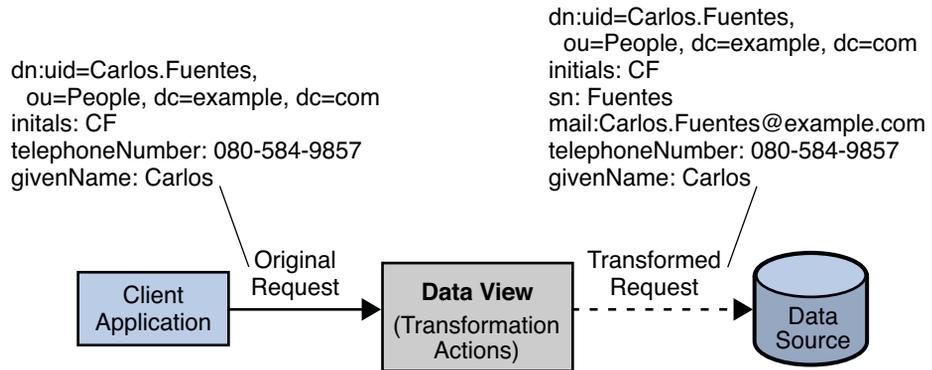
The following transformation is defined on the physical data view of Example A's directory:

```
$ dpconf add-virtual-transformation -h myHost -p 2389 -D "cn=Proxy Manager" \
  exampleB-view-name mapping attr-value-mapping objectclass internal-value:user \
  view-value:inetOrgPerson
```

EXAMPLE 18-5 Constructing an Attribute With a Write Transformation

Example A stores user entries in its directory. All user entries require a `mail` attribute. If user entries without a `mail` attribute are added, a schema violation error is returned. Example A has a client application that adds user entries to the directory. Some user entries do not contain a `mail` attribute and the client application is incapable of generating one. To avoid schema violations when a user entry is added, a transformation is defined that adds the `mail` attribute to an add request. The value of the `mail` attribute is taken from the `uid` provided in the client add request, with the addition of `@example.com`.

The following diagram indicates the transformation that occurs on an add request.



EXAMPLE 18-5 Constructing an Attribute With a Write Transformation (Continued)

This transformation is defined on the physical data view by using the following `dpconf` command.

```
$ dpconf add-virtual-transformation -h myHost -p 2389 -d "cn=Proxy Manager" \
exampleA-view-name write add-attr mail \${uid}@example.com
```

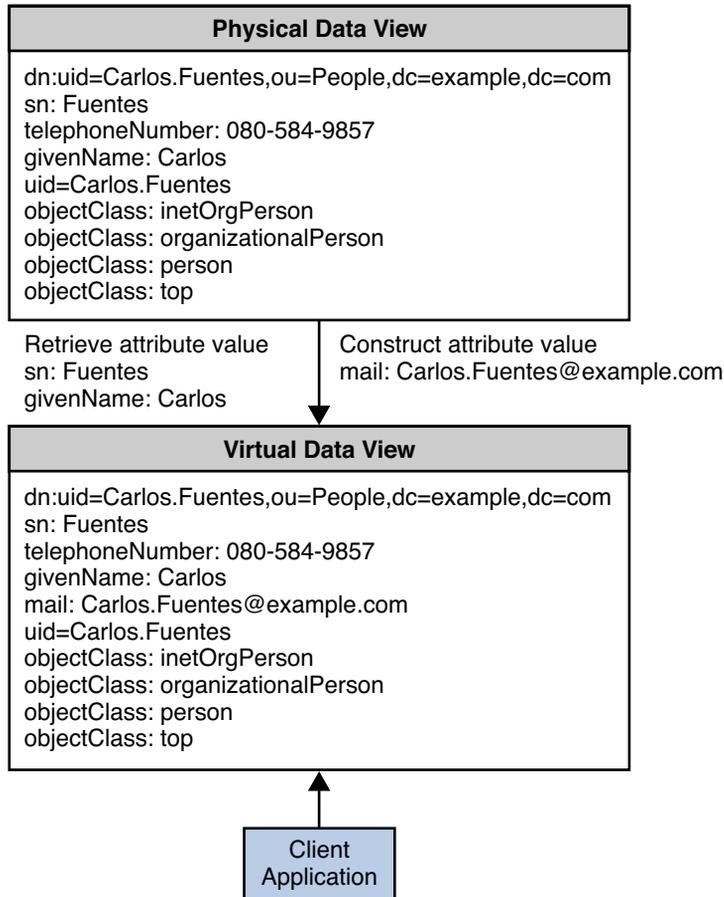
In this command, `\${uid}` means the value of the `uid` attribute for that entry.

EXAMPLE 18-6 Constructing an Attribute With a Read Transformation

Example A does not store the mail addresses of its users in its directory. However, a new client application requires that a user's mail address be returned with the user entry.

All mail addresses in the organization take the form `firstname.lastname@example.com`. The organization defines a virtual view in which the mail attribute is added to each user entry for reads only. The value of the mail attribute is generated by taking the value of the `givenName` and `sn` attributes that already exist in the user entry.

The following diagram indicates the transformation that occurs on user entries when they are returned in a search.



EXAMPLE 18-6 Constructing an Attribute With a Read Transformation (Continued)

This transformation is defined on the physical data view by using the following `dpconf` command.

```
$ dpconf add-virtual-transformation -h myHost -p 2389 -d "cn=Proxy Manager" \
  exampleA-view-name read add-attr mail \${givenname}.\${sn}@example.com
```

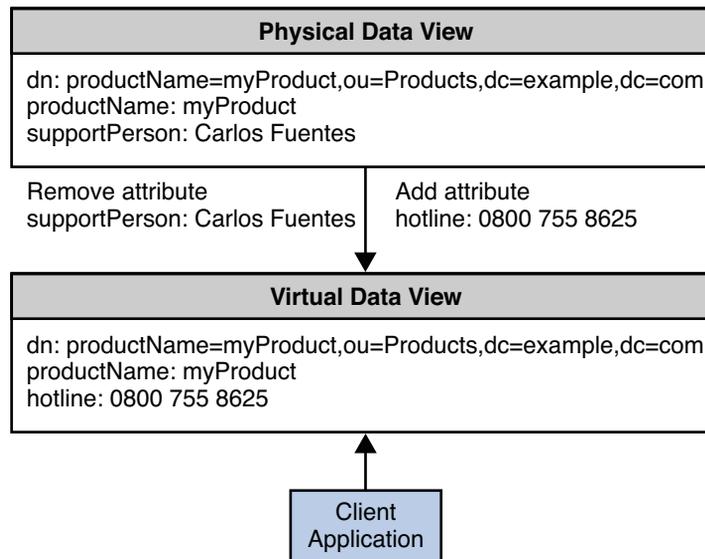
EXAMPLE 18-7 Adding a Default Attribute Value

Example A stores a number of products in its directory. In the past, each product was associated with a support person, an employee responsible for handling all support calls for that product. In the physical data store, each product is therefore associated with a `supportPerson` attribute, whose value is the DN of an employee in the organization.

EXAMPLE 18-7 Adding a Default Attribute Value (Continued)

The organization has changed its business process for support queries and now sends all product queries to a central hotline. To handle this change without changing the physical data, the organization defines a virtual data view where all product entries do not have a supportPerson attribute, but have a hotLine attribute instead. The value of the hotLine attribute is an 0800 number that is the same for all products.

The following diagram indicates the transformation that occurs on product entries when they are returned in a search.



This transformation is defined on the physical data view by using the following `dpconf` commands:

```

$ dpconf add-virtual-transformation -h myHost -p 2389 -d "cn=Proxy Manager" \
  exampleA-view-name read remove-attr supportPerson
$ dpconf add-virtual-transformation -h myHost -p 2389 -d "cn=Proxy Manager" \
  exampleA-view-name read add-attr hotLine "0800755 8625"
  
```

EXAMPLE 18-8 Using a Virtual Transformation to Rename a DN

Example A has a client application that needs to sort entries according to their object class.

To do this, Example A defines a virtual transformation that rewrites the RDN of entries to include the object class of the entry along with its `cn`, whenever an entry is returned to that specific client application.

EXAMPLE 18-8 Using a Virtual Transformation to Rename a DN *(Continued)*

The following transformation is defined on the physical data view of Example A's directory:

```
$ dpconf add-virtual-transformation -h myHost -p 2389 -d "cn=Proxy Manager" \  
exampleB-view-name mapping attr-value-mapping dn internal-value:cn=\${cn} \  
view-value:cn=\${cn},objectclass=\${objectclass}
```

Additional Virtual Data View Properties

In addition to the transformation actions described previously, certain properties can be defined on a data view, which restrict the way in which data can be managed through that data view. These properties essentially provide a list of the attributes that can be read or modified through the virtual data view.

The following additional properties can be defined on a data view to present a restricted virtual data view:

- **Non-viewable attributes.** A list of the attributes that cannot be read through this data view. This list is specified by adding the multi-valued property `non-viewable-attr` to the data view. This property should be used if the number of attributes that cannot be read is small.
- **Non-writable attributes.** A list of the attributes that cannot be added or modified through this data view. This list is specified by adding the multi-valued property `non-writable-attr` to the data view. This property should be used if the number of attributes that cannot be added or modified is small.
- **Viewable attributes.** A list of the attributes that can be read through this data view. This list is specified by adding the multi-valued property `viewable-attr` to the data view. This property should be used if the number of attributes that can be read is small.
- **Writable attributes.** A list of the attributes that can be added or modified through this data view. This list is specified by adding the multi-valued property `writable-attr` to the data view. This property should be used if the number of attributes that can be added or modified is small.

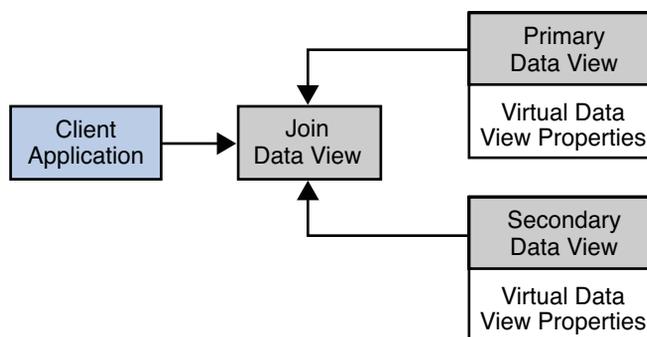
Non-viewable attributes and viewable attributes are mutually exclusive. Similarly, non-writable attributes and writable attributes are mutually exclusive.

Join Data Views

A join data view is an *aggregation* of multiple data views. The current release of Directory Proxy Server supports the aggregation of *two* data views into one join data view.

A join data view is created by specifying its name and the two existing data views that will be aggregated. One of these existing data views is considered the *primary* data view, and the other the *secondary* data view. Before you create the join data view, you need to configure the rules on the secondary data view that determine how the data is aggregated.

The following figure shows the aggregation of a primary and secondary data view to form one join data view.



Primary and Secondary Data Views

The hierarchical organization of the sources for a join data view enables Directory Proxy Server to make default decisions where the data from the primary and secondary data views do not match.

The primary data view controls the existence of entries in the join data view. The secondary data view provides supplementary data for this list of entries. In other words, if an entry exists in the secondary data view but not in the primary data view, it does not appear in the join data view.

The primary data view is the authoritative source by default. When an attribute is present on both source data views but has a different value on each, a multi-valued attribute is returned. This behavior is configurable, however. For example, you can choose to accept only the value in the primary data view, or only the value in the secondary data view.

Additional Secondary Data View Properties

In addition to the virtual data view properties described in “[Additional Virtual Data View Properties](#)” on page 266, certain properties can be defined only on a secondary data view. These properties determine how data from the two views is aggregated and how requests to the data views are handled. The following sections describe these additional properties.

Join Rules

Join rules determine how an entry from a secondary data view relates to an entry from a primary data view. Join rules are not mandatory on a secondary data view. However, if no join rule is defined, the secondary data view is not queried during LDAP operations. Directory Proxy Server provides two types of join rules, DN join rules and filter join rules.

DN Join Rules

A DN join rule determines the DN of entries in the secondary data view. A DN join rule is configured on the secondary data view by using the `dn-join-rule` property. Only one DN join rule can be configured on a secondary data view. If a DN join rule is configured on a data view, a filter join rule cannot be configured on that data view.

A DN join rule has DN syntax and can take one of the following forms:

- The DN of the secondary entry is constructed from an attribute in the primary entry. For example, the following DN join rule stipulates that the DNs of entries in the secondary data view should include the `cn` from the primary data view, plus the `ou=people` suffix.

```
cn=\${primary-data-view.cn},ou=people
```

The DN must *not* contain the base DN of the secondary data view. In this sense, it is a *relative DN*.

- The DN of the secondary entry is the same as the DN of the primary entry.

The syntax of such a join rule is as follows:

```
\${primary-data-view.dn}
```

In this case, the portion of the primary and the secondary DNs below the base DN are identical, although the full DNs may differ. Imagine, for example, that the primary data view has a base DN of `o=primary` and the secondary data views has a base DN of `o=secondary`. A join rule of `\${primary-data-view.dn}` implies that the DITs below the base DN are identical. So, the entry `uid=1,o=secondary` would be associated with `uid=1,o=primary`.

Filter Join Rules

A filter join rule defines the relationship between the primary and secondary data views. A filter join rule is configured on the secondary data view by using the `filter-join-rule` property. This rule indicates how an entry should be retrieved from the secondary data view based on something in the primary data view.

Only one filter join rule can be configured on a secondary data view. If a filter join rule is configured on a data view, a DN join rule cannot be configured on that data view. A filter join rule takes the form of a filter that is used to construct an attribute from one or more attributes from the primary data view.

For example, the following filter join rule stipulates that an entry be retrieved if the entry `uid` in the primary data view matches the entry `uid` in the secondary data view.

```
uid=\${primary.uid}
```

Handling of Shared Entries

The `contains-shared-entries` property determines what should be done if an entry in the secondary data view is used by more than one entry in the primary data view.

Imagine for example, that the primary data view contains a list of user entries and the secondary data view contains a list of department numbers. A single department number in the secondary data view might apply to more than one user in the primary data view. If a user is deleted from the primary data view, you do not necessarily want that user's department number to be deleted from the secondary data view.

The `contains-shared-entries` property is set on the secondary data view only. This property is set to `TRUE` by default. This means that deleting an entry in the primary data view will not result in the deletion of the shared entry in the secondary data view. Adding an entry to the primary data view will only add the entry to the secondary data view if it does not already exist.

Handling of Binds

The `process-bind` property specifies whether a bind can be performed on the secondary data view.

By default, primary data views allow binds and secondary data views do not. The `process-bind` property is not set by default. If this property is set to `true` on a secondary data view, binds are permitted on that data view.

How Directory Proxy Server Handles Read and Write Operations to Join Data Views

If an attribute exists on both the primary and secondary data view, the attribute values are merged by the join data view. For read operations, this implies that a multi-valued attribute is returned, with the values from both data views. For write operations, the proxy queries both data views and determines where to write the value based on the content of the write operation.

If one backend data source fails during an add operation Directory Proxy Server performs an automatic rollback. The roll back takes the form of a delete operation on the data source that did not fail. This ensures the consistency of the data between the two data sources. If a roll back

cannot be performed, an error is logged and an optional administrative alert is raised. Automatic roll back is on by default. You can configure automatic roll back by setting the `revertAddOnFailure` attribute to `off` (directly in `cn=config`).

If one backend data source fails during a delete operation, no roll back is performed. An error is logged and an optional administrative alert is raised.

Virtual Data Transformations on Join Data Views

Virtual data transformations are described in [“Virtual Data Transformations” on page 256](#). The syntax of a transformation parameter differs slightly if the data transformation is defined on a join data view. Because an attribute can be obtained from more than one data view, variables that define the attribute content must be *fully qualified*. That is, the source attribute value must include the name of the data view from which the attribute is taken.

For example, the following parameter creates an attribute from existing attributes in both the primary and secondary data views:

```
\${primaryDataView.firstName}.\${secondaryDataView.lastName}@{\primaryDataView.domainName}
```

The `firstName` and `domainName` attributes are taken from the primary data view, and the `lastName` attribute is taken from the secondary data view.

Coordinator Data Views

Coordinator Data View groups a sequence of data views so that they appear as a single data view. This grouping enables users to access entries that are stored in separate data views, without knowing where each entry is stored while performing operations. The data view automatically discovers where each entry is stored and performs operations on them.

Features of Coordinator Data View

- When entities from two different sources are unified into a single name space, no distribution algorithm is used to locate entries that are still stored under separate data sources.
- When naming services are deployed with a directory servers hierarchy, the queries would hit the local server first. If no matching entry is found, the query would contact a more global server.
- When data is distributed among multiple data views, the Coordinator data view groups the distributed data views to appear as a single data view which can be further used as a primary or secondary data view in Join Data View. In this way, the Coordinator data view enables entry aggregation and distribution.

- When the distribution key is not available in the query, the Coordinator data view routes the request to a distribution data view that further iterates across the distributed data views to locate the entry.

For all the configuration details, see “[Creating and Configuring Coordinator Data Views](#)” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*

LDIF Data Views

An LDIF data view is a simple virtual data view in which an LDIF file is made to look like an LDAP data source. An LDIF data view is defined by using the `dpconf` command as follows:

```
dpconf create-ldif-data-view VIEW_NAME LDIF_FILE_NAME SUFFIX_DN
```

No additional transformations are required. Directory Proxy Server automatically performs the transformations required to make the LDIF data look like LDAP data to client applications.

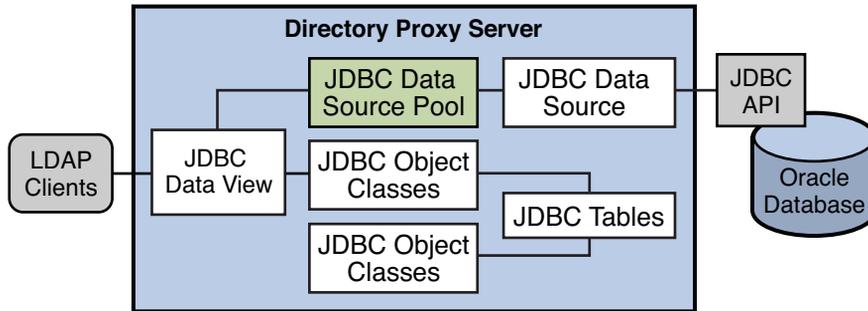
For information about creating and configuring LDIF data views, see “[Creating and Configuring LDIF Data Views](#)” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

JDBC Data Views

A JDBC data view enables you to make a relational database accessible to LDAP client applications. The following configuration objects are required to set up a JDBC data view:

- **JDBC data source.** Defined for each relational database. Currently, only one JDBC data source is supported per JDBC data view.
- **JDBC data source pool.** Defined for each JDBC data source.
- **JDBC data view.** Aggregates JDBC object classes into a single data view accessible by LDAP client applications.
- **JDBC object class.** Maps one or more JDBC tables to an LDAP object class.
- **JDBC table.** Defined for each relational database table.
- **JDBC attribute.** Defines an LDAP attribute from a specified column in a JDBC table.

The following diagram shows how an LDAP client application is able to view an Oracle database in the format of an LDAP DIT, through the configuration of the JDBC objects described previously. These objects are discussed in more detail in the following sections.



An LDAP client application can also *bind* to a JDBC data view, or to a join data view that includes a JDBC data view. In this case Directory Proxy Server obtains the password from the JDBC database to do the password check. The password can be obtained in clear, SHA, or SSHA.

JDBC Data Sources and Data Source Pools

A JDBC data source is defined for each relational database. The properties of a JDBC data source include the name and location of the relational database, and the user name and password required to access the database. For a complete list of the properties that can be set for a JDBC data source, run the following command:

```
$ dpconf get-jdbc-data-source-prop -h myHost -p 2389 -d "cn=Proxy Manager"\
  jdbc-data-source-name
```

Currently, only one JDBC data source is supported for each JDBC data view. In other words, you cannot load balance across JDBC data sources.

Like LDAP data sources, JDBC data sources are organized into data source pools. The properties of a JDBC data source pool are similar to those of an LDAP data source pool. For more information about LDAP data source pools see [“LDAP Data Source Pools” on page 229](#).

Note – Directory Proxy Server relies on metadata retrieved from the relational database. This metadata is read when Directory Proxy Server starts, or when a new JDBC data view is added. The metadata is not reread each time Directory Proxy Server processes a request. If you change the metadata in the relational database, you must restart Directory Proxy Server to take the changes into account.

The metadata is changed when any of the following changes are made:

- Changes to the structure of the database (adding or removing tables, rows, or columns)
 - Changes to the case sensitivity of any column in a table
-

JDBC Object Classes

A JDBC object class maps an LDAP object class to one or more relational database tables. A JDBC object class works in a similar way to a join data view (see “[Join Data Views](#)” on page 267). Just as a join data view has primary and secondary source data views, a JDBC object class can obtain its information from more than one table. One table must be defined as the primary table, and additional tables, if they exist, are defined as secondary tables. The primary table controls the list of entries and additional information on these entries is extracted from the secondary tables.

When you define a JDBC object class, you must specify the following operands:

- The name of the JDBC data view to which this object class is attached.
- The name of the JDBC object class.
- The primary JDBC table from which the object class will obtain its list of entries.
- A DN pattern that controls how DNs are constructed in the data view.
- Optionally, one or more secondary JDBC tables.

JDBC Tables

A JDBC table must be created for each relational database table that will be used in the JDBC data view. When you create a JDBC table you specify the name of the table in the relational database, and the name you want to assign to this table in the JDBC data view.

The following properties apply to JDBC tables:

- **SQL table.** (`sql-table`) Specifies the name of the relational database table.
This value must be specified when you create the JDBC table but can be changed if the SQL table name changes.
- **Single row table.** (`is-single-row-table`) Specifies that an LDAP entry has only one matching row in the relational database table.
Generally, performance is improved if this property is set to `true` because there is no ordering in the SQL request.
- **Shared entries.** (`contains-shared-entries`) This property determines what should be done if a row in a secondary table is used by more than one entry in the primary table.
Imagine for example, that the primary table contains a list of user details and the secondary table contains department numbers. A single department number in the secondary table might apply to more than one user in the primary table. If a user is deleted, you do not necessarily want that user's department number to be deleted from the secondary table.
The `contains-shared-entries` property is set on secondary tables only. If this property is set to `TRUE`, deleting an LDAP entry will result in deletion of the user in the primary table but not in the deletion of the corresponding row in the secondary table.

- **Filter join rule.** (`filter-join-rule`) A filter join rule defines the relationship between primary and secondary tables.

A filter join rule is mandatory on secondary tables, and indicates how an entry should be retrieved from the secondary table based on something in the primary table.

Only one filter join rule can be configured on each secondary table. A filter join rule takes the form of a filter that is used to construct an LDAP attribute.

For example, the following command creates a filter join on the secondary phone table. This rule stipulates that an entry be retrieved from the phone table if the `user_id` field in that table matches the `id` field in the employee table.

```
$ dpconf set-jdbc-table-prop -h myHost -p 2389 -d "cn=Proxy Manager" \
  phone filter-join-rule:user_id=\${employee.id}
```

JDBC Attributes

JDBC attributes map LDAP attributes to entries in relational database tables. The definition of a JDBC attribute includes the name of the LDAP attribute, and the table and column in which the corresponding information is located.

For example, the following command maps the `employeeNumber` attribute to the `ID` field of the `EMPLOYEE` table.

```
$ dpconf add-jdbc-attr -h myHost -p 2389 -d "cn=Proxy Manager" \
  EMPLOYEE employeeNumber ID
```

The following properties apply to JDBC attributes:

- **LDAP syntax.** (`ldap-syntax`) This property defines the syntax used to construct the LDAP attribute from an entry in the relational database table.
Changes to JDBC attribute syntax require a server restart before they are taken into account.
- **SQL column.** (`sql-column`) The column in the relational database table from which the LDAP attribute is obtained.
- **SQL syntax.** (`sql-syntax`) This property defines the syntax used to construct an entry in the relational database table from an LDAP entry.

Case Sensitivity in JDBC Data Views

In some cases, the LDAP attribute might be *case insensitive*, while the corresponding column in the relational database is *case sensitive*. Directory Proxy Server handles this by adding an `UPPER` keyword to equality and substring indexes. This can have serious performance implications. If the relational database requires case-sensitivity, you should therefore create specific indexes on the upper case values.

Access Control On Virtual Data Views

In a virtual data view, Directory Proxy Server exposes virtual data. Directory Proxy Server is therefore responsible for controlling who can access that data, and what parts of the data can be accessed. To control access to virtual data, you can define virtual ACIs. When Directory Proxy Server receives a request on a virtual data view, it uses the virtual ACIs, and any authentication information provided by the user, to allow or deny access to the information that is requested.

This section describes the syntax and architecture of virtual ACIs. For information about configuring virtual ACIs, see “[Defining Access Control on Virtual Data Views](#)” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Virtual ACI Definition

Virtual ACIs are defined by using the `dpsaci` operational attribute. The `dpsaci` attribute is multi-valued. This means that several ACIs can be defined for the same portion of a directory.

Directory Proxy Server is responsible for the management of the `dpsaci` attribute. This attribute can be configured along with the physical data but it is not stored with the data. When the `dpsaci` attribute is included in a request, Directory Proxy Server extracts it from the request and manages it in a dedicated ACI repository, through its own ACI data view.

A modify request that targets a virtual data view and contains the `dpsaci` attribute is effectively split into two requests by Directory Proxy Server. The first request handles only the virtual data, and the second request handles the virtual ACI.

Note – By default, write operations are forbidden on non-LDAP data views.

Global ACIs

Global ACIs are defined in the entry `cn=data-source-name,cn=virtual access controls`. These ACIs are evaluated by an ACI engine to deny or allow requests from a connection handler using that ACI pool. Global ACIs are required to allow or deny application administrators to access certain data. These application administrators can then provide more finely-grained access control to users, by placing ACIs directly in the data.

Only the proxy manager can create a pool of ACIs and manage ACIs directly through the ACI data view. Application administrators cannot manage ACIs directly through the ACI data view, even if they have the right to add entries. Application managers can only manage ACIs directly through the data.

ACIs that are defined in the data itself, are evaluated by Directory Proxy Server. These ACIs are entries in the pool of ACIs defined by the proxy manager, that is they are child entries of the entry `cn=data-source-name,cn=virtual access controls`.

ACIs have a performance impact. Therefore, if you use ACIs within the data itself, keep to a minimum the number of rules in the global ACIs, because these ACIs are evaluated every time the subtree is accessed.

Virtual ACI Syntax

The `dpsaci` attribute resembles the Directory Server `aci` attribute in syntax and behavior. For a description of Directory Server ACI syntax, see [“How Directory Server Provides Access Control” on page 78](#).

The following list describes the differences between virtual ACIs and Directory Server ACIs.

- **Target keywords.** Only the `target`, `targetAttr` and `targetscope` keywords are supported.
- **Permission keywords.** The `ALL` access `write` does not permit `selfwrite` operations.
- **Bind rule subject.** For performance reasons, virtual ACIs do not support the `ldap:///suffix??sub?(filter)` as a value for the `userdn` keyword.
- **Bind rule context.** Virtual ACIs do not support SASL authentication. In addition, the `ip` keyword does not support subnet masks.

Virtual ACI Storage and Access

Virtual ACIs are stored centrally, in an LDIF file or in an LDAP directory. When you create a Directory Proxy Server instance, the virtual ACIs are stored in the LDIF file `instance-path/config/access_controls.ldif` by default. You can change the location of the virtual ACIs, particularly if you need to share ACIs across multiple proxy servers. For information about how to change the location of virtual ACIs, see [“To Define a New ACI Storage Repository” in Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition](#).

The ACI repository is accessed through an LDAP or LDIF data view, depending on the type of repository. By default, the access control data view is an LDIF data view named `virtual_access_controls`. The view base exposed by the access control data view *must* exist in the ACI repository.

The ACI repository contains one or more pools of ACIs. An ACI pool is defined by an LDAP entry of the type `aciSource`, directly below the view base of the data view. The ACI pool is a subtree of entries. It can contain access controls, and can be the parent entry of other entries containing ACIs.

Virtual ACI Application

Virtual ACIs are applied per connection handler. The name of the ACI pool to be used is defined as the `aci-source` property of the connection handler. Virtual access controls are not evaluated if you bind as the Proxy Manager.

Virtual Schema Checking

Directory Proxy Server exposes its own schema that is different to the schema of a physical data source. The Directory Proxy Server schema can be stored locally in an LDIF file, or in a remote Directory Server. You can configure where the schema is stored with the `dpconf` command. A schema is defined *per connection handler*. The schema for a specific connection handler can be retrieved or updated using `ldapsearch` or `ldapmodify`. When the schema is updated, Directory Proxy Server must be restarted before the changes take effect.

Schema Checking

Generally, schema checking is performed by the server that exposes the schema. In a scenario where Directory Proxy Server acts as a proxy to one or more Directory Servers, the Directory Servers check that add and modify requests adhere to their LDAP schema. When Directory Proxy Server exposes its own schema, Directory Proxy Server must check that add and modify requests adhere to these schema.

Because a schema is defined for a specific connection handler, schema checking is enabled per connection handler. Schema checking is enabled by setting the `schemaCheck` attribute of a connection handler to `true`.

Virtual Data Views and LDAP Groups

With virtual data views, you can define local virtual groups, and use them through ACIs. You can also rely on existing groups defined on backend servers. You can transform the groups from an LDAP directory to appear in the virtual namespace by using DN mapping. You can also transform all member DNs by using attribute value renaming.

With a join data view, you can join two static groups from two different LDAP backends, as long as there are no member naming conflicts. You can also create a read-only virtual group, by using an ACI on the `uniqueMember` attribute, for example.

Directory Proxy Server server uses groups in the area of ACIs only. The ACI engine can reference both static and dynamic groups by using the `groupdn` keyword.

Virtual ACIs support both static and dynamic groups. However, the `isMemberOf` feature is not supported. Due to the severe performance impact, nested groups are also not supported.

With dynamic groups, attribute value renaming does not apply to the value of the dynamic group, because this value is an LDAP URL and is therefore not DN syntax. In other words, if a dynamic group value contains a DN, the DN part is not renamed.

Connections Between Directory Proxy Server and Backend LDAP Servers

This chapter describes the connections between Directory Proxy Server and backend LDAP servers. The chapter covers the following topics:

- “LDAP Data Sources” on page 279
- “Connections Between Directory Proxy Server and Backend LDAP Servers” on page 280
- “Forwarding Request From Directory Proxy Server to Backend LDAP Servers” on page 281

LDAP Data Sources

The connections between Directory Proxy Server and backend LDAP servers are configured through *LDAP data sources*. An LDAP data source identifies the name and port numbers of an LDAP server, and the authentication policy that is applied by Directory Proxy Server when forwarding operations to the LDAP server. LDAP data sources also configures how the LDAP server is monitored.

An LDAP data source can be any LDAP v3 server. Certain advanced functionality of Directory Proxy Server might rely on features that are available only in Oracle's Directory Server, but the configuration of this functionality is optional. For example, the “Get Effective Rights” control in Oracle's Directory Server is used by Directory Proxy Server for proxied authorization.

The health of a backend LDAP server is monitored by testing the connections between Directory Proxy Server and the backend LDAP server. For information about how Directory Proxy Server monitors LDAP data sources, see “[How Data Sources Are Monitored](#)” on page 324.

For information about how to create and configure LDAP data sources, see “[Creating and Configuring LDAP Data Sources](#)” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Connections Between Directory Proxy Server and Backend LDAP Servers

This section describes how connections between Directory Proxy Server and backend LDAP servers are opened and closed. It also describes the use of connection pools for multiple client requests.

Opening and Closing Connections Between Directory Proxy Server and Backend LDAP Servers

At startup, Directory Proxy Server opens a connection to each data source that is configured, and enabled.

When an error is detected on a connection, Directory Proxy Server closes the connection and tries to reestablish it immediately. If Directory Proxy Server cannot connect to a data source, the data source is considered unavailable. For more information about how Directory Proxy Server responds to failed connections, see [“Responding to the Failure of a Data Source” on page 326](#).

Connection Pools Between Directory Proxy Server and Backend LDAP Servers

Connections between Directory Proxy Server and backend LDAP servers are pooled for use with multiple client requests. Each data source can have one pool of SSL connections and one pool of non-SSL connections. The `ssl-policy` property of the data source and the `is-ssl-mandatory` property of the connection handler determine whether SSL is used when contacting the data source.

The number of connections that can be opened to a data source can be configured independently for BIND, READ, and WRITE operations. The same limit applies to SSL connections and to non-SSL connections.

The following properties can be configured for each data source and for each type of operation:

- The initial number of connections made to the data source
- If more than the initial number of connections are requested, the number of new connections made
- The maximum number of connections that can be made to the data source

When BIND replay is configured, Directory Proxy Server attempts to reuse connections that have already been opened, to optimize performance. If a client opens an authenticated connection, the connection is taken from the BIND pool. Therefore, when BIND replay is used,

the connection pool for BIND operations is used more than the connection pools for READ or WRITE operations. For more information about BIND replay, see [“Directory Proxy Server Configured for BIND Replay”](#) on page 281.

When a connection to a data source is not used for 5 minutes, the connection is removed from the pool.

Forwarding Request From Directory Proxy Server to Backend LDAP Servers

Client requests can be forwarded from Directory Proxy Server to backend LDAP servers with different levels of authorization and authentication, and with or without the identity of the client. The configuration of the data source determines the way in which a request is forwarded. For information about proxy authorization in client requests, see [“Directory Proxy Server Configured for Proxy Authorization”](#) on page 283. For information about how to configure proxy authorization in client requests, see [“Proxy Authorization”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

When client requests contain a proxy authorization control, the control is always forwarded with the request, irrespective of how Directory Proxy Server forwards the request. The use case where Directory Proxy Server is configured for proxy authorization *and* the client request itself contains a proxy authorization control is described in [“Directory Proxy Server Configured for Proxy Authorization and the Client Request Does Contain a Proxy Authorization”](#) on page 286.

For information about how client requests are forwarded from Directory Proxy Server to backend LDAP servers, see the following sections:

- [“Directory Proxy Server Configured for BIND Replay”](#) on page 281
- [“Directory Proxy Server Configured for Proxy Authorization”](#) on page 283
- [“Directory Proxy Server Configured to Forward Requests As an Alternate User”](#) on page 287
- [“Directory Proxy Server Configured to Forward Requests Without the Client Identity”](#) on page 287

Directory Proxy Server Configured for BIND Replay

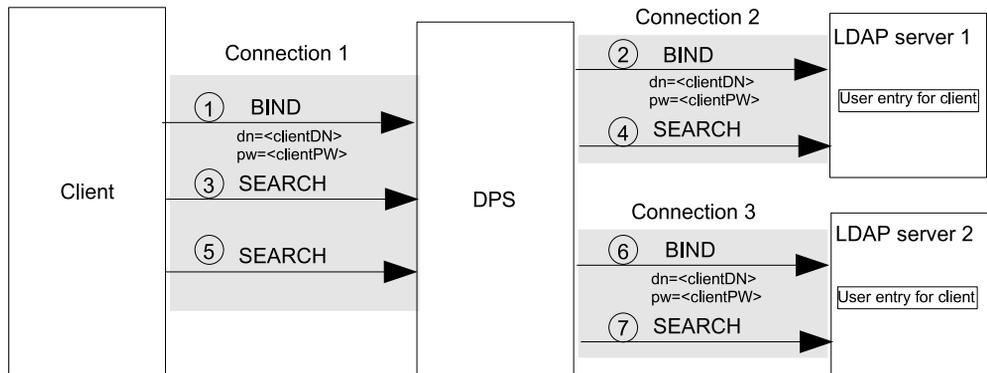
Directory Proxy Server forwards a BIND request from a client and the credentials of the client to an LDAP server. If the BIND is successful, all subsequent requests from the client to that LDAP server are processed with the authorization of the client.

In BIND replay, if the client makes a subsequent request that is forwarded to another LDAP server, the Directory Proxy Server uses the credentials already provided by the client to BIND to the other LDAP server before forwarding the request.

If a client request contains a proxy authorization control, Directory Proxy Server forwards the control to the backend server.

The following figure shows client identity and credentials being used for authorization by BIND replay.

FIGURE 19-1 Authentication in BIND Replay



When Directory Proxy Server is initiated, it opens a connection to each LDAP server. When a client connects to Directory Proxy Server it makes requests in the following stages:

1. The client requests a BIND, and provides a DN and a password.
2. Directory Proxy Server authenticates the client to LDAP server 1 by using the client's credentials. An entry for the client exists in LDAP server 1 and the BIND request is granted.
3. The client issues a SEARCH request that is targeted at LDAP server 1.
4. Directory Proxy Server forwards the SEARCH request to LDAP server 1, reusing connection 2.

The SEARCH request is performed with the authorization of the client. If the client request contains a proxy authorization control, the request is processed with authorization of the user specified in the proxy authorization control.

If the client sends more SEARCH requests that are targeted at LDAP server 1, the Directory Proxy Server forwards the request without performing additional binds.

5. The client sends a SEARCH request targeted at LDAP server 2
6. The Directory Proxy Server authenticates the client to LDAP server 2 by using the client's credentials obtained in Step 1. An entry for the client exists in LDAP server 2 and the BIND request is granted.
7. The Directory Proxy Server forwards the SEARCH request to LDAP server 2, reusing connection 3.

If the client is not authenticated to Directory Proxy Server, the BIND request is forwarded as anonymous.

If the client identity is mapped onto another identity, Directory Proxy Server uses the mapped identity to bind to the LDAP server. All requests on that connection are processed with the authorization for the mapped identity. For information about user mapping, see [“Directory Proxy Server Configured to Forward Requests As an Alternate User” on page 287](#).

When Directory Proxy Server is configured for BIND replay, authentication by SASL external bind cannot be used. In BIND replay, Directory Proxy Server authenticates the client to a backend LDAP server by using the client DN and password. In SASL external bind, no password is provided by the client. Furthermore, the password that is stored in the user entry cannot be read in clear text.

For performance reasons, you should configure Directory Proxy Server to use BIND replay only when the extra configuration required for proxy authorization is not feasible, or where proxy authorization is not supported. For information about proxy authorization, see [“Directory Proxy Server Configured for Proxy Authorization” on page 283](#)

Directory Proxy Server Configured for Proxy Authorization

When Directory Proxy Server is configured for proxy authorization, Directory Proxy Server can add a proxy authorization control to a client request. The client request is then forwarded with the authorization of the specified in the proxy authorization control.

To simplify the configuration of ACIs, Directory Proxy Server can be configured to allow anonymous reads and to apply proxy authorization for write operations.

If Directory Proxy Server is configured for proxy authorization and the client request contains its own proxy authorization control, Directory Proxy Server does not add a proxy authorization control. In this case, Directory Proxy Server checks with the backend LDAP server that the client has the right to use its proxy authorization control. If the client has the right to use its proxy authorization control, Directory Proxy Server forwards the request with the authorization specified in the client's proxy authorization control.

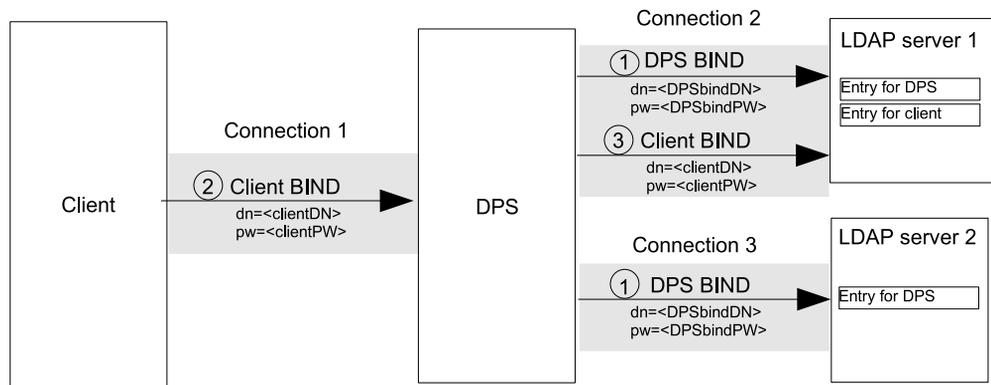
For information about how to configure proxy authorization in Directory Proxy Server, see [“Forwarding Requests With Proxy Authorization” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*](#)

Connections When Directory Proxy Server Is Configured for Proxy Authorization

When Directory Proxy Server is configured for proxy authorization, a client is usually authenticated to the Directory Proxy Server by a non-anonymous BIND or by a SASL external BIND, however, clients can also be anonymous. Directory Proxy Server is usually bound to the data sources by using an administrative identity.

Figure 19–2 shows the connections between a client, Directory Proxy Server, and backend LDAP servers, when Directory Proxy Server is configured for proxy authorization.

FIGURE 19–2 Connections for Proxy Authorization



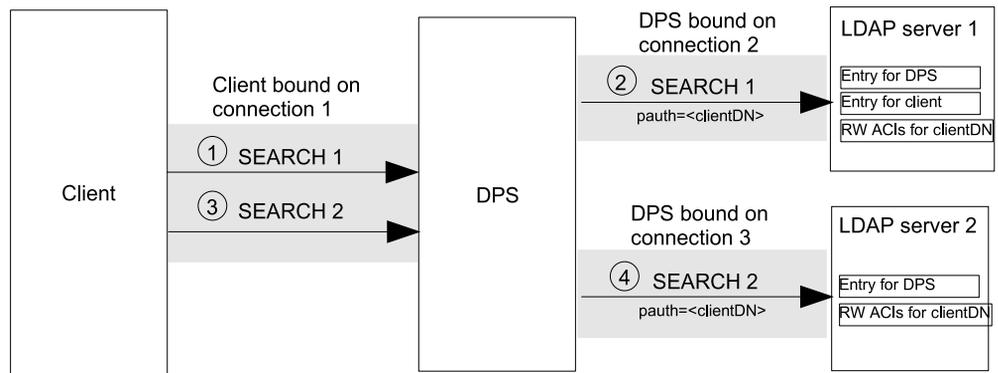
The connections for proxy authorization are made in the following stages:

1. When Directory Proxy Server is initiated, it opens a connection to each LDAP server. Directory Proxy Server binds to LDAP server 1 and LDAP server 2 by providing its DN and password, `DPSbindDN` and `DPSbindPW`.
An entry for `DPSbindDN` exists in both the LDAP servers and the BIND requests are granted. Directory Proxy Server is bound to the LDAP servers, on connection 2 and connection 3.
2. When a client connects to Directory Proxy Server, the client binds by providing its DN and a password, `clientDN` and `clientPW`.
3. The Directory Proxy Server authenticates the client to LDAP server 1 by using the client's credentials and by reusing connection 2.
An entry for the client exists in LDAP server 1 and the BIND request is granted. The client is bound to Directory Proxy Server on connection 1.

Directory Proxy Server Configured for Proxy Authorization and the Client Request Does Not Contain a Proxy Authorization

Figure 19–3 shows the flow of information when Directory Proxy Server is configured for proxy authorization. The client in Figure 19–2 makes, and Directory Proxy Server adds a proxy authorization control.

FIGURE 19–3 Information Flow When Proxy Authorization Control Is Added by Directory Proxy Server



1. The client sends a SEARCH request SEARCH 1, that does not contain a proxy authorization control. The request is targeted at LDAP server 1.
2. Directory Proxy Server adds a proxy authorization control to the request and forwards the SEARCH operation to LDAP server 1, reusing connection 2.

The SEARCH operation is performed with the authorization of the user specified in the proxy authorization control. That authorization is defined in the RW ACIs on the LDAP server for the user specified in the proxy authorization control.

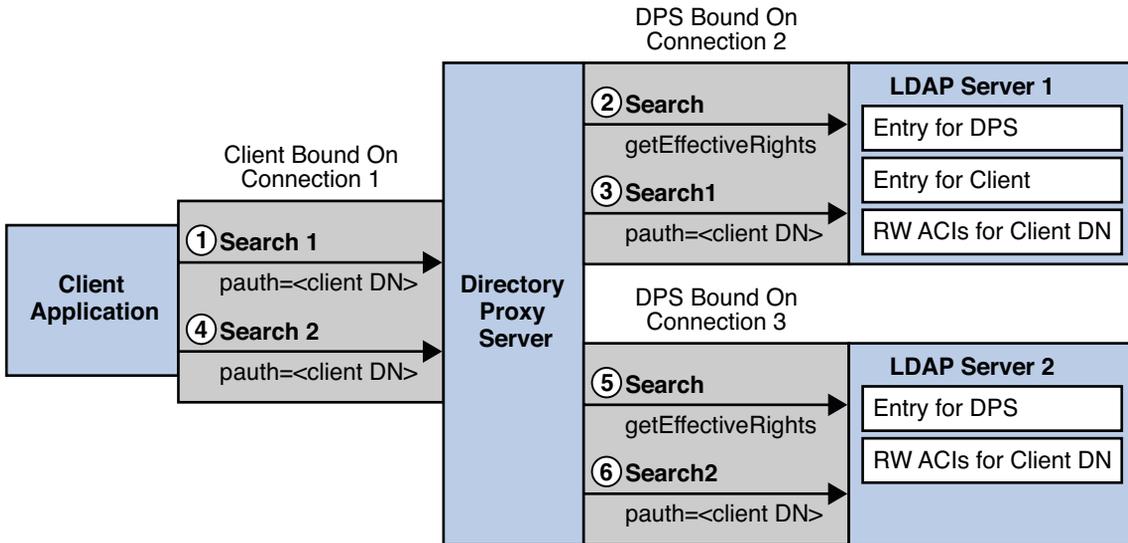
3. The client sends a second SEARCH request, SEARCH 2, that does not contain a proxy authorization control. The request is targeted at LDAP server 2.
4. The Directory Proxy Server forwards the SEARCH operation to LDAP server 2, reusing connection 3.

Notice that it is not necessary for the client to bind to LDAP server 2 before the request can be processed, and it is not necessary for the LDAP server to contain an entry for the client.

Directory Proxy Server Configured for Proxy Authorization and the Client Request Does Contain a Proxy Authorization

Figure 19–3 shows the flow of information when the client in Figure 19–2 makes a request that *does* contain a proxy authorization control. Directory Proxy Server verifies that the client has the right to use its proxy authorization control.

FIGURE 19–4 Information Flow When Proxy Authorization Control Is Contained in the Client Request



1. The client sends a SEARCH request SEARCH 1, that contains a proxy authorization control. The request is targeted at LDAP server 1.
2. Directory Proxy Server verifies that the clientDN has the right to use a proxy authorization control on LDAP server 1, by getting the effective rights of the client on LDAP server 1. For information about how to get effective rights, see “[Viewing Effective Rights](#)” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*
3. Directory Proxy Server forwards the SEARCH operation to LDAP server 1, reusing connection 2.

The SEARCH operation is performed with the authorization of the user specified in the proxy authorization control. The authorization is defined in the RW ACIs on the LDAP server.

4. The client sends a second SEARCH request, SEARCH 2, that contains a proxy authorization control. The request is targeted at LDAP server 2.
5. Directory Proxy Server verifies that the clientDN has the right to use a proxy authorization control on LDAP server 2, by getting the effective rights of the client on LDAP server 2.

6. The Directory Proxy Server forwards the SEARCH operation to LDAP server 2, reusing connection 3.

Notice that it is not necessary for the client to bind to LDAP server 2 before the request is processed, and it is not necessary for the LDAP server to contain an entry for the client.

Security Issues When Directory Proxy Server Is Configured for Proxy Authorization

Consider the following security risks before configuring Directory Proxy Server for proxy authorization:

- When Directory Proxy Server is configured for proxy authorization, it assumes the rights of any client for which it forwards a request. A Directory Proxy Server that is not authorized to perform write operations on data, can perform those operations by using proxy authorization.
- An LDAP server must contain an entry with the appropriate R/W ACIs for the user specified in the proxy authorization control. If the entry was accessed illegally by a third party, that party might be able to impersonate.
- The authorization identity configured in the proxy authorization control must be protected from tampering.

Directory Proxy Server Configured to Forward Requests Without the Client Identity

In some deployment scenarios, it is not necessary to maintain the identity of a client when the client makes request. Directory Proxy Server can be configured to forward requests to LDAP servers without the client identity. The LDAP servers process the requests with the identity and authorization of the Directory Proxy Server.

Directory Proxy Server Configured to Forward Requests As an Alternate User

Client requests can be performed with the identity of an alternate user by using the feature called *user mapping*. In user mapping, the client identity is mapped to the identity of an alternate user. After a BIND operation, the Directory Proxy Server submits subsequent operations as the alternate user.

When a client identity is mapped to another identity, requests from that client can be forwarded to the backend LDAP servers by using BIND replay or by using proxy authorization.

Client identities can be mapped to alternate identities either locally on the Directory Proxy Server or remotely on an LDAP server. Figure 19–5 and Figure 19–6 illustrate local mapping and remote mapping.

FIGURE 19-5 Local Mapping of a Client Identity to an Alternate Identity

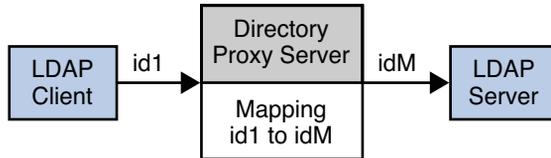
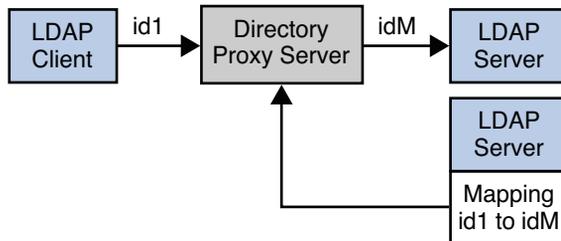


FIGURE 19-6 Remote Mapping of Client Identity to an Alternate Identity



In local mapping, the identity mapping is configured in the Directory Proxy Server. The configuration cannot be changed without reconfiguring the Directory Proxy Server. Local mapping can be configured for unauthenticated clients, authenticated clients, and for clients authenticated by proxy.

In remote mapping, the identity mapping is configured in an entry in the remote LDAP server. The mapping can be changed by modifying the entry in the remote LDAP server. It is not necessary to reconfigure the Directory Proxy Server to change the mapping. Remote mapping can be configured for unauthenticated clients and for clients authenticated by proxy.

Remote mapping must not be used for data sources configured for BIND replay. In BIND replay, the Directory Proxy Server forwards a client request by using the authentication provided in the BIND operation. However, in remote mapping the client DN and password provided in the BIND operation are mapped to an alternate DN and password. The client's password cannot be retrieved from the backend LDAP server.

If the user mapping is enabled but the mapping fails, the client identity is mapped to a default identity. A user mapping can fail when a client identity is mapped to a non-existent alternative identity or when there has been a configuration error.

For information about how to configure user mapping, see “[Forwarding Requests as an Alternate User](#)” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*

Connections Between Clients and Directory Proxy Server

All the incoming connections to Directory Proxy Server are categorized into connection handlers according to a set of criteria. A connection handler defines the resource limits and request filters that apply to the connection, and the data views that are exposed to the connection.

This chapter covers the following topics:

- [“Criteria for Allocating a Connection to a Connection Handler” on page 291](#)
- [“Data Views for Connection Handlers” on page 294](#)
- [“Resource Limits Policies for Connection Handlers” on page 296](#)
- [“Request Filtering Policies for Connection Handlers” on page 297](#)

Criteria for Allocating a Connection to a Connection Handler

An instance of Directory Proxy Server can have many connection handlers. When a client connects to Directory Proxy Server, the proxy evaluates whether the attributes of the connection match the criteria of one of the connection handlers. When a match is found, the connection is classified into that connection handler. All of the policies defined for that connection handler apply to the connection. Operations performed through that connection are exposed to all of the data views or to a list of data views defined by the connection handler.

After being classified into a connection handler, a connection can be automatically reclassified into another connection handler by Directory Proxy Server. For example, if a client connects anonymously, the connection is allocated to the connection handler configured for anonymous connections. If the client later provides a bind DN on the same connection, the connection can be reallocated to another connection handler. Similarly, a non-secure LDAP connection is initially classified into a connection handler for non-secure connections. If the client uses startTLS to promote the connection to secure mode, the connection is automatically reclassified into a connection handler for secure connections.

A connection is evaluated against connection handlers in order of the priority of the connection handler. Priority one is the highest priority connection handler. The connection is classified into the first connection handler for which there is a match. Connection handlers with the most specific criteria should have a higher priority than those with less specific or more general criteria. For example, a connection handler that specifies a bind DN should have a higher priority than a connection handler that specifies a simple bind.

If a connection does not match the criteria of any configured connection handler, the connection is allocated to the *default connection handler*. The criteria of the default connection handler cannot be modified. In addition, the default connection handler cannot be disabled or deleted. However, the policies and data views of the default connection handler can be changed.

The default connection handler is the lowest priority connection handler. If a new connection handler is created without a priority, the new connection handler is given a higher priority than the default connection handler. If two connection handlers have the same priority, the order in which the connection is evaluated against them is not specified.

The criteria expression of a connection handler is a logical AND between criteria of different types and a logical OR between criteria of the same type. For example, if a criteria is specified for client IP address and a criteria is set for client domain name, both of the criteria must be met. However, if two criteria are set for client IP address, either, not both, of the criteria must be met.

The following list summarizes the criteria used to classify connections into connection handlers. For information about how to configure the criteria, see [“Creating, Configuring, and Deleting Connection Handlers” in Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition](#).

- **Client IP address and mask.** A set of IPv4 or IPv6 address masks. The IP address of a client connection must match at least one of the masks in order for the connection to be accepted by the connection handler.

The IP address can be in one of the following formats:

- IP address in dotted decimal form. For example, 129 . 153 . 129 . 14.
- IP address and bits, in the form of network number/mask bits. For example, 129 . 153 . 129 . 0/24.
- IP address and quad, in the form of a pair of dotted-decimal quads. For example, 129 . 153 . 129 . 0/255 . 255 . 255 . 128.
- All addresses:ALL, a catch-all for clients that are not placed into other, higher priority, groups.
- 0 . 0 . 0 . 0. This address is for groups for which initial membership is not considered. For example, for groups that clients switch to after their initial bind.
- IP address of the local host. IP address 127 . 0 . 0 . 1 is the IP address of a client that is running on the same machine as Directory Proxy Server.

- **Client domain name.** A set of domain names. A client network domain must match at least one of the suffixes in order for the connection to be accepted by the connection handler.

In order to be able to filter the client's domain name, Directory Proxy Server must be able to convert the incoming IP address into the fully qualified domain name. If the naming service returns a hostname without the domain name, Directory Proxy Server cannot filter the client's domain name.

Directory Proxy Server does not assume any domain suffix, therefore the fully qualified domain name must be provided. A domain name suffix with a leading period, for example, `.oracle.com`, will cause all hosts with domain names that end in that suffix to match.

The domain name can be in one of the following formats:

- Full name, for example, `box.eng.oracle.com`.
- Suffix name, for example, `.eng.oracle.com`. If the suffix name is used to identify clients, ensure that DNS is set up to return fully qualified names to the DNS queries.
- Fully qualified name of the local host. This criteria is for a client that is running on the same machine as Directory Proxy Server.
- **Bind DN.** A regular expression that must be matched by the bind DN of a client.

For example, the following regular expression could be used as a bind DN criteria for a connection handler: `uid=(.*) , dc=example , dc=com`. A client that binds with a uid such as `uid=user1 , dc=example , dc=com` matches the criteria and can be allocated to the connection handler. A client that binds with another DN such as `ou=accounts , dc=example , dc=com` does not match the criteria and cannot be allocated to the connection handler.

- **Group DN** Directory Proxy Server allocates the connection handler to a connection only if the user entry represented by the bind DN is a member of any of the groups specified in group DN criteria attribute. Directory Proxy Server searches for the group and the members in only the data views that are attached to the connection handler. The group DN criteria attribute does not accept regular expressions but only a proper group DN.
- **LDAP search filter.** A search filter that the entry of a bound client must match.

For example, the following filter could be used as a criteria for a connection handler: `uid>=1000`. Bound clients with a uid that matches the filter can be allocated to the connection handler.

- **Authentication method.** An authentication method that must match the client entry in order for the connection to be accepted by the connection handler.

The authentication method can be one of the following:

- SIMPLE
- SASL/EXTERNAL
- Anonymous
- **IP port.** A set of IP port numbers. A client connection must come through one of the specified ports in order for the connection to be accepted by the connection handler.

- **SSL connection.** A flag indicating whether or not client connections must use SSL in order to be accepted by the connection handler.

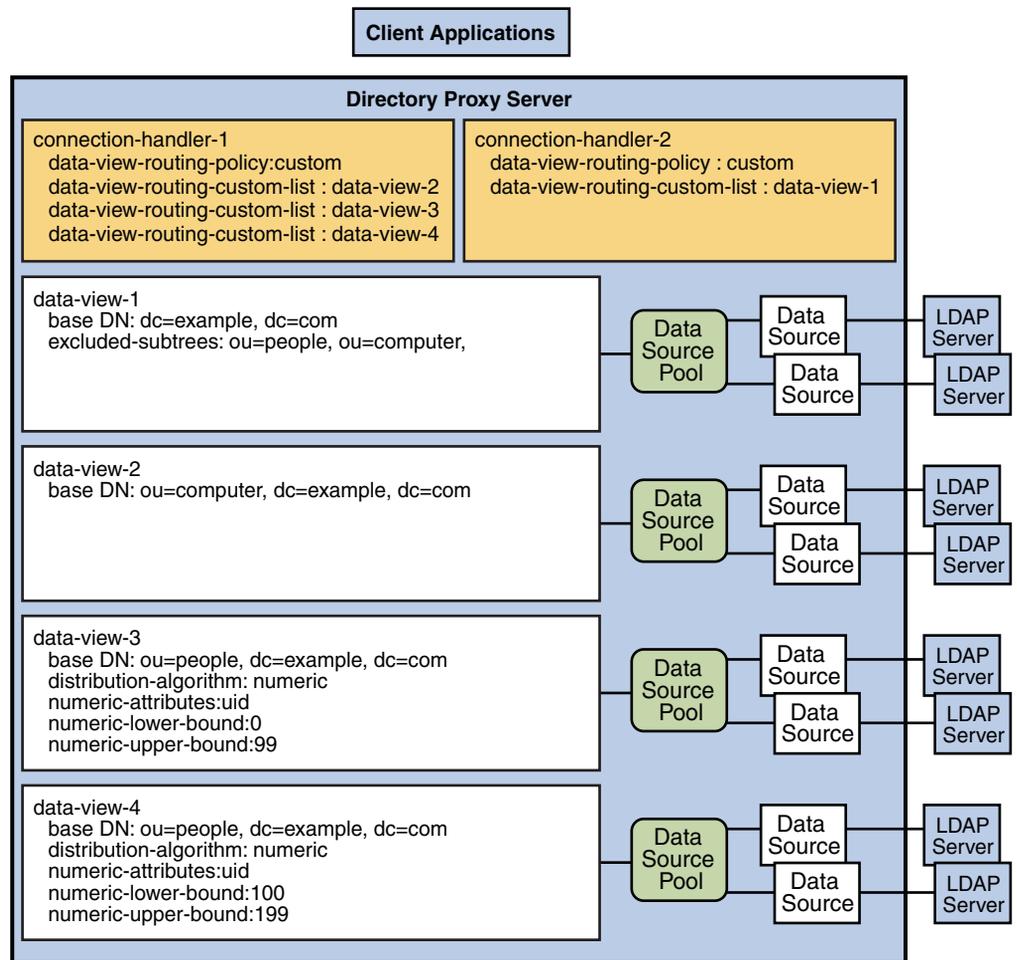
Data Views for Connection Handlers

When a connection is allocated to a connection handler, requests on the connection are exposed to a list of data views configured for that connection handler. The list of data views for a connection handler can contain zero, one, or multiple data views.

If the list of data views is empty, requests on the connection are not distributed to any data view. Applications using the connection cannot access any data and a No such Object error is returned.

If the list of data views contains multiple data views, requests on the connection are distributed to the data view that most specifically corresponds to the target DN of the request. For example, in [Figure 20-1](#), requests on a connection in `connection-handler-1` can be distributed to `data-view-2`, `data-view-3` or `data-view-4`. However, if a search request has a target DN of `ou=people,dc=example,dc=com`, the request is distributed either to `data-view-3` or to `data-view-4`.

FIGURE 20-1 List of Data Views in a Connection Handler



Affinity can be defined between a client connection and the data view selected to respond to requests on that connection. This feature is called *data view affinity*. When data view affinity is enabled, successive requests on a client connection are exposed exclusively to the data view used for the first request on that connection.

When data view affinity is enabled it takes precedence over other types of routing. For example, in [Figure 20-1](#), a search request with a target DN of `ou=computer, dc=example, dc=com` is exposed to `data-view-2`. All subsequent requests on that client connection are exposed exclusively to `data-view-2`. If a subsequent request on that client connection has a target DN of `ou=people, dc=example, dc=com`, the request is exposed to the data view for `ou=computer, dc=example, dc=com`, not the data view for `ou=people, dc=example, dc=com`.

For information about how to configure data view affinity, see “[To Configure Affinity for Data Views](#)” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Resource Limits Policies for Connection Handlers

A resource limits policy defines the maximum resources that Directory Proxy Server can process for a given connection handler. By using this type of connection handler policy, you can limit the resources allocated to connections, requests, and referrals.

A connection handler can have zero or one resource limits policy. If no resource limits policy is defined, no limits are applied to connections, requests and referrals. For information about how to configure resource limits policies and examples of resource limits policies, see “[Creating and Configuring a Resource Limits Policy](#)” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

The following list summarizes the resource limits that can be configured:

- - Connections
 - Maximum number of connections.
 - Maximum number of simultaneous connections from a single client.
 - Maximum number of operations per connection. If a client exceeds the maximum number of operations on one connection, the connection is closed by Directory Proxy Server.
 - Maximum number of simultaneous operations per connection.
If the maximum number of simultaneous operations per connection is 1, clients must perform synchronous operations. Additional requests for simultaneous operations, except for requests to abandon an operation, will fail with a Server Busy error.
- - Searches
 - Maximum permitted size of a search operation result
 - Maximum permitted duration of a search operation
 - Minimum length of a substring allowed in a search filter
 - Customized search limits, described in “[Customized Search Limits](#)” on page 297
- - Referrals
 - Maximum number of hops when following referrals
 - Bind policy to be applied when referrals are followed:
 - Use password if supplied, else follow the referral as anonymous

- Always follow the referral as anonymous
- Policy applied when a referral is returned by the server:
 - Follow referrals
 - Forward referrals to the client
 - Discard referrals

For information about how to configure a resource limits policy, see “[Creating and Configuring a Resource Limits Policy](#)” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*

Customized Search Limits

Customized limits can be defined for search operations, based on the search base and search scope. If the target DN of a search is specified in a list, and the scope of a search is one-level or subtree, the maximum size of the search result can be configured.

Custom search limits are defined for a specific resource limits policy. If the resource limits policy is deleted, the custom search limits defined for that policy are also deleted. If custom search limits are not specified, standard search size limits are applied.

Request Filtering Policies for Connection Handlers

Request filtering policies control access of clients to data. A connection handler can reference zero or one request filtering policy.

The following aspects of client access can be defined by using this type of connection handler policy:

- The types of operation that clients are allowed to perform or are prohibited from performing.

Each of the following types of operation can be allowed or prohibited: add, bind, compare, delete, extended operations, modify, modify DN, search, and search based on inequality filters.
- Attributes that are allowed or prohibited from being used in search filters and compare operations.

All attributes can be permitted in search filters and compare operations, or a list of attributes can be permitted or prohibited.
- The scope of search operations.

The scope can be the base DN, one level below the base DN, or the entire subtree below the base DN.
- The subtrees that clients are allowed to access or are prohibited from accessing.

For information, see [“Subtrees in the Request Filtering Policy” on page 298](#).

- Entries that can be accessed in search operations and data that can be returned by search operations.

For information, see [“Search Data Hiding Rules in the Request Filtering Policy” on page 298](#).

For information about how to configure a request filtering policy, see [“Creating and Configuring Request Filtering Policies and Search Data Hiding Rules” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*](#).

Subtrees in the Request Filtering Policy

The request filtering policy is configured with one or more allowed subtrees and zero, one, or more prohibited subtrees. The subtrees identify the part of a data view that can be accessed by clients.

Allowed Subtrees

An allowed subtree is specified by a minimum base DN. Clients are permitted to perform operations on entries at the minimum base DN or below the minimum base DN. By default, the minimum base DN is the root DN.

If a client requests a search operation that is targeted at a DN superior to the minimum base DN, Directory Proxy Server rewrites the DN to target the minimum base DN. If a client performs any other operation that is targeted at a DN superior to the minimum base DN, the operation is denied.

Prohibited Subtrees

A prohibited subtree is a branch of the allowed subtree that cannot be accessed by the client. The base DN of a prohibited subtree must be subordinate to the minimum base DN of an allowed subtree. If a client performs an operation that is targeted at a prohibited subtree, the operation is denied.

Search Data Hiding Rules in the Request Filtering Policy

Rules that determine how to return the result of a search operation to a client are called *search data hiding rules*. For information about creating search data hiding rules, see [“To Create Search Data Hiding Rules” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*](#).

The result of a search operation can be returned in one of the following ways:

- The target entry is not returned
- The target entry is returned but the specified attributes are filtered out
- The target entry is returned but the unspecified attributes are filtered out

Search data hiding rules can be applied to the following entries:

- Entries with the specified DN
- Entries with the specified DN pattern
- Entries with a specified attribute name/attribute value pair (*attrName: attrValue*)

Search data hiding rules are defined for a given request filtering policy and cannot be used by another request filtering policy. If a request filtering policy is deleted, its associated search data hiding rules are automatically deleted. Zero, one or multiple search data hiding rules can be defined in one request filtering policy.

Directory Proxy Server Client Authentication

This chapter describes how Directory Proxy Server identifies incoming client connections. The chapter covers the following topics:

- “Client Authentication Overview” on page 301
- “Simple Bind Authentication” on page 302
- “Certificate-Based Authentication” on page 303
- “Anonymous Access” on page 305
- “Directory Proxy Server Client Listeners” on page 306

Client Authentication Overview

Client authentication determines how a client identifies itself to Directory Proxy Server.

From a protocol perspective, client authentication can occur at two levels:

- **LDAP level.** Authentication occurs in the LDAP bind operation.
- **Connection level.** Authentication occurs in the network connection established between the client and Directory Proxy Server.

Directory Proxy Server can also be configured to accept client requests without authentication.

The following list summarizes the supported authentication options. These options are discussed in more detail in the remainder of this chapter.

- **Simple bind authentication.** Simple bind authentication occurs at the bind level. When the client binds, it provides a unique name (bind DN) and password to Directory Proxy Server. Directory Proxy Server forwards these credentials, along with the bind request, to a backend LDAP server.

Simple bind authentication can also be made over a secure connection. However, the server still identifies the client from its bind DN.

- **Certificate-based authentication** Certificate-based authentication occurs at the connection level when the connection is secure. When authentication occurs at the connection level, the client connects over an encrypted (SSL) connection and provides a certificate. Directory Proxy Server checks the validity of the client certificate and maps the certificate to an LDAP DN.
- **No authentication.** If the client does not provide a certificate, or a bind DN and password, no authentication occurs. In this case, the client connects to Directory Proxy Server anonymously. This is known as *anonymous access*.

Simple Bind Authentication

Simple bind authentication is the most common way to authenticate LDAP clients. In a simple bind, the client either binds anonymously, that is, with an empty bind DN, or by providing a DN and a password. Directory Proxy Server binds to a data source to validate the credentials and to authenticate the client. An entry for the client must exist on the data source, otherwise the client is considered to be anonymous. When a client is authenticated, Directory Proxy Server records the identity of the client.

Directory Proxy Server is configured for simple bind authentication by default. No additional configuration is required. Because the client provides a password to Directory Proxy Server, simple bind authentication is also known as *password-based authentication*.

Password Encryption and Verification

The way in which passwords are encrypted and checked depends on the type of *data view* through which the client accesses the data source. For information about data views, see [Chapter 17, “Directory Proxy Server Distribution,”](#) and [Chapter 18, “Directory Proxy Server Virtualization.”](#)

For LDAP data views, Directory Proxy Server relies on the backend LDAP server for password encryption and verification. When a client modifies a password by using an ADD or MODIFY operation, the backend LDAP server can apply a password encryption policy when it stores the password. When the client issues a BIND request, the backend LDAP server is responsible for verifying the password.

For LDIF and JDBC data views, Directory Proxy Server is responsible for password encryption and verification.

- LDIF data views. When a client modifies a password, Directory Proxy Server applies the encryption policy defined by the `db-pwd-encryption` property of the data view. The encryption policy can be PLAIN, SHA, or SSHA. The password is still stored in the data source, that is, in the LDIF file.
- JDBC data views. When a client modifies a password, Directory Proxy Server applies the 3DES encryption mechanism to encrypt the JDBC data source password.

When encrypted passwords are stored, the encrypted value is prefixed by the encryption policy. So for example, a stored, encrypted password might look like {SSHA}mcasopjebjakie or {SHA}askjdlaifbnja. When the client issues a BIND request, Directory Proxy Server verifies the password and expects the encryption policy tag.

Certificate-Based Authentication

Certificate-based authentication over an SSL connection is the most secure type of authentication. Therefore, when authentication occurs at the connection layer, the client does not need to provide an additional name (bind DN) and password to Directory Proxy Server during the LDAP bind.

A client can only perform certificate-based authentication over an SSL connection. The basic steps in establishing an SSL connection are as follows:

1. The client requests that a secure connection be established.

As part of this request, Directory Proxy Server provides a *server certificate* to the client. A server certificate is a single certificate associated with one instance of Directory Proxy Server. When a secure connection is used, the server certificate identifies the instance of Directory Proxy Server to the client.

The establishment of the connection includes a negotiation phase. During this phase, the client and Directory Proxy Server attempt to agree on the encryption policy that is used. The server certificate contains the list of encryption policies (ciphers) that are supported by the Directory Proxy Server.
2. Depending on the security configuration of the proxy server, the server might require the client to provide a certificate.
3. The client provides a certificate to the server, either because the client is configured to do so, or because the proxy server has requested it.
4. The client then sends an LDAP bind request to Directory Proxy Server to establish the client's identity on that connection.
5. If the request is a simple bind, Directory Proxy Server uses the bind DN and password provided by the client.
6. If the request is a SASL external bind, Directory Proxy Server does one of two things:
 - Considers the subject of the certificate as the bind DN of the client.
 - Maps the certificate by searching the backend server for an entry that matches the received certificate. If the `verify-certs` property is set, Directory Proxy Server verifies that the received certificate is the one stored in the entry that is found.

The following configuration properties determine how Directory Proxy Server performs that search:

```
cert-data-view-routing-policy
cert-data-view-routing-custom-list
cert-search-bind-dn
cert-search-bind-pwd-file
cert-search-base-dn
cert-search-attr-mappings
```

7. When the proxy server has the bind DN, it can verify the validity of the client.

For more information about SSL for Directory Proxy Server, see [“Secure Sockets Layer for Directory Proxy Server” on page 308](#).

For certificate-based authentication to occur, Directory Proxy Server must be configured to accept client certificates and the client must be configured to use SASL external bind.

Configuring Certificates in Directory Proxy Server

When you create a Directory Proxy Server instance, the certificate database is automatically populated with the CA certificates of certain trusted CAs. You can add trusted CA certificates to the certificate database if necessary, by using the Directory Service Control Center (DSCC) or by using the `dpadm` command. For more information, see [“To Install a CA-Signed Server Certificate for Directory Proxy Server” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*](#).

When a client provides a certificate to Directory Proxy Server, the server verifies that certificate against the list of trusted CA certificates in its certificate database. The verification is successful if the server's certificate database contains the client certificate itself, or the CA certificate with which the client certificate was generated.

The server certificate can be one of the following:

- **Self-signed certificate.** A public and private key pair, where the public key is signed by Directory Proxy Server.
- **Trusted CA certificate.** A single certificate that is automatically generated by the company's internal certificate server or by a known Certificate Authority (CA).

Directory Proxy Server also supports the use of a *server certificate chain*. A server certificate chain is a collection of certificates that are automatically generated by the company's internal certificate server or by a known CA. The certificates in a chain trace back to the original CA, providing proof of identity. This proof is required each time you obtain or install a new server certificate.

When an instance of Directory Proxy Server is created, a default self-signed certificate is created. By default, Directory Proxy Server manages the SSL certificate database password internally.

You can install any number of certificates on a server. When you configure SSL for an instance of Directory Proxy Server, you must install at least one server certificate and one trusted CA certificate.

For an explanation of how certificate-based authentication works, see [“Certificate-Based Authentication” on page 303](#). For information about how to configure certificate-based authentication for Directory Proxy Server, see [“To Configure Certificate-based Authentication” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*](#).

Using SASL External Bind

When a client binds to Directory Proxy Server with the Simple Authentication and Security Layer (SASL) external bind, Directory Proxy Server obtains the credentials of the client from the certificate, rather than from the bind DN.

The server obtains the credentials in one of two ways:

- Considers the subject of the certificate as the bind DN of the client
- Maps the certificate subject to data within its own database, to deduce the bind DN

SASL external bind cannot be used if Directory Proxy Server is configured for BIND replay. In BIND replay, Directory Proxy Server authenticates the client to a backend LDAP server by using the client DN and password. In SASL external bind, no password is provided by the client. Furthermore, the password that is stored in the user entry cannot be read in clear text. For information about bind replay, see [“Directory Proxy Server Configured for BIND Replay” on page 281](#).

SSL can be used to protect subsequent interactions between the client and Directory Proxy Server.

For information about how to configure authentication by SASL external bind, see [“To Configure Directory Proxy Server for SASL External Bind” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*](#).

Anonymous Access

Anonymous access makes data available to any client, regardless of whether the user has authenticated.

For information about how to configure Directory Proxy Server for anonymous connections from clients, see [“To Configure Anonymous Access” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*](#).

Directory Proxy Server Client Listeners

Directory Proxy Server enables you to configure certain aspects of a client connection through a *client listener*. Two client listeners are provided, a secure listener (`ldaps-listener`) and a non-secure listener (`ldap-listener`).

The secure listener specifies that the connection is made to a secure port, over SSL. The non-secure listener specifies that the connection is made to a non-secure port, without SSL. Clients use either the secure listener or the non-secure listener, depending on the type of connection required by that client.

Note – A client can also establish a secure connection to a non-secure port if the client supports Start TLS.

Both the secure and non-secure listener specify the following aspects of a client connection:

<code>is-enabled</code>	Specifies whether clients are able to use that listener to connect to Directory Proxy Server
<code>listen-port</code>	The port number on which Directory Proxy Server listens for client connections
<code>listen-address</code>	The IP address of the listener
<code>connection-idle-timeout</code>	The maximum time a client connection can remain idle before being closed
<code>connection-read-data-timeout</code>	The maximum time that a listener can wait for new data to be available
<code>connection-write-data-timeout</code>	The maximum time that a listener can wait to send results back to clients
<code>max-connection-queue-size</code>	The maximum size of a listener's connection queue
<code>max-ldap-message-size</code>	The maximum size of an LDAP message.
<code>number-of-threads</code>	The number of threads allocated to a listener to for simultaneous client connections and requests
<code>use-tcp-no-delay</code>	Whether or not TCP_NODELAY is enabled for connections between a client and Directory Proxy Server

For information about how to configure listeners, see “[Configuring Listeners Between Clients and Directory Proxy Server](#)” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Security in Directory Proxy Server

This chapter describes the mechanisms that can be used to secure data that passes through Directory Proxy Server.

The chapter covers the following topics:

- [“How Directory Proxy Server Provides Security” on page 307](#)
- [“Secure Sockets Layer for Directory Proxy Server” on page 308](#)
- [“Ciphers and Protocols for Directory Proxy Server” on page 309](#)

How Directory Proxy Server Provides Security

Directory Proxy Server provides security through a combination of the following methods:

- **Encryption**

Encryption protects the privacy of information. When data is encrypted, the data is scrambled in a way that only a legitimate recipient can decode. Directory Proxy Server supports SSL encryption. For information about SSL, see [“Secure Sockets Layer for Directory Proxy Server” on page 308](#).
- **Authentication**

Authentication is a means for one party to verify another’s identity. For example, a client gives a password to Directory Proxy Server during an LDAP bind operation. Policies define the criteria that a password must satisfy to be considered valid, for example, age, length, and syntax. Directory Proxy Server supports anonymous authentication, password-based authentication, and certificate-based authentication. For information about authentication, see [Chapter 21, “Directory Proxy Server Client Authentication.”](#)
- **Access control instructions (ACIs)**

ACIs govern the access rights granted to client applications, and provide a way of specifying required credentials or bind attributes. Directory Proxy Server implements access control through request filtering policies and through virtual ACIs. For information about request

filtering policies , see [“Request Filtering Policies for Connection Handlers”](#) on page 297. For information about virtual ACIs, see [“Access Control On Virtual Data Views”](#) on page 275.

- Auditing and Logs

Auditing can be used to determine whether security has been compromised. The log files maintained by Directory Proxy Server can be audited to track who has accessed the server, and what operations they have performed. For information about log files, see [Chapter 24, “Directory Proxy Server Alerts and Monitoring,”](#) and [Chapter 23, “Directory Proxy Server Logging.”](#)

Secure Sockets Layer for Directory Proxy Server

The Secure Sockets Layer (SSL) provides encrypted communications between a client and Directory Proxy Server. By using SSL with authentication, data sent to and from Directory Proxy Server can be encrypted.

When an instance of Directory Proxy Server is created, SSL is enabled by default and the following directories and files are created:

A randomly generated password to protect the certificate database

The password is stored in *instance-path/etc/pass.txt*

A key store database for certificates

The keystore database is located in *instance-path/alias/cert.jks*

A key store database for a symmetric encryption key

The keystore database is located in *instance-path/alias/key.jceks*

The key store databases are protected by the same password.

For more information about SSL, see [“Secure Sockets Layer \(SSL\)”](#) on page 101. For information about how to configure SSL between clients and Directory Proxy Server, see [“Configuring Listeners Between Clients and Directory Proxy Server”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*

Directory Proxy Server supports the Start TLS extended operation. StartTLS can be used to provide security over a regular LDAP connection. With StartTLS, clients can bind to a non-secure port and then use the TLS protocol to initiate a secure connection.

Ciphers and Protocols for Directory Proxy Server

The ciphers and protocols that can be used by Directory Proxy Server depend on the JVM that is used. By default, Directory Proxy Server uses the default ciphers and protocols for the JVM.

You can retrieve a list of ciphers and protocols by using the `dpconf` command:

Enabled ciphers	The list of ciphers that are currently enabled for both the LDAP and LDAPS listeners. Because the LDAP and LDAPS listeners are synchronized, the properties are part of the global server configuration, and not the listener configuration.
Supported ciphers	The list of ciphers supported by the JVM for Directory Proxy Server. The Root DSE lists all the supported ciphers under the <code>supportedSSLCiphers</code> attribute. The <code>enabledSSLCiphers</code> attribute is a subset of <code>supportedSSLCiphers</code> attribute.
Enabled protocols	The list of protocols that are currently enabled for both the LDAP and LDAPS listeners. Because the LDAP and LDAPS listeners are synchronized, the properties are part of the global server configuration, and not the listener configuration.
Supported protocols	The list of protocols supported by the JVM for Directory Proxy Server.

For reference information about cipher suites, see [“Cryptographic Algorithms Used With SSL” on page 103](#). For information about how to choose ciphers, see [“Choosing SSL Ciphers and SSL Protocols for Directory Proxy Server” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*](#).

Directory Proxy Server Logging

Directory Proxy Server logs information in access logs and error logs. Additionally, a plug-in can be configured to log messages to a syslog daemon. Unlike Directory Server, Directory Proxy Server does not provide an audit log.

Log files for Directory Proxy Server can be configured through Directory Service Control Center or on the command line. For information about how to configure log files, see [Chapter 27, “Directory Proxy Server Logging,”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

For information about access logs and error logs, see the following sections:

- “Introduction to Directory Proxy Server Logs” on page 311
- “Log File Rotation” on page 312
- “Log File Deletion” on page 313
- “Message Severity” on page 313
- “Error Logs for Directory Proxy Server” on page 314
- “Access Logs for Directory Proxy Server” on page 316
- “Tracking Client Requests Through Directory Proxy Server and Directory Server Access Logs” on page 319

Note that the log message format is still evolving in this release of Directory Proxy Server.

Introduction to Directory Proxy Server Logs

The Directory Proxy Server logging service provides access logs and error logs. The logs are flat files that contain information about client operations and about the health of Directory Proxy Server. By default, log files are stored under *instance-path/logs* with the permission of 600. If an instance of Directory Proxy Server is started without valid log files, log files are created in the default location and a warning is sent to DSCC.

You can configure the following aspects of the logs:

- Set the log level for each message category
- Globally set the default log-level for all message categories
- Globally enable all logs
- Set the name, location and permissions of log files
- Set the maximum number of log files
- Define a rotation policy for each log file
- Include or exclude search filters in access log messages for search operations

Log messages can also be sent to the syslog daemon. For information about how to log messages to a syslog daemon, see [“Logging Alerts to the syslogd Daemon”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Log File Rotation

Log files can be rotated manually at any time, or can be rotated automatically when the following events occur:

- When the log reaches a specified size
- At a specified interval
- At a specified start-time, start-day, and interval
- At a specified start-time, start-day, and interval, if the log file is bigger than a specified size
- At a specified interval, if the log file is bigger than a specified size

The start-time, start-day, and interval can have the following combinations:

- Time-of-day followed by an interval of days, hours, or minutes
- Day-of-week and time-of-day, followed by an interval of weeks
- Day-of-month and time-of-day, followed by an interval of months

The time-of-day takes precedence over the interval. For example, a log that is specified to be rotated at 3am and then every 10 hours is rotated at the following times: 03:00, 13:00, 23:00, and again at 03:00 (not 07:00).

If the log is configured for rotation on the 31st of the month but the month has fewer than 31 days, the log is rotated on the first day of the following month.

Log File Deletion

A log file deletion policy defines when backup log files are deleted. The log file currently in use is never deleted by a deletion policy.

The following deletion policies can be enabled:

- **Deletion based on time.** Log files are deleted when they reach a specified age.
- **Deletion based on size.** Log files are deleted when the total size of all the log files reaches a specified limit. The size of the current log file is taken into account, although this file is not deleted.
- **Deletion based on free disk space.** When the free disk space reaches a specified minimum, the oldest backup log file is deleted. If the free disk space is still lower than the minimum, the next oldest backup log file is deleted, and so forth.

By default, log file deletion is based on free disk space, with a default value of 1 Megabyte. When all three deletion policies are activated simultaneously, they are processed in order of time, size, and free disk space. For information about how to configure log file deletion, see [“Deleting Directory Proxy Server Logs”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Message Severity

Messages are included in log files or filtered out of log files according to the severity of the message, the category of the message, and the log-level that has been configured for that category. The categories and log-levels for the error logs and access logs are different, and are discussed in the sections that follow.

Messages are ranked according to their severity. Messages can have one of the following severities, where error is highest severity and debug is the lowest severity:

1. error
2. warning
3. info
4. debug

Messages with a severity that is lower than the log-level configured for its message category are not included in the log file. Messages with a severity that is equal to or higher than the log-level configured for its associated message category are included in the log file.

Error Logs for Directory Proxy Server

Error logs contain information about the health of the Directory Proxy Server. Error messages are categorized according to the cause of the message. The following table lists the categories of messages that can be included in an error log.

TABLE 23-1 Message Categories for Error Logs

Category Name	Category Description
CONFIG	Information about configuration
DECODE	Information about operation decoding
PLUGIN	Information about plug-in processing
PROCESSING	Information about a significant event that occurred during client processing
BACKEND	Information about an operation with a data source
INTERNAL	Information about an internal error in the core server
SHUTDOWN	Information about an event at server shutdown
STARTUP	Information about an event at server startup

Error Log Levels

Each message category can be configured with one of the following log-levels:

1. `none` No messages are included in the log file.
2. `error` Only error messages are included in the log file.
3. `warning` Error messages and warning messages are included in the log file.
4. `info` Errors, warnings and informational messages are included in the log file.
5. `all` All messages are included in the log file. In most cases, this setting produces the same results as the `info` setting. In certain situations, this setting enables additional debugging messages to be logged.
6. `inherited` The log level is inherited from the value of the `default-log-level` property.

By default, the log level for each message category is `inherited`. As the `default-log-level` property is set to `info`, each category inherits the `info` log level.

The log-level of a message category works in conjunction with the severity level of a message to determine which messages are included in the log file. For more information, see [“Message Severity” on page 313](#).

Format of an Error Message

An error log message has this format:

timestamp - message category - message severity - message text

[Example 23-1](#) shows an extract from an error log.

EXAMPLE 23-1 Extract of an Error Log

```
[11/Feb/2010:14:52:28 +0100] - STARTUP - INFO - Logging Service configured
[11/Feb/2010:14:52:28 +0100] - STARTUP - INFO - Java Version: 1.6.0_16
      (Java Home: /local/instances/dsee7/jre)
[11/Feb/2010:14:52:28 +0100] - STARTUP - INFO - Java(TM) SE Runtime Environment
      (build 1.6.0_16-b01)
[11/Feb/2010:14:52:28 +0100] - STARTUP - INFO - Java HotSpot(TM) 64-Bit Server VM
      (build 14.2-b01, mixed mode)
[11/Feb/2010:14:52:28 +0100] - STARTUP - INFO - Java Heap Space: Total Memory
      (-Xms) = 241MB, Max Memory (-Xmx) = 241MB
[11/Feb/2010:14:52:28 +0100] - STARTUP - INFO - Operating System:
      SunOS/sparcv9 5.10
[11/Feb/2010:14:52:29 +0100] - STARTUP - INFO - SSL initialization succeeded.
[11/Feb/2010:14:52:29 +0100] - CONFIG - WARN - Attribute
      certMappingDataViewPolicy in entry cn=LDAPS Listener,cn=Client
      Listeners,cn=config missing. Using ALL_DATA_VIEW
[11/Feb/2010:14:52:29 +0100] - STARTUP - INFO - Creating 50 worker threads.
[11/Feb/2010:14:52:30 +0100] - STARTUP - INFO - Sun-Directory-Proxy-Server/7.0
      B2009.1104.2146 started on host lecap in directory /local/instances/dps-1
[11/Feb/2010:14:52:30 +0100] - STARTUP - INFO - Listening for client connections
      on 0.0.0.0:1389
[11/Feb/2010:14:52:30 +0100] - STARTUP - INFO - Listening for secure client
      connections on 0.0.0.0:1636
[11/Feb/2010:14:52:31 +0100] - BACKEND - WARN - LDAP server groupy:11998/ is
      up and running.
[11/Feb/2010:17:43:10 +0100] - SHUTDOWN - INFO - Directory Proxy Server received a
      shutdown request from external signal (caught by shutdown hook)
[11/Feb/2010:17:43:10 +0100] - BACKEND - WARN - LDAP server groupy:11998/ is up
      and running.
[11/Feb/2010:17:43:11 +0100] - SHUTDOWN - INFO - Directory Proxy Server stopped.
[11/Feb/2010:17:43:19 +0100] - STARTUP - INFO - Logging Service configured
[11/Feb/2010:17:43:19 +0100] - STARTUP - INFO - Java Version: 1.6.0_16
      (Java Home: /local/instances/dsee7/jre)
[11/Feb/2010:17:43:19 +0100] - STARTUP - INFO - Java(TM) SE Runtime Environment
      (build 1.6.0_16-b01)
[11/Feb/2010:17:43:19 +0100] - STARTUP - INFO - Java HotSpot(TM) 64-Bit Server VM
      (build 14.2-b01, mixed mode)
[11/Feb/2010:17:43:19 +0100] - STARTUP - INFO - Java Heap Space: Total Memory
      (-Xms) = 241MB, Max Memory (-Xmx) = 241MB
[11/Feb/2010:17:43:19 +0100] - STARTUP - INFO - Operating System:
      SunOS/sparcv9 5.10
[11/Feb/2010:17:43:19 +0100] - STARTUP - INFO - Initializing LDAP server
      cn=dsccldap_groupy:11998,cn=data sources,cn=config
[11/Feb/2010:17:43:19 +0100] - STARTUP - INFO - SSL initialization succeeded.
[11/Feb/2010:17:43:20 +0100] - CONFIG - WARN - Attribute certMappingDataViewPolicy
      in entry cn=LDAPS Listener,cn=Client Listeners,cn=config missing. Using ALL_DATA_VIEW
```

Access Logs for Directory Proxy Server

Access logs contain information about the requests being processed by Directory Proxy Server. Access logs contain information about two types of connection:

- Connections between clients and Directory Proxy Server
- Connections between Directory Proxy Server and data sources

Access log messages are categorized according to the cause of the message. The following table lists the categories of messages that can be included in the access log.

TABLE 23-2 Message Categories for Access Logs

Category Name	Category Description
CONNECT	Information about a client connection
DISCONNECT	Information about a client disconnection
OPERATION	Information about operations requested by a client
PROFILE	Information about the profiles of a connection handler
SERVER_OP	Information about operations that are forwarded to data sources
SERVER_OP_DETAIL	Detailed information about operations that are forwarded to data sources

Access Log Levels

Each message category can be configured with one of the following log-levels:

1. `none` No access messages are included in the log file.
2. `info` Informational messages are included in the log file.
3. `all` All messages are included in the log file. In most cases, this setting produces the same results as the `info` setting. In certain situations, this setting enables additional debugging messages to be logged.
4. `inherited` The log level is inherited from the value of the `default-log-level` property.

By default, the log level for each message category is `inherited` but for `SERVER_OP_DETAIL`, the log level is `none`. As the `default-log-level` property is `info`, all the message categories except `SERVER_OP_DETAIL` inherits the log level `info`.

The log-level of a message category works in conjunction with the severity level of a message to determine which messages are included in the log file. For more information, see [“Message Severity” on page 313](#).

Format of an Access Log Message

An access log message has this format:

```
timestamp - category - severity - connectionNumber operationNumber  
messageID operationType messageText
```

[Example 23–2](#) shows an extract of an access log. The log shows a client request that starts with a message in the CONNECT category and ends with a message in the DISCONNECT category. The operation requested by the client is shown by the message in the OPERATION category, and results in several messages in the SERVER_OP category. The logged messages have the INFO and DEBUG severity.

EXAMPLE 23–2 Extract of an Access Log

```
[07/17/2005:17:29:45 +0200] - CONNECT      - INFO - conn=1591031  
  client=129.157.192.132:49216 server=0.0.0:9389 protocol=LDAP  
[07/17/2005:17:29:45 +0200] - OPERATION  - INFO - conn=1591031 op=0  
  msgid=1 SEARCH base="o=movie" scope=2 filter="(objectClass=*)" "  
[07/17/2005:17:29:45 +0200] - SERVER_OP   - INFO - conn=1591031 op=0  
  SEARCH base="o=movie" scope=2 filter="(objectClass=*)" "  
  s_msgid=318022 s_authid="" s_conn=39  
[07/17/2005:17:29:45 +0200] - SERVER_OP   - INFO - conn=1591031 op=0  
  SEARCH base="o=movie" scope=2 filter="(objectClass=*)" s_msgid=316902  
  s_authid="" s_conn=76  
[07/17/2005:17:29:45 +0200] - SERVER_OP   - INFO - conn=1591031 op=0  
  SEARCH RESPONSE err=0 msg="" nentries=4 s_conn=76  
[07/17/2005:17:29:45 +0200] - SERVER_OP   - DEBUG - Global status code = 0  
[07/17/2005:17:29:45 +0200] - SERVER_OP   - INFO - conn=1591031 op=0  
  SEARCH RESPONSE err=0 msg="" nentries=11 s_conn=39  
[07/17/2005:17:29:45 +0200] - SERVER_OP   - DEBUG - Global status code = 0  
[07/17/2005:17:29:45 +0200] - OPERATION  - INFO - conn=1591031 op=0  
  SEARCH RESPONSE err=0 msg="" nentries=22  
[07/17/2005:17:29:45 +0200] - OPERATION  - INFO - conn=1591031 op=1  
  UNBIND  
[07/17/2005:17:29:45 +0200] - DISCONNECT - INFO - conn=1591031  
  reason=unbind"
```

Message Parts in an Access Log

Messages for the connections between a client and the Directory Proxy Server are labeled in the same way as in Directory Server. [Table 23–4](#) describes parts of the messages between the client and the Directory Proxy Server in [Example 23–2](#). For an explanation of all of the possible message parts, see [“Content of Access, Error, and Audit Logs” on page 166](#).

TABLE 23–3 Message Parts for Connections Between a Client and a Directory Proxy Server

Log Message Part	Description
conn	Identifier for the connection between the client and the Directory Proxy Server.

TABLE 23–3 Message Parts for Connections Between a Client and a Directory Proxy Server
(Continued)

Log Message Part	Description
op	The number of an operation on a given connection. The first operation on a connection has the value op=0. Subsequent requests on the connection have increasing numbers, op=1, op=2, etc.
msgid	The number of a message to be sent to a client application. The LDAP protocol is mainly asynchronous. If a client request requires a response from a server, the response is given in the following steps: <ul style="list-style-type: none"> ■ The directory server acknowledges the request and assigns a msgid ■ The directory server responds to the request by using the msgid identifier A response can be sent in multiple packets, where each packet is identified by the same msgid.
nentries	The number of entries returned by a search request.
err	The result code returned from the LDAP operation. The error number 0 means that the operation was successful. For a list of LDAP result codes, see “Result Codes in Log Files” on page 171 .
msg	A human readable error diagnostic.

Messages for the connections between Directory Proxy Server and a data source are prefixed with s_. [Table 23–4](#) describes parts of the messages between the Directory Proxy Server and the data source in [Example 23–2](#).

TABLE 23–4 Message Parts for Connections Between a Directory Proxy Server and a Data Source

Log Message Part	Description
s_msgid	Identifier for the message between the Directory Proxy Server and a data source.
s_authzid	Authorization identity for an operation to be processed under when the Directory Proxy Server forwards the request to a data source by using proxy authorization.
s_conn	Identifier for the connection between the Directory Proxy Server and the data source.

Access Log Buffer

Access log messages are stored in a buffer. The buffer is flushed to the access log at the following times:

- When the buffer is full
- When the access log is rotated
- When Directory Proxy Server is stopped

By default, the size of the access log buffer is 1M. However, the size of the buffer can be configured to control the frequency with which it is flushed.

The buffer is also flushed periodically, that is, every 2.5 seconds, if none of the other conditions is met.

You can configure the size of the access log buffer by setting the `log-buffer-size` property. For information about how to configure access log properties, see “[Configuring Directory Proxy Server Logs](#)” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Tracking Client Requests Through Directory Proxy Server and Directory Server Access Logs

Access logs show client accesses to the server and corresponding server responses. Directory Proxy Server access logs further show information about the connections set up against data sources, in this case Directory Server instances.

Tracking client requests can be broken down into the following steps:

- Tracking the operations performed within a single client connection
- Identifying the client that performed a certain operation

Tracking Operations by Connection

Directory Proxy Server typically sets up connections with backend servers before it handles client connections. This means that the proxy can pool operations, binding and rebinding only when necessary and avoiding connection setup overhead. Directory Proxy Server identifies these backend connections in its access log with tags of the form `s_conn=data-source:number`, where `data-source` is a data source name from the configuration and `number` is a server connection number assigned by the proxy. Such `s_conn` server connections can then be matched to connection numbers in Directory Server access logs using the port number from which the proxy connected to the directory as a client when establishing the connection. Therefore, `s_conn` in proxy access log messages be translated into `conn` in directory access log messages.

Tracking Operations in Directory Proxy Server

In the Directory Proxy Server access log, each client operation is contained within a `CONNECT` and a `DISCONNECT` message. Between these two messages, several `OPERATION` messages can appear. Each `OPERATION` message can contain several `SERVER_OP` messages.

The `OPERATION` messages refer to operations performed by the client. The `SERVER_OP` messages refer to operations performed by Directory Proxy Server.

The following extract of a Directory Proxy Server access log file shows the start (CONNECT) and end (DISCONNECT) of a connection, `conn=0`. The log shows all the OPERATION requests performed by a client this connection and the related SERVER_OP requests sent to the backend server by Directory Proxy Server on behalf of the client.

```
[timestamp] - CONNECT      - INFO - conn=0 client=129.157.192.132:59112 server=0.0.0.0:9389 protocol=LDAP
[timestamp] - OPERATION   - INFO - conn=0 op=0 BIND dn="uid=u1,ou=users,o=movie" method="SIMPLE"
[timestamp] - SERVER_OP    - INFO - conn=0 op=0 BIND dn="uid=u1,ou=users,o=movie" method="SIMPLE" s_msgid=2
                                     s_conn=server-1:1
[timestamp] - SERVER_OP    - INFO - conn=0 op=0 BIND RESPONSE err=0 msg="" s_conn=server-1:1
[timestamp] - OPERATION   - INFO - conn=0 op=0 BIND RESPONSE err=0 msg="" etime=0
[timestamp] - OPERATION   - INFO - conn=0 op=1 msgid=2 SEARCH base="o=movie" scope=2 filter="(objectclass=*)"
[timestamp] - SERVER_OP    - INFO - conn=0 op=1 SEARCH base="o=movie" scope=2 filter="(objectclass=*)" s_msgid=3
                                     s_conn=server-1:1
[timestamp] - SERVER_OP    - INFO - conn=0 op=1 SEARCH RESPONSE err=0 msg="" nentries=12 s_conn=server-1:1
[timestamp] - OPERATION   - INFO - conn=0 op=1 SEARCH RESPONSE err=0 msg="" nentries=12 etime=0
[timestamp] - OPERATION   - INFO - conn=0 op=2 UNBIND
[timestamp] - SERVER_OP    - INFO - conn=0 op=-1 BIND dn="" method="SIMPLE" s_msgid=4 s_conn=server-1:1
[timestamp] - SERVER_OP    - INFO - conn=0 op=-1 BIND RESPONSE err=0 msg="" s_conn=server-1:1
[timestamp] - DISCONNECT  - INFO - conn=0 reason="unbind"
```

Following this log, it is possible to track all operations that were performed by or on behalf of a particular client.

Tracking Operations Between Directory Proxy Server and Directory Server

When Directory Proxy Server starts up, it establishes connections with all the remote servers identified in its configuration. These connections are logged in the Directory Proxy Server access log, and are identified by the field `s_conn=server-name:number`. The *server-name* is defined in the Directory Proxy Server configuration and refers to a specific backend server. The *number* indicates how many connections there have been to this backend server, through the same port.

For example, in the following extract from the Directory Proxy Servers `s_conn=server-1:1` is the first connection to remote server `server-1` through port `59100`.

```
SERVER_OP - INFO - Created connection for BIND s_conn=server-1:1 client=129.157.192.132:59100
```

When this connection is established, the corresponding line in the Directory Server access log shows that the connection from Directory Proxy Server through port `59100` is identified with the connection ID `conn=244`.

```
conn=244 op=-1 msgId=-1 - fd=19 slot=19 LDAP connection from 129.157.192.132:59100 to 129.157.192.132
```

For the remainder of the life of this connection, `server-1:1` in the Directory Proxy Server can be mapped to `conn=24` in the Directory Server access log.

This kind of mapping between connections also requires that Directory Proxy Server and the backend Directory Server are synchronized.

Note that a connection from Directory Proxy Server to a backend Directory Server can remain alive for several days. If you rotate logs, either manually or automatically, it might therefore be necessary to access archived log files to trace the operations performed during a connection.

Client Identification

A client is identified in the access logs by its IP address and, optionally, by its bind DN. When a client establishes a connection to Directory Proxy Server, the following kind of message is logged in the Directory Proxy Server access log:

```
[timestamp] - CONNECT - INFO - conn=0 client=IP1:port1 server=IP2:port2 protocol=LDAP
```

Directory Proxy Server identifies this client connection as **conn=0**.

When Directory Proxy Server establishes a connection with a remote Directory Server, the following kind of message is logged in the Directory Proxy Server access log:

```
[timestamp] - SERVER_OP - INFO - Created connection for READ s_conn=server-1:1 client=IP2:port3
server=IP4:port4 protocol=LDAP main
```

Directory Proxy Server identifies this connection to the remote server as **s_conn=server-1:1**.

At the same time, the following kind of message is logged in the Directory Server access log:

```
[timestamp] conn=13 op=-1 msgId=-1 - fd=23 slot=23 LDAP connection from IP2:port3 to IP4
```

So, Directory Server identifies the connection as **conn=13**.

Tracking the connection in this way enables you to identify the full connection path from the client to Directory Server.

Directory Proxy Server does not wait for a client connection before it establishes a connection to a remote server. The Directory Proxy Server configuration specifies that certain connections are dedicated to bind operations, others to read operations, and others to write operations. When Directory Proxy Server starts up, it establishes all connections to the remote servers, according to this configuration.

When a connection has been established completely (from the client to Directory Server) the client can be identified by its DN.

Directory Server recognizes the client DN as one of the following:

- **True client bind DN.** The bind DN is the client's own bind DN if Directory Proxy Server is configured in Use Bind mode.
- **Modified client bind DN.** The bind DN is modified if Directory Proxy Server is configured in User Proxy Auth Control mode. The DN is modified as a result of DN renaming or user mapping.

A single connection can be used by multiple clients (though not simultaneously). To identify a client connection correctly in the access logs, Directory Proxy Server and Directory Server must be synchronized, that is, the server clock must be as close as possible. This will ensure that the timestamps in the access logs correspond. If the servers are not synchronized, you should synchronize them by using a time server, or evaluate the difference between the server clocks and search the access logs taking this difference into account.

Directory Proxy Server Alerts and Monitoring

The Directory Proxy Server provides monitoring information about its own status. Directory Proxy Server also monitors data sources to determine whether they are alive and to detect failed connections. If a data source fails, Directory Proxy Server can switch new requests over to a working data source in a data source pool and can replay failed requests to this new data source.

This chapter describes how monitoring is implemented in Directory Proxy Server. The chapter covers the following topics:

- “Administrative Alerts for Directory Proxy Server” on page 323
- “Monitoring Data Sources” on page 324
- “Monitoring Directory Proxy Server” on page 327

Administrative Alerts for Directory Proxy Server

Directory Proxy Server generates a set of predefined administrative alerts. You can select one or more of the predefined administrative alerts and configure Directory Proxy Server to take a specific action when the alert events occur:

The actions that can be taken include the following:

- Create a syslog entry. Alerts are sent to the syslog with the facility of USER.
- Send an e-mail message.
- Run a script command.

Table 24–1 lists the predefined administrative alerts for Directory Proxy Server.

TABLE 24–1 Administrative Alerts for Directory Proxy Server

Alert event	Alert code	Configuration Parameter
Server startup	1000	info-server-startup
Clean server shutdown	1001	info-server-shutdown-clean

TABLE 24-1 Administrative Alerts for Directory Proxy Server (Continued)

Alert event	Alert code	Configuration Parameter
Abrupt server shutdown	1002	error-server-shutdown-abrupt
Configuration reloaded	1003	info-configuration-reload
Configuration reload failure due to bad configuration. Run-time configuration not impacted.	1004	warning-configuration-reload-failure-no-impact
Configuration reload failure due to bad configuration. Run-time configuration possibly impacted.	1005	error-configuration-reload-failure-with-impact
Data source not available	2000	warning-data-source-unavailable
Data source available	2001	info-data-source-available
Listener not available	3000	warning-listener-unavailable
Data inconsistency on data sources	4000	warning-data-sources-inconsistent
Resources limit exceeded	5000	error-resource-limit-exceeded
Warning resources limit exceeded	5100	warning-resource-limit-exceeded

For information about how to configure administrative alerts for Directory Proxy Server, see “Configuring Administrative Alerts for Directory Proxy Server” in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Monitoring Data Sources

Directory Proxy Server continuously monitors data sources to determine whether they are alive and to detect failed connections. This section describes how Directory Proxy Server monitors data sources, and what action is taken when data sources fail.

How Data Sources Are Monitored

Directory Proxy Server performs the following tests to monitor the health of a data source:

- Listens for errors on the traffic between Directory Proxy Server and the data source
- Periodically establishes a dedicated connection to the data source if there is no traffic from that data source for a specified time interval
- Periodically pings each existing connection to each data source to prevent that connection from being closed and to detect closed connections

These tests are described in the following sections.

Monitoring a Data Source by Listening for Errors

When this type of monitoring is configured, Directory Proxy Server listens for errors on the traffic between itself and the data source. If Directory Proxy Server detects that a client operation fails, the proxy tests the data source related to the failure.

This type of monitoring is called *reactive monitoring* because Directory Proxy Server reacts to an error, but otherwise performs no active testing of the data sources.

Directory Proxy Server can be configured to perform this type of reactive monitoring only, without performing the monitoring described in [“Monitoring Data Sources by Periodically Establishing Dedicated Connections” on page 325](#) and [“Monitoring Data Sources by Testing Established Connections” on page 325](#). When only reactive monitoring is configured, the monitoring is less complete but does not cause additional traffic.

Monitoring Data Sources by Periodically Establishing Dedicated Connections

When this type of monitoring is configured, Directory Proxy Server establishes a dedicated connection to a data source when no requests are made to the data source or responses are given by the data source for a specified time period. By periodically establishing a dedicated connection to a data source, Directory Proxy Server monitors whether the data source is working.

This type of monitoring is more complete than [“Monitoring a Data Source by Listening for Errors” on page 325](#) because Directory Proxy Server does not wait to detect a failure before it tests the data source. However, this type of monitoring is less complete than [“Monitoring Data Sources by Testing Established Connections” on page 325](#), because the proxy does not test whether the existing connections to a data source are working.

This type of monitoring can be used in addition to [“Monitoring Data Sources by Testing Established Connections” on page 325](#).

Monitoring Data Sources by Testing Established Connections

When this type of monitoring is configured, Directory Proxy Server tests each connection to each data source at regular intervals. In this way, the proxy prevents connections from being dropped because of inactivity, and detects closed connections.

This type of monitoring can be used in addition to [“Monitoring Data Sources by Periodically Establishing Dedicated Connections” on page 325](#).

Directory Proxy Server can be configured to test connections in the following scenarios:

- Pooled connections that are not used for a period of time
- Connections for persistent searches that are not active for a period of time
- Connections between a client and Directory Proxy Server operating in tunneling mode

Testing established connections consumes system resources, but it provides good security for connections. If you are using the Active Directory product, you must use this method of monitoring because the Active Directory product closes inactive connections.

To test an established connection, Directory Proxy Server issues a search request with the following parameters:

- Search base DN
- Connection time out
- Search time out
- Search filter

If a connection is found to be down, Directory Proxy Server polls the connection at a specified interval to detect its recovery. You can configure this interval by setting the `down-monitoring-interval` property. For more information, see [“To Monitor a Data Source by Testing Established Connections”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Directory Proxy Server monitors data sources by using a search filter. Data sources that return a result that satisfies the filter are considered to be working.

Responding to the Failure of a Data Source

When Directory Proxy Server detects an error on a connection, the proxy closes the connection and tries to reestablish the connection immediately. If the proxy can reestablish the connection, it considers the data source to be up and running. If the proxy cannot reestablish the connection, it flags the data source as unavailable. Directory Proxy Server stops distributing requests to the data source and closes all other connections to the data source.

If a request fails because of a failed connection or a failed data source, Directory Proxy Server replays the request over another connection to the same data source or replays the request to another data source. If the request is replayed to another data source, the load balancing algorithm determines which data source is used.

If there are no data sources to which Directory Proxy Server can replay the request, the proxy returns an error to the client.

Replaying the request enables the failure to be transparent to the client. Requests are replayed for the following operations:

- Search
- Bind
- Compare

Requests are not replayed for write operations because Directory Proxy Server cannot be sure whether the operation was performed before the connection failure occurred.

When a data source recovers after a being unavailable, Directory Proxy Server returns the data source to the list of candidate data sources. The work that was being carried out by the other candidate data sources is redistributed to include this data source, according to the load balancing algorithm.

When the failed data source recovers, Directory Proxy Server recommences monitoring the traffic between the data sources and their clients.

Monitoring Directory Proxy Server

Directory Proxy Server runs inside a Java Virtual Machine (JVM) and depends on the memory of the JVM. To ensure that Directory Proxy Server is running correctly, its memory consumption must be monitored. For information about how to monitor Directory Proxy Server memory consumption, see [“Retrieving Monitored Data About Directory Proxy Server by Using the JVM”](#) in *Oracle Fusion Middleware Administration Guide for Oracle Directory Server Enterprise Edition*.

Monitoring information for Directory Proxy Server is provided under the `cn=monitor` entry. The `cn=monitor` entry is managed by Directory Proxy Server in a local, in-memory database.

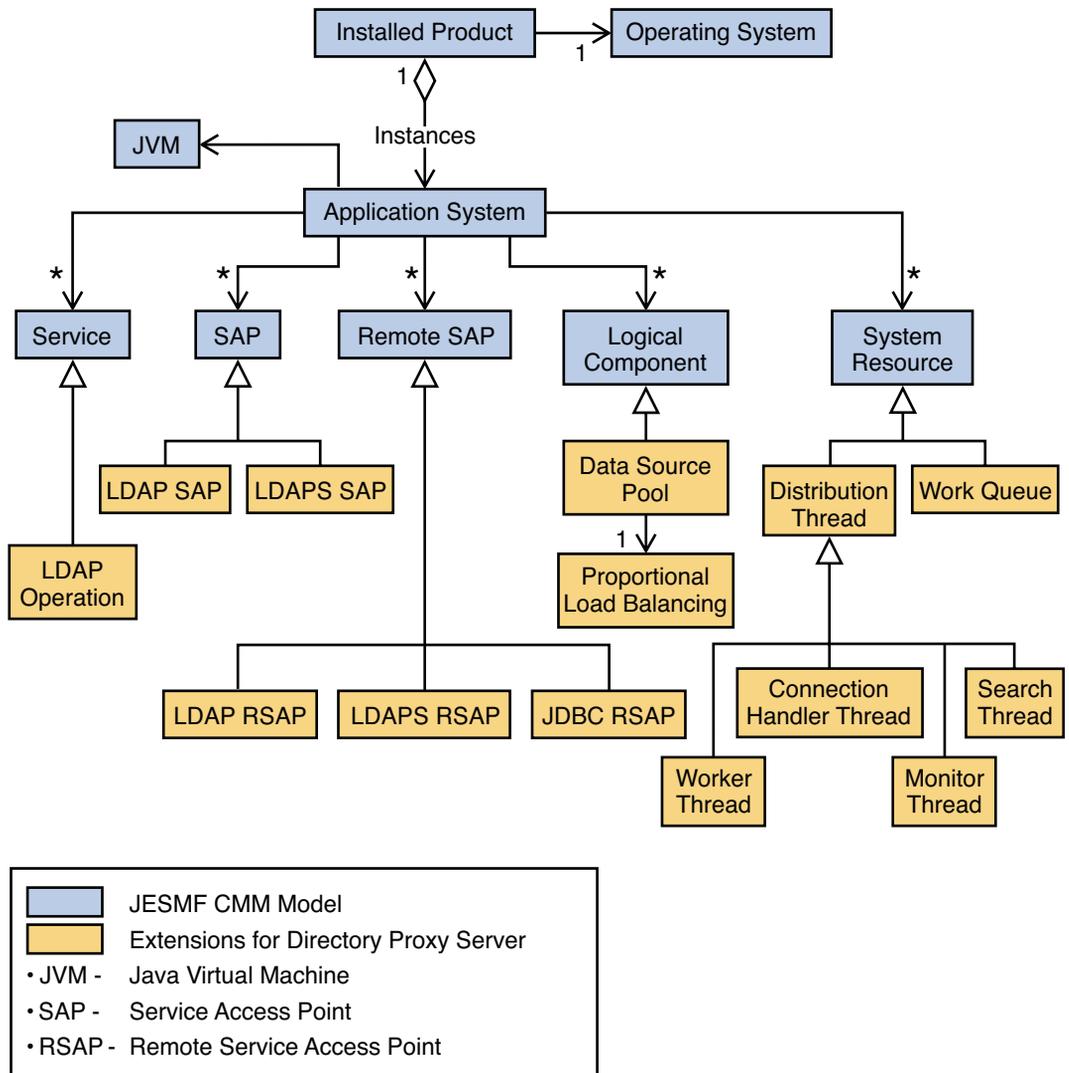
For information about monitoring Directory Proxy Server, see the following sections:

- [“Monitoring Framework for Directory Proxy Server”](#) on page 327
- [“Simplified Layout of the `cn=monitor` Entry”](#) on page 328
- [“Status of Monitored Information”](#) on page 329
- [“Description of Each Entry Under the `cn=monitor` Entry”](#) on page 330
- [“Detailed Layout of the `cn=monitor` Entry”](#) on page 341

Monitoring Framework for Directory Proxy Server

Directory Proxy Server monitoring relies on the Java Enterprise System (ES) Monitoring Framework. The Java ES monitoring framework has been extended to provide a monitoring framework for Directory Proxy Server. The following UML diagram illustrates the Directory Proxy Server monitoring framework.

FIGURE 24-1 Monitoring Framework for Directory Proxy Server



Simplified Layout of the cn=monitor Entry

This section provides a simplified layout of the cn=monitor entry. For the detailed layout of the cn=monitor entry and a description of all of the entries and attributes under cn=monitor, see “Detailed Layout of the cn=monitor Entry” on page 341.

```
cn=monitor
|
+-- cn=Product (Installed Product)
```

```

|
+-- cn=ProductName
|
+-- cn=Operating System
+-- cn=Instance (Application System)
|
+-- cn=InstanceId
|
+-- cn=Service
|
+-- cn=Add
+-- cn=Delete
+-- cn=Modify
+-- cn=ModifyDN
+-- cn=Search
+-- cn=Compare
+-- cn=Bind
+-- cn=Resource (System Resource)
+-- cn=Work Queue
+-- cn=Worker Thread
|
+-- cn=worker_thread_name
+-- cn=Search Thread
|
+-- cn=search_thread_name
+-- cn=Monitor Thread
|
+-- cn=monitor_thread_name
+-- cn=Connection Handler Thread
|
+-- cn=connection_handler_thread_name
+-- cn=SAP (Service Access Point)
+-- cn=LDAP
+-- cn=LDAPS
+-- cn=RSAP (Remote SAP)
+-- cn=LDAP Server servername
+-- cn=LDAPS Server servername
+-- cn=RDBM Server servername
+-- cn=Component (Logical Component)
+-- cn=DataSource Pool
|
+-- cn=poolname
|
+-- cn=Proportional Load Balancing
|
+-- cn=Add
+-- cn=Search
+-- cn=Delete
+-- cn=Compare
+-- cn=Modify
+-- cn=ModifyDN
+-- cn=Bind
+-- cn=Saturation Load Balancing
+-- cn=Affinity Load Balancing
+-- cn=JVM
+-- cn=DB System
+-- cn=DB Service

```

Status of Monitored Information

Every element that is monitored has an operational status. [Table 24–2](#) gives the status of monitored information.

TABLE 24-2 Status of Monitored Information

Value	Name	Description
0	UNKNOWN	No information available for this element
2	OK	Element is fully operational
3	DEGRADED	Element is working but not optimally
4	STRESSED	Element is working under stressed environment (for example, overload)
5	PREDICTIVE_FAILURE	Element is working but may fail in the near future
6	ERROR	Severe error has been raised
8	STARTING	Element is starting
9	STOPPING	Element is stopping
10	STOPPED	Element is stopped
12	NO_CONTACT	Element has never been reached
13	LOST_COMMUNICATION	Element has been reached once, but it is currently unreachable

Description of Each Entry Under the `cn=monitor` Entry

For information about each entry in the `cn=monitor` subtree, see the following sections:

- “`cn=Product`” on page 330
- “`cn=Operating System`” on page 331
- “`cn=Instance`” on page 331
- “`cn=Service`” on page 332
- “`cn=SAP`” on page 332
- “`cn=RSAP`” on page 333
- “`cn=Component`” on page 335
- “`cn=JVM`” on page 337
- “`cn=Resource`” on page 337

`cn=Product`

The `cn=Product` entry identifies the set of files being installed. An installed product is identified by the entry `cn=ProductName`.

cn=Product contains the following groups of attributes:

Settings

- version identifies the full release number containing major release, minor release and optionally micro release (for example, 6.1).
- buildNumber identifies the syntax of the build number.
- patchId identifies the patch of the product. This attribute can be empty.

State Provides operational status and availability status.

Statistics Provides a set of statistics metrics such as performance and usage.

cn=Operating System

The cn=Operating System entry identifies which operating system the product package is installed under. This entry has the following monitoring DN:

```
cn=Operating System, cn=ProductName, cn=Product, cn=monitor
```

cn=Operating System contains the following groups of attributes:

Settings

- operatingSystemName identifies the name of the operating system such as SunOS.
- operatingSystemVersion identifies the release of the operating system such as 5.10.

State Provides operational status and availability status.

Statistics Provides a set of statistics metrics such as performance and usage.

cn=Instance

The cn=Instance entry identifies an instance of the installed product. More than one instance of a product can exist on a single data source. Each instance is identified by an instance ID, where *instanceId=host:instance-path*.

The cn=Instance entry has the following monitoring DN:

```
cn=InstanceId, cn=Instance, cn=Operating System, cn=ProductName,  
cn=Product, cn=monitor
```

cn=Operating System contains the following groups of attributes:

Settings Provides configuration attribute values.

State operationalStatus identifies the status of the element, with the following values: 0, 2, 8, 9, and 10. For information about the values, see [Table 24-2](#).

Statistics Provides a set of statistics metrics such as performance and usage.

cn=Service

The `cn=Service` entry identifies information about LDAP operations, or services, for an instance of Directory Proxy Server.

LDAP operations are `add`, `delete`, `modify`, `modifyDN`, `search`, `compare`, and `bind`. Each LDAP operation has a specific monitoring entry below `cn=Service`. For example, the `add` operation has the following DN:

```
cn=add, cn=Service, cn=InstanceId, cn=Instance, cn=Operating System,  
cn=ProductName, cn=Product, cn=monitor
```

Entries below `cn=Service` can contain the following groups of attributes:

Settings Provides configuration attribute values.

State Provides operational status and availability status.

Statistics

- `total` identifies the number of operations received by this instance of Directory Proxy Server.
- `succeeded` identifies the number of successful operations in this instance of Directory Proxy Server.
- `failed` identifies the number of failed operations in this instance of Directory Proxy Server.
- `abandoned` identifies the number of operations abandoned by this instance of Directory Proxy Server.

cn=SAP

A Service Access Point (SAP) provides information on how to access a service. The `cn=SAP` entry has the following monitoring DN:

```
cn=listenerThread, cn=SAP, cn=instanceId, cn=Instance,  
cn=OperatingSystem, cn=Product, cn=monitor
```

Entries below `cn=SAP` can contain the following groups of attributes:

Settings

- `name` identifies the SAP name, either LDAP or LDAPS.
- `isSecure` identifies whether LDAPS is used. If the value is `TRUE`, LDAPS is used.
- `host` identifies the hostname of the current data source.

- `port` identifies the port number to access this instance of Directory Proxy Server.

State

- `enabled` identifies if the SAP is enabled.
- `operationalStatus` identifies the status of the SAP. If the value is 2 or OK, the SAP is fully operational.
- `statusDescription` provides a detailed status description.
- `startTime` identifies the date and time at which the SAP was started.
- `stopTime` identifies the date and time at which the SAP was stopped.
- `stopException` provides a description of the error if a stop operation fails. If this attribute is empty, no error has occurred.

Statistics

- `acceptedConnections` identifies the number of accepted TCP connections. One counter exists for all LDAP operations. The counter is service agnostic.
- `refusedConnections` identifies the number of refused TCP connections.

cn=RSAP

The `cn=RSAP` entry identifies the type of remote service. The remote SAP can be one of the following types:

- LDAP(S) to access directory servers such as Oracle Directory Server or Microsoft ADAM.
- ODBC to access RDBM systems such as the Oracle Database.

LDAP Remote SAP

The `cn=RSAP` entry for an LDAP remote SAP can have one of the following monitoring DNs:

```
cn=LDAP servername, cn=RSAP, cn=instanceId, cn=Instance,
  cn=OperatingSystem, cn=Product, cn=monitor
```

```
cn=LDAPS servername, cn=RSAP, cn=instanceId, cn=Instance,
  cn=OperatingSystem, cn=Product, cn=monitor
```

Entries below `cn=RSAP` can contain the following groups of attributes:

Settings

- `name` identifies the SAP name, either LDAP or LDAPS.
- `isSecure` identifies whether LDAPS is used. If the value is TRUE, LDAPS is used.
- `host` identifies the hostname of the host server.

- `port` identifies the port number to access this instance of Directory Proxy Server.

State

- `operationalStatus` identifies the status of the element, with the following values: 2, 4, 12, and 13. For information about these values, see [Table 24–2](#).
- `statusDescription` provides the detailed description of the status.
- `started` identifies if RSAP is started.
- `readOnly` identifies if it is in read only mode.

Statistics

- `totalConnections` identifies the total number of connections including the established connections.
- `totalAvailableConnections` identifies the total number of available connections for bind, read and write operations. The value 0 means that access to that data source is congested.
- The following attributes are given for bind operations but also exist for read operations and write operations:
 - `totalBindConnections` identifies the number of established connections for bind operations. All of the connections are kept in a pool of bind connections.
 - `availableBindConnections` identifies the number of free bind connections in the pool.
 - `bindConnectionsRequested` identifies the number of requests to get a free bind connection from the pool.
 - `bindConnectionsProvided` identifies the number of bind connections provided upon request.
 - `bindConnectionsRefused` identifies the number of requests being refused because the pool is empty (even after a wait) or because the remote data source is down.
 - `bindConnectionsWaitsRequired` identifies the number of requests being blocked in a wait state, waiting for a bind connection to be freed.
 - `bindConnectionsReturnedValid` identifies the number of connections being released.
 - `bindConnectionsReturnedInvalid` identifies the number of connections being released as invalid. A connection is said to be invalid when errors have occurred.

cn=Component

The cn=Component entry identifies the part of the software being accessed through a service. The following parts of the software are identified by the cn=Component entry:

- Load balancing algorithm
- Connection class
- Data view

Proportional Load Balancing Algorithm For All Data Sources

The cn=Component entry for the proportional load balancing algorithm for all data sources has the following monitoring DN:

```
cn=ProportionalLB, cn=DataSourcePool poolname, cn=Component,
  cn=instanceId, cn=Instance, cn=OperatingSystem, cn=Product, cn=monitor
```

Entries below the cn=Component entry for the proportional load balancing algorithm contain the following groups of attributes for all data sources:

Settings

- `className` provides the name of the class.

State

- `enabled` identifies the status of the remote SAP. If the value is TRUE, the load balancing algorithm is active.

Statistics

- `totalBindConnectionsProvided` identifies the total number of connections provided for bind operations.
- `totalBindConnectionsRefused` identifies the number of refused connections for bind operations.

Connections can be refused for one of the following reasons:

- The pool of data sources is empty.
- All the data sources in the pool are down.
- The data source selected by the load balancing algorithm has no free connection to reach the remote service.
- `totalAddConnectionsProvided` see `totalBindConnectionsProvided`
- `totalAddConnectionsRefused` see `totalBindConnectionsRefused`
- `totalCompareConnectionsProvided` see `totalBindConnectionsProvided`
- `totalCompareConnectionsRefused` see `totalBindConnectionsRefused`
- `totalDeleteConnectionsProvided` see `totalBindConnectionsProvided`

- totalDeleteConnectionsRefused see totalBindConnectionsRefused
- totalModifyConnectionsProvided see totalBindConnectionsProvided
- totalModifyConnectionsRefused see totalBindConnectionsRefused
- totalModifyDNConnectionsProvided see totalBindConnectionsProvided
- totalModifyDNConnectionsRefused see totalBindConnectionsRefused
- totalCompareConnectionsProvided see totalBindConnectionsProvided
- totalCompareConnectionsRefused see totalBindConnectionsRefused

Proportional Load Balancing Algorithm For Individual Data Sources

The `cn=Component` entry for the proportional load balancing algorithm for individual data sources has the following monitoring DN:

```
cn=Add, cn=servername, cn=Proportional LB, cn=DataSource Pool poolname,
cn=Component, cn=instanceId, cn=Instance, cn=OperatingSystem,
cn=Product, cn=monitor
```

Similar monitoring DNs exist for the delete, modify, modifyDN, search, compare, and bind operations.

Entries below the `cn=Component` entry for the proportional load balancing algorithm contain the following groups of attributes for individual data sources:

Settings

- Provides configuration attribute values.

State

- `operationalStatus` identifies the status of the element, with the following values: 2, and 5. For information about these values, see [Table 24-2](#).
- `statusDescription` provides the detailed status description.

Statistics

- `providedConnections` the number of connections provided to reach the data source for the operation.
- `providedPercentage` the percentage of connections provided to reach the data source for the operation.
- `refusedConnections` the number of refused requests to get a connection to that data source.
- `refusedPercentage` the percentage of refused requests.

cn=JVM

The `cn=JVM` entry identifies the JVM that is being used to run the instance of Directory Proxy Server. The `cn=JVM` entry has the following monitoring DN:

```
cn=JVM, cn=instanceId, cn=Instance, cn=DPS60, cn=Product, cn=monitor
```

Entries below `cn=JVM` can contain the following groups of attributes:

Settings

- `version` identifies the version of the JVM used to run the instance of Directory Proxy Server.
- `JVMInstallation` identifies the location of the JVM installation.

State

- `operationalStatus` identifies the status of the element, with the following values: 2, and 5. For information about these values, see [Table 24–2](#).
- `statusDescription` provides the detailed status description.

Statistics

- `totalJVMMemory` identifies the total amount of memory allocated for the JVM to run.
- `maxJVMMemory` identifies the maximum amount of JVM memory.
- `freeJVMMemory` identifies the amount of free memory.
- `realFreeJVMMemory` identifies the free JVM memory which can be used.
- `JVMMemoryLowLevelCount` provides the number of times JVM memory changes its state from green to orange.
- `JVMMemoryVeryLowLevelCount` provides the number of times JVM memory changes its state from orange to red.
- `availableCPU` identifies the CPU capacity available.

cn=Resource

The `cn=Resource` entry identifies the set of resources being used by the software. Resources include buffers, file descriptors, and hard disks.

The following elements are identified by the `cn=Resource` entry:

- [“Connection Handler Thread” on page 338](#)
- [“Work Queue” on page 339](#)
- [“Worker Thread” on page 340](#)
- [“Search Thread” on page 340](#)
- [“Monitor Thread” on page 340](#)

Connection Handler Thread

The connection handler thread decodes incoming requests. The connection handler is oriented to the LDAP or LDAPS protocol. When a request has been fully decoded, the request is put in the work queue.

The cn=Resource entry for the connection handler thread has the following monitoring DN:

```
cn=connection_handler_thread_name, cn=Connection Handler Thread,  
  cn=Resource, cn=instanceId, cn=Instance, cn=DPS60, cn=Product,  
  cn=monitor
```

Entries below the cn=Resource entry for the connection handler thread contain the following groups of attributes:

Settings

- threadID provides the unique thread identification number.
- threadStack provides the information on threads stack.

State

- operationalStatus identifies the status of the element. The value 2 indicates that the element is fully operational.
- startTime identifies the date and time at which the thread was started.
- started identifies if the thread has started.
- running identifies if the thread is in running state.
- statusDescription provides the detailed status description.

Statistics

The following statistics can be gathered:

- Byte buffer pool statistics under cn=ByteBufferPool:
 - numTries
 - numHits
 - numMissesEmpty
 - numMissesSize
 - numReleases
 - availableStandardBuffers
 - availableOversizedBuffers
- String buffer pool statistics under cn=StringBufferPool:
 - numTries
 - numHits
 - numMisses
 - numReleases

- availableBuffers
- Vector pool statistics under cn=VectorPool:
 - numTries
 - numHits
 - numMisses
 - numReleases
 - availableBuffers

Work Queue

Incoming requests from clients are stored by connection handler threads in the work queue. The requests are then processed by the worker thread. The cn=Resource entry for the work queue has the following monitoring DN:

```
cn=Work Queue, cn=Resource, cn=instanceId, cn=Instance, cn=DPS60,
cn=Product, cn=monitor
```

Entries below the cn=Resource entry for the work queue contain the following groups of attributes:

Settings

- maxNormalPriorityPeak identifies the maximum number of requests of normal priority that can be put in the queue. When this threshold is reached, the connection handler is suspended.
- maxHighPriorityPeak. identifies the maximum number of requests of high priority that can be put in the queue. When this threshold is reached, the connection handler is suspended.

State

- curNormalPriorityInQueue provides the current normal priority requests in queue.
- curHighPriorityInQueue provides the current high priority requests in queue.
- operationalStatus identifies the status of the element, with the following values: 2, and 4. For information about these values, see [Table 24–2](#).
- statusDescription provides the detailed status description.

Statistics

- numNormalPriorityPuts identifies the number of requests of normal priority that are put in the queue by the connection handler threads.
- numNormalPriorityGets identifies the number of request of normal priority retrieved from the queue by worker threads.

- `numHighPriorityPuts` identifies the number of requests of high priority that are put in the queue by the connection handler threads.
- `numHighPriorityGets` identifies the number of request of high priority retrieved from the queue by worker threads.
- `numAbandonRequests` identifies the number of requests that are abandoned.
- `numAbandonSuccesses` identifies the number of requests that are abandoned while in the queue.

Worker Thread

The worker thread processes requests from the work queue.

The `cn=Resource` entry for the worker thread has the following monitoring DN:

```
cn=worker_thread_name, cn=Worker Thread, cn=Resource,  
cn=instanceId, cn=Instance, cn=DPS60, cn=Product, cn=monitor
```

Entries below the `cn=Resource` entry for the search thread contain the same groups of attributes as described in [“Connection Handler Thread” on page 338](#), and the following attributes:

Statistics

- `operationsProcessed` identifies the number of operations processed by the worker thread.
- `exceptionsCaught` identifies the number of exceptions raised during the processing of operations.

Search Thread

When a search is performed on several data views, parallel search threads can be used. The `cn=Resource` entry for the search thread has the following monitoring DN:

```
cn=search_thread_name, cn=Search Thread, cn=Resource, cn=instanceId,  
cn=Instance, cn=DPS60, cn=Product, cn=monitor
```

Entries below the `cn=Resource` entry for the search thread contain the same groups of attributes as described in [“Connection Handler Thread” on page 338](#).

Monitor Thread

The monitor thread checks the availability of remote data sources. A remote data source is considered to be available when the monitor thread can create one connection to the remote data source. The `cn=Resource` entry for the monitor thread has the following monitoring DN:

cn=monitor_thread_name, cn=Monitor Thread, cn=Resource, cn=instanceId,
cn=Instance, cn=DPS60, cn=Product, cn=monitor

Entries below the cn=Resource entry for the search thread contain the same groups of attributes as described in [“Connection Handler Thread” on page 338](#), and the following groups of attributes:

Settings

- backendServer identifies the name of the monitored remote data source.
- checkInterval identifies the interval of time (in seconds) between two checks.
- additionalCheckType identifies additional checking. The following values can be used:
 - 1 (no additional checks)
 - 2 (create a bind connection to the data source)
 - 3 (create a read connection to the data source)

State

- serverAvailable identifies the status of the remote data source. The value is true if the remote data source is up and running.

Statistics

- totalChecks identifies the total number of checks.
- availabilityChecksFailed identifies the number of failed availability checks. An availability check is successful when a remote data source is up and running.
- additionalChecksFailed identifies the number of failed additional checks.

Detailed Layout of the cn=monitor Entry

This section provides a detailed layout of the cn=monitor subtree.

```
cn=monitor
|
+-- cn=Product (Installed Product)
   |
   +-- cn=ProductName
      || setting:
      || - version
      || - buildNumber
      || - patchId
   +-- cn=Operating System
      || setting:
      || - operatingSystemName
      || - operatingSystemVersion
      || state:
      || - (empty)
```

```

|| statistics:
|| - (empty)
+-- cn=Instance (Application System)
|
+-- cn=InstanceId (= host:port:instanceDir)
|
|+-- cn=Service
|   +-- cn=Add
|       || statistics:
|       || - total
|       || - succeeded
|       || - failed
|       || - abandoned (?)
|   +-- cn=Search
|       || (same as Add operation above)
|   +-- cn=Delete
|   +-- cn=Compare
|   +-- cn=Modify
|   +-- cn=ModifyDN
|   +-- cn=Bind
+-- cn=SAP (Service Access Point)
+-- cn=listenerThread
    || settings:
    || - name
    || - isSecure
    || - host (?)
    || - port (?)
    || state:
    || - enabled
    || - operationalStatus
    || - statusDescription
    || - startTime
    || - stopTime
    || - stopException
    || statistics:
    || - acceptedConnections
    || - refusedConnections
+-- cn=listenerThread
    || (same as above)
+-- cn=RSAP (Remote SAP)
+-- cn=LDAP Server servername
    || settings:
    || - name
    || - isSecure
    || - host (?)
    || - port (?)
    || state:
    || - operationalStatus
    || - statusDescription
    || - started
    || - readOnly
    || statistics:
    || - totalConnections
    || - totalAvailableConnections
    || - totalBindConnections
    || - availableBindConnections
    || - bindConnectionsRequested
    || - bindConnectionsProvided

```

```

    || - bindConnectionsRefused
    || - bindConnectionsWaitsRequired
    || - bindConnectionsReturnedValid
    || - bindConnectionsReturnedInvalid
    || - (idem for readConnections)
    || - (idem for writeConnections)
+-- cn=LDAPS Server servername
    || (same as LDAP Server above)
+-- cn=RDBM Server servername
    || settings:
    || - TBC
    || state:
    || - TBC
    || statistics:
    || - TBC
+-- cn=Component (Logical Component)
+-- cn=DataSource Pool poolname
+-- cn=Proportional LB
    || settings:
    || - classname
    || state:
    || - enabled
    || statistics:
    || - totalBindConnectionsProvided
    || - totalBindConnectionsRefused
    || - totalAddConnectionsProvided
    || - totalAddConnectionsRefused
    || - totalCompareConnectionsProvided
    || - totalCompareConnectionsRefused
    || - totalDeleteConnectionsProvided
    || - totalDeleteConnectionsRefused
    || - totalModifyConnectionsProvided
    || - totalModifyConnectionsRefused
    || - totalModifyDNConnectionsProvided
    || - totalModifyDNConnectionsRefused
    || - totalCompareConnectionsProvided
    || - totalCompareConnectionsRefused
+-- cn=Add
    || settings:
    || - (empty)
    || status:
    || - operationalStatus
    || - statusDescription
    || statistics:
    || - providedConnections
    || - providedPercentage
    || - refusedConnections
    || - refusedPercentage
+-- cn=Search
    || (same as Add operation above)
+-- cn=Delete
+-- cn=Compare
+-- cn=Modify
+-- cn=ModifyDN
+-- cn=Bind
+-- cn=Saturation LB
+-- cn=Affinity LB
+-- cn=JVM

```

```

|| settings:
|| - version
|| - jvmInstallation
|| state:
|| - operationalStatus
|| - statusDescription
|| statistics:
|| - totalJVMMemory
|| - maxJVMMemory
|| - freeJVMMemory
|| - realFreeJVMMemory
|| - JVMMemoryLowLevelCount
|| - JVMMemoryVeryLowLevelCount
|| - availableCPU
+-- cn=Resource (System Resource)
+-- cn=Worker Thread
+-- cn=worker_thread_name
|| settings:
|| - threadID
|| - threadStack
|| state:
|| - operationalStatus
|| - statusDescription
|| - startTime
|| - started
|| - running
|| statistics:
|| - operationsProcessed
|| - exceptionsCaught
+-- cn=Byte Buffer Pool
|| statistics:
|| - numTries
|| - numHits
|| - numMissesEmptyPool
|| - numMissesBufferSize
|| - numReleases
|| - availableStandardBuffers
|| - availableOversizedBuffers
+-- cn=String Buffer Pool
|| statistics:
|| - numTries
|| - numHits
|| - numMisses
|| - numReleases
|| - availableBuffers
+-- cn=Vector Pool
|| statistics:
|| - numTries
|| - numHits
|| - numMisses
|| - numReleases
|| - availableVectors
+-- cn=Search Thread
+-- cn=search_thread_name
|| settings:
||
|| state:
|| - operationalStatus

```

```

    || - startTime
    || - stopTime
    || statistics:
    ||
+-- cn=Byte Buffer Pool
    || (see Worker Thread)
+-- cn=String Buffer Pool
    || (see Worker Thread)
+-- cn=vector Pool
    || (see Worker Thread)
+-- cn=Monitor Thread
+-- cn=monitor_thread_name
    || settings:
    || - started
    || - running
    || - startTime
    || - threadID
    || - threadStack
    || - backendServer
    || - checkInterval
    || - additionalCheckType
    || state:
    || - operationalStatus
    || - statusDescription
    || - serverAvailable
    || statistics:
    || - totalChecks
    || - availabilityChecksFailed
    || - additionalChecksFailed
+-- cn=Byte Buffer Pool
    || (see Worker Thread)
+-- cn=String Buffer Pool
    || (see Worker Thread)
+-- cn=vector Pool
    || (see Worker Thread)
+-- cn=Connection Handler Thread
+-- cn=connection_handler_thread_name
    || settings:
    || - threadID
    || - threadStack
    || state:
    || - operationalStatus
    || - startTime
    || - started
    || - running
    || - statusDescription
    || statistics:
    || - (empty)
+-- cn=Byte Buffer Pool
    || (see Worker Thread)
+-- cn=String Buffer Pool
    || (see Worker Thread)
+-- cn=Vector Pool
    || (see Worker Thread)
+-- cn=Work Queue
    || settings:
    || - maxNormalPriorityPeak
    || - maxHighPriorityPeak

```

```
    || - operationalStatus
    || - statusDescription
    || state:
    || - curNormalPriorityInQueue
    || - curHighPriorityInQueue
    || statistics:
    || - numNormalPriorityPuts
    || - numNormalPriorityGets
    || - numHighPriorityPuts
    || - numHighPriorityGets
    || - numAbandonRequests
    || - numAbandonSuccesses
+-- cn=DB System
+-- cn=DB Service
```

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