Oracle® Fusion Middleware Administration Guide for Oracle Unified Directory

11*g* Release 1 (11.1.1)

Part No: 821–1273
June 2011

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Contents

Preface

The *Oracle Unified Directory 11g Release 1 (11.1.1) Administration Guide* is intended to provide typical configuration and administration tasks that are required on a deployed Oracle Unified Directory server.

Who Should Use This Book

This document is intended for administrators of deployed Oracle Unified Directory servers.

Before You Read This Book

Before reading this document you should be familiar with the following documents:

- *Oracle Unified Directory Release Notes*

Related Books

The following documents provide related information for the daily administration of Oracle Unified Directory:

- *Oracle Unified Directory Command-Line Usage Guide*
- *Oracle Unified Directory Configuration Reference*

Documentation and Support

See the following web sites for additional resources:

- Documentation (`http://www.oracle.com/technetwork/indexes/documentation/index.html`)
- Support (`http://www.oracle.com/us/support/software/index.html`)

Oracle Software Resources

Oracle Technology Network (`http://www.oracle.com/technetwork/index.html`) offers a range of resources related to Oracle software:

- Discuss technical problems and solutions on the Discussion Forums (`http://forums.oracle.com`).
- Get hands-on step-by-step tutorials with Oracle By Example (`http://www.oracle.com/technetwork/tutorials/index.html`).

Typographic Conventions

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

TABLE P–1 Typographic Conventions

Typeface	Meaning	Example
`AaBbCc123`	The names of commands, files, and directories, and onscreen computer output	Edit your `.login` file. Use `ls -a` to list all files. `machine_name% you have mail.`

`AaBbCc123`	What you type, contrasted with onscreen computer output	`machine_name%` **`su`**
		`Password:`

aabbcc123	Placeholder: replace with a real name or value	The command to remove a file is `rm` *filename*.
AaBbCc123	Book titles, new terms, and terms to be emphasized	Read Chapter 6 in the *User's Guide*. A *cache* is a copy that is stored locally. Do *not* 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 Oracle Solaris OS. Note that the default system prompt that is displayed in command examples varies, depending on the Oracle Solaris release.

TABLE P–2 Shell Prompts

Shell	Prompt
Bash shell, Korn shell, and Bourne shell	`$`
Bash shell, Korn shell, and Bourne shell for superuser	`#`
C shell	`machine_name%`
C shell for superuser	`machine_name#`

CHAPTER 1

Starting and Stopping the Server

Note – The procedures described in the following sections apply to the Oracle Unified Directory directory server, proxy server, and replication gateway.

This section includes the following topics:

- "Starting the Server" on page 21
- "Stopping the Server" on page 23
- "Checking if the Server is Started or Stopped" on page 24

Starting the Server

To start the server, run the `start-ds` command on UNIX or Linux systems or the `start-ds.bat` command on Windows systems. By default, the `start-ds` command starts the server as a background process when no options are specified. You can use the `start-ds` command with the `--nodetach` option to run the server as a foreground process. For more information, see "start-ds" in *Oracle Fusion Middleware Command-Line Usage Guide for Oracle Unified Directory*.

The `start-ds` command automatically attempts to find the correct Java environment to use when starting the server. You can specify the path to the Java installation, and provide additional options directly to the JVM when the directory server is starting. For more information, see "Configuring the Default JVM and Java Arguments" in *Oracle Fusion Middleware Installation Guide for Oracle Unified Directory*.

▼ To Start the Server by Using `start-ds`

1 **Change to the appropriate directory.**

```
(UNIX, Linux)  $ cd install-dir/bin
(Windows)      C:\> cd install-dir\bat
```

2 **Type `start-ds`.**

```
(UNIX, Linux)  $ start-ds
(Windows)      C:\> start-ds
```

▼ To Start the Server as a Foreground Process

1 **Change to the appropriate directory.**

```
(UNIX, Linux)  $ cd install-dir/bin
(Windows)      C:\> cd install-dir\bat
```

2 **Type `start-ds` with `-N` or `--nodetach`.**

```
(UNIX, Linux)  $ start-ds --nodetach
(Windows)      C:\> start-ds --nodetach
```

You can stop the directory server by pressing `Control-C` in the terminal window in which the server is running or by running the `stop-ds` utility from another window.

▼ To Restart the Server

1 **Change to the installation directory.**

```
(UNIX, Linux)  $ cd install-dir/bin
(Windows)      C:\> cd install-dir\bat
```

2 **Type `stop-ds` with `-R` or `--restart`.**

```
(UNIX, Linux)  $ stop-ds --restart
(Windows)      C:\> stop-ds --restart
```

▼ To Start the Server by Using a Script (UNIX/Linux)

The `start-ds` command provides a "quiet" option (`-Q` or `--quiet`) that suppresses output during the startup process unless a significant error occurs. You can use this option in a startup script.

1 **Create a shell script and add the following `start-ds` command.**

```
install-dir/bin/start-ds --quiet
```

2 **Run the script.**

Stopping the Server

On any system (whether the server is running in the foreground or the background), or even from a remote system, you can stop the server using one of the following methods. For more information about the `stop-ds` command, see "stop-ds" in *Oracle Fusion Middleware Command-Line Usage Guide for Oracle Unified Directory*.

▼ To Stop the Server by Using `stop-ds`

1 **Change to the appropriate directory.**

```
(UNIX, Linux)  $ cd install-dir/bin
(Windows)         C:\> cd install-dir\bat
```

2 **Type `stop-ds`**

```
(UNIX, Linux)  $ stop-ds
(Windows)      C:\> stop-ds
```

▼ To Stop the Server that is Running in the Foreground

This procedure assumes that the directory server is running as a foreground process (using the `-N` or `--nodetach` option).

● **Type Control-C in a terminal window on UNIX or in the Command Prompt window on Windows systems to stop the server.**

Alternatively, run the `stop-ds` command from another window.

▼ To Stop the Server by Using a Script (UNIX/Linux)

The `stop-ds` command provides a "quiet" option (`-Q` or `--quiet`) that suppresses output during the stopping process unless a significant error occurs. You can use this option in a shutdown script.

1 **Create a shell script and add the following `stop-ds` command.**

```
install-dir/bin/stop-ds --quiet
```

2 **Run the script.**

Checking if the Server is Started or Stopped

At any time, you can check if the server is started or stopped by using the `status` command.

▼ To Check the Server Status

1 **Change to the appropriate directory.**

```
(UNIX, Linux)  $ cd install-dir/bin
(Windows)      C:\> cd install-dir\bat
```

2 **Type `status`**

```
(UNIX, Linux)  $ status
(Windows)      C:\> status
```

CHAPTER 2

Configuring the Server Instance

The easiest way to access the server configuration is by using the `dsconfig` command or, for certain aspects of the configuration, by using Oracle Directory Services Manager.

This section covers the following topics:

- "Managing the Server Configuration With `dsconfig`" on page 25
- "Managing the Server Configuration With Oracle Directory Services Manager" on page 54
- "Managing Administration Traffic to the Server" on page 62
- "Configuring Commands As Tasks" on page 64
- "Deploying and Configuring the DSML Gateway" on page 68

Managing the Server Configuration With `dsconfig`

The topics in this section are intended for administrators or users who want to configure and manage a deployed Oracle Unified Directory instance. These topics provide an overview of the `dsconfig` command-line utility and its use in server configuration.

The `dsconfig` command can be used to configure both the Oracle Unified Directory directory server and the Oracle Unified Directory proxy. For a list of the supported sub-commands for the directory server or proxy instance, and for more specific information about this command, see "dsconfig" in *Oracle Fusion Middleware Command-Line Usage Guide for Oracle Unified Directory*.

You can also use `dsconfig` to configure a number of proxy—specific components. For more information, see .

Overview of the `dsconfig` Command

The `dsconfig` command provides a simple mechanism for accessing the server configuration. `dsconfig` presents the configuration as a set of components, each of which can be managed through one or more sub-commands.

dsconfig can also be used interactively. In interactive mode, dsconfig functions much like a wizard, walking you through the server configuration. For more information, see "Using dsconfig in Interactive Mode" on page 28.

Note –

- dsconfig can only be used to configure a *running* server instance. Offline configuration is not supported by dsconfig.
- Like the other administration commands, dsconfig uses the administration connector to access the server. For more information, see "Managing Administration Traffic to the Server" on page 62. All of the examples in this section assume that the administration connector is listening on the default port (4444) and that the command is accessing the server running on the local host. If this is not the case, the --port and --hostname options must be specified.

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dsconfig and Certificate Checking

dsconfig accesses the server over a secured connection with certificate authentication. If you run dsconfig in interactive mode, you are prompted as to how you want to trust the certificate.

If you run dsconfig in non-interactive mode (that is, with the -n option), specification of the trust store parameters depends on whether you run the command locally or remotely.

- **Running dsconfig locally.** (The command is launched on the server that you are administering.) If you do not specify the trust store parameters, the server uses the local instance trust store by default. Unless you specify otherwise, the local instance trust is *instance-dir*/OUD/config/admin-truststore.
- **Running dsconfig remotely.** (The command is launched on a different server to the one you are administering.) You *must* specify the trust store parameters or the -X (--trustAll) option. The easiest way to specify the trust store parameters is to run the command once in interactive mode and to save the certificate that is presented by the server in your trust store.

```
$ dsconfig

>>>> >>>> Specify Oracle Unified Directory LDAP connection parameters

Directory server hostname or IP address [host1.example.com]:
Directory server administration port number [4444]:

How do you want to trust the server certificate?

    1)  Automatically trust
    2)  Use a truststore
    3)  Manually validate

Enter choice [3]: 3

Administrator user bind DN [cn=Directory Manager]:
```

```
Password for user 'cn=Directory Manager':

Server Certificate:

User DN  : CN=host1.example.com, O=Administration Connector Self-Signed Certificate
Validity : From 'Wed Apr 29 11:13:21 MEST 2009'
             To 'Fri Apr 29 11:13:21 MEST 2011'
Issuer   : CN=host1.example.com, O=Administration Connector Self-Signed Certificate


Do you trust this server certificate?

    1)  No
    2)  Yes, for this session only
    3)  Yes, also add it to a truststore
    4)  View certificate details

Enter choice [2]: 3

Truststore path: /local/instances/certificates/jctruststore

Password for keystore '/local/instances/certificates/jctruststore':

...
```

When you have saved the certificate in the trust store, you can specify those trust store parameters in non-interactive mode.

```
$ dsconfig -h localhost -p 4444 list-connection-handlers -n \
--trustStorePath /local/instances/certificates/jctruststore \
--trustStorePasswordFile /local/instances/certificates/jctruststore.pin -w password
Connection Handler       : Type : enabled : listen-port : use-ssl
-------------------------:------:---------:-------------:--------
JMX Connection Handler   : jmx  : false   : 1689        : false
LDAP Connection Handler  : ldap : true    : 1389        : false
LDAPS Connection Handler : ldap : false   : 636         : true
LDIF Connection Handler  : ldif : false   : -
```

`dsconfig` Sub-Commands

`dsconfig` provides an intuitive list of sub-commands to manage various elements of the configuration.

You can use these sub-commands to add, delete, list, view, and modify different components:

Subcommand	Function
`dsconfig create-`*component options*	Creates a new component
`dsconfig delete-`*component options*	Deletes an existing component
`dsconfig get-`*component*`-prop` *options*	Displays the properties of a component
`dsconfig list-`*component*`s` *options*	Lists the existing defined components
`dsconfig set-`*component*`-prop` *options*	Modifies the properties of a component

For example, the following five sub-commands are used to manage connection handlers:

Subcommand	Function
`dsconfig create-connection-handler` *options*	Creates connection handlers
`dsconfig delete-connection-handler` *options*	Deletes connection handlers
`dsconfig get-connection-handler-prop` *options*	Displays the properties of a connection handler
`dsconfig list-connection-handlers` *options*	Lists the existing defined connection handlers
`dsconfig set-connection-handler-prop` *options*	Modifies the properties of a connection handler

Not all types of components can be created and deleted. For example, a directory server has only a single global configuration. For this reason, the global configuration is managed with only two sub-commands:

Subcommand	Function
`dsconfig get-global-configuration-prop` *options*	Displays the global configuration properties
`dsconfig set-global-configuration-prop` *options*	Modifies the global configuration properties

The configurable properties of all components can be queried and modified to change the behavior of the component. For example, an LDAP connection has properties that determine its IP listener address, its port, and its SSL configuration.

`dsconfig` Advanced Properties

There are a number of component properties that are considered *advanced* properties. The advanced properties are not displayed by default, and have default values that apply in most cases. If you want to modify the values or the advanced properties, use `--advanced` before the subcommand. For example:

```
$ dsconfig --advanced get-extension-prop
```

Using `dsconfig` in Interactive Mode

Unless you specify all configuration parameters and the `-n` (`--no-prompt`) option, `dsconfig` runs in interactive mode. Interactive mode functions like a wizard, walking you through the server configuration. Interactive mode is a good approach to start using `dsconfig`.

When you run `dsconfig` in interactive mode, you can specify that you want the equivalent command (including all your selections) to be displayed, or to be written to a file. The following example shows how to use the `--displayCommand` option to display the equivalent non-interactive command when configuring the trust manager. Note that the equivalent command is displayed at the point at which the command has been applied and validated by the directory server.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password --displayCommand
...
The TrustStore Manager Provider was modified successfully

The equivalent non-interactive command-line is:
dsconfig --hostname "localhost" --port "4444" --bindDN "cn=directory
manager" --bindPassword ****** --trustAll
set-trust-manager-provider-prop --provider-name "PKCS12" --set
"enabled:true"
```

To copy the equivalent command to a file, use the `--commandFilePath` option, as shown in the following example:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password --commandFilePath /tmp/filename
```

Getting Help With `dsconfig`

The `dsconfig` command has extensive online help that is accessed using the `--help` option.

Global Usage

Use the following command to display `dsconfig`'s global usage:

```
$ dsconfig --help
```

Finding the Correct Subcommand

The global usage information does not include the list of available sub-commands. To retrieve the list of sub-commands, use one of the `--help-`*xxx* options, where *xxx* determines the group of sub-commands to be displayed.

Note – Use the `--help-all` option used to display all of the available sub-commands.

For example, to find all the sub-commands relating to caching and back-end configuration, use the following command:

```
$ dsconfig --help-core-server
```

Getting Help for an Individual Subcommand

When you have determined which subcommand you want, you can get more detailed help on that subcommand by using the subcommand's `--help` option as follows:

```
$ dsconfig create-monitor-provider --help
```

Displaying a Summary of a Component's Properties

The `dsconfig` command has built-in documentation for all of the components and their properties. This documentation can be accessed by using the `list-properties` subcommand. For example, a summary of the properties associated with a work queue can be displayed by using the following command:

```
$ dsconfig list-properties -c work-queue
```

Note – If the `-c` option is not specified, a summary of the properties for all components is displayed.

Displaying Detailed Help on a Property

The summary table displays only brief usage information for each property. More detailed information are available using the verbose mode of the `list-properties` subcommand:

```
$ dsconfig list-properties -c work-queue --property num-worker-threads -v
```

Note – If the `--property` option is not specified, verbose help is provided for all the work-queue properties.

Configuring a Server Instance With `dsconfig`

The `dsconfig` command is the recommended utility for accessing the server configuration. Accessing the configuration directly over LDAP, using the `ldap*` utilities is discouraged.

▼ To Display the Properties of a Component

Each component has one or more properties that can be displayed by using the component's `get-`*xxx*`-prop` subcommand. Each component is associated with a single LDAP entry in the server configuration, and each property is associated with a single LDAP attribute.

- **To display the properties of the default LDAP connection handler, run the following command:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n\
 get-connection-handler-prop \
  --handler-name "LDAP Connection Handler"
```

```
Property : Value(s)
------------------------:-------------------------------------------------------
allow-ldap-v2 : true
allow-start-tls : false
allowed-client : -
denied-client : -
enabled : true
keep-stats : true
key-manager-provider : -
listen-address : 0.0.0.0
listen-port : 1389
ssl-cert-nickname : server-cert
ssl-cipher-suite : -
ssl-client-auth-policy : optional
ssl-protocol : -
trust-manager-provider : -
use-ssl : false
```

Note – The `dsconfig` command displays the default values or behavior for properties that have not been customized.

To List Components

You can view a list and summary of the instances of one component by using the component's `list-`*`xxx`*s subcommand. This can be particularly useful if you have more than one instance of the same component.

- **To list all of the available connection handlers, run this command:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
list-connection-handlers
```

Depending on your installation, the output will be similar to the following.

```
Connection Handler : Type : enabled : listen-port : use-ssl
------------------------:-----:-----------:-------------:--------
JMX Connection Handler : jmx : false : 1689 : false
LDAP Connection Handler : ldap : true : 1389 : false
LDAPS Connection Handler : ldap : true : 1636 : true
LDIF Connection Handler : ldif : true : - : -
```

To Create a Component

New instances of a component can be created by using the component's `create-`*`xxx`* subcommand. Often there are several *subtypes* of the component. For example, there are currently three types of connection handler: LDAP, JMX, and LDIF. Because all of these are created by using the same subcommand, you must specify the type of component that you want to create. Do this by using the subcommand's `-t` or `--type`.

When you create a new component, you must specify the component's mandatory properties. The mandatory properties depend on the type of component that is being created. For example, an LDAP connection handler might have different mandatory properties to a JMX connection handler. If a mandatory property is left undefined, `dsconfig` enters interactive mode and prompts you for the undefined properties. If you include the `-n` (non-interactive) option, `dsconfig` fails to create the component and displays an error message indicating which properties need to be defined.

1 **Display the types of connection handler that can be created by accessing the help for the connection handler component.**

```
$ dsconfig create-connection-handler --help

Usage: dsconfig create-connection-handler {options}
Creates Connection Handlers

Global Options:
See "dsconfig --help"

SubCommand Options:
--handler-name {NAME}
The name of the new Connection Handler
--set {PROP:VALUE}
Assigns a value to a property where PROP is the name of the property and
VAL is the single value to be assigned. Specify the same property multiple
times in order to assign more than one value to it
-t, --type {TYPE}
The type of Connection Handler which should be created. The value for TYPE
can be one of: custom | jmx | ldap | ldif
```

2 **Create a new LDAP connection handler, specifying values for the mandatory `enabled` and the `listen-port` properties.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  create-connection-handler \
  -t ldap --handler-name "My LDAP Connection Handler"
```

An error message similar to the following will be displayed.

```
The LDAP Connection Handler could not be created because the following
mandatory properties were not defined:

Property     Syntax
----------------------------------
enabled      false | true
listen-port  1 <= INTEGER <= 65535
```

▼ To Modify the Properties of a Component

The properties of a component can be modified by using the component's `set-`*xxx*`-prop` subcommand. Multiple properties can be modified at the same time by using multiple occurrences of the `--set` option. The following example uses the `set-connection-handler-prop` subcommand to modify the properties of a connection handler.

Note – Many components have a Java class property that specifies the name of a Java class to be used as the implementation of the component. Do not modify this property, as doing so could prevent your server from operating correctly. These properties are treated as *advanced* properties and hidden from view unless you run `dsconfig` with the `--advanced` option.

- **To configure the LDAP connection handler to accept LDAPv2 connections, run this command:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-connection-handler-prop \
  --handler-name="LDAP Connection Handler" --set allow-ldap-v2:true
```

To Modify the Values of a Multi-Valued Property

You can set multiple values for a property by using the `--set` and `--add` options in successive `dsconfig` commands.

Note – You cannot use the `--set` and `--add` options simultaneously in the same command.

To set more than one value for a property that currently has no values, use the `--set` option to set the first value, and the `--add` option (in a separate command) for subsequent values. You cannot use the `--add` option if the property does not have an existing value, either a default value or a value that you have already set.

Note – Many components have a Java class property that specifies the name of a Java class to be used as the implementation of the component. Do not modify this property, as doing so could prevent your server from operating correctly. These properties are treated as *advanced* properties and hidden from view unless you run `dsconfig` with the `--advanced` option.

The following example sets multiple values for the `allowed-client` property.

- **To restrict connections through the LDAP connection handler to specific clients, run these commands:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-connection-handler-prop \
  --handler-name "LDAP Connection Handler"  --set allowed-client:myhost
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-connection-handler-prop \
  --handler-name "LDAP Connection Handler" \
  --add allowed-client:myhost.example --add allowed-client:myhost.example.com
```

▼ To Delete a Component

Existing instances of a component can be removed using the component's `delete-`*xxx*.

● **Delete the LDAP connection handler that was created in the previous example:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X -n \
  delete-connection-handler \
  --handler-name "My LDAP Connection Handler"
```

▼ To Use `dsconfig` in Batch Mode

The `-F` or `--batchFile` option of the `dsconfig` command enables you to specify a number of operations that are completed in a single command by consolidating those operations in a file. This can significantly improve performance when several `dsconfig` commands are required.

To use `dsconfig` in batch mode, complete the following steps:

1 **Create a file that contains all of the required commands.**

For example, the following file (named `new-backend.txt`) achieves three separate tasks:

- creates a new back end
- adds a set of indexes
- sets the backend index entry limit

```
create-backend --set base-dn:cn=myexample,cn=com --set enabled:true \
  --type local-db --backend-name myBackend
create-local-db-index --backend-name myBackend --set index-type:equality \
  --type generic --index-name cn
create-local-db-index --backend-name myBackend --set index-type:equality \
  --type generic --index-name telephoneNumber
create-local-db-index --backend-name myBackend --set index-type:equality \
  --set index-type:substring --type generic --index-name mail
create-local-db-index --backend-name myBackend --set index-type:equality \
  --type generic --index-name sn
create-local-db-index --backend-name myBackend --set index-type:equality \
  --type generic --index-name uniqueMember
set-local-db-index-prop --backend-name myBackend --index-name uniqueMember \
  --set index-entry-limit:5000
create-local-db-index --backend-name myBackend --set index-type:equality \
  --type generic --index-name member
create-local-db-index --backend-name myBackend --set index-type:equality \
  --type generic --index-name uid
set-backend-prop --backend-name myBackend --set index-entry-limit:6000
```

2 **Run the `dsconfig` command with that file as a parameter.**

```
$ dsconfig -h localhost -p 4444 -D cn="directory manager" -w password \
  -F new-backend.txt -X -n
```

Configuring the Connection Handlers With dsconfig

Connection handlers are responsible for handling all interaction with client applications, including accepting connections, reading requests, and sending responses.

The following sections describe how to configure the connection handlers by using the `dsconfig` command. These sections provide examples on only a few aspects of the configuration. For details about all the configuration properties, use the following command: `$ dsconfig list-properties -c connection-handler`.

For information about configuring secure connections, see "Configuring SSL and StartTLS for LDAP and JMX" on page 140.

▼ To Display All Connection Handlers

The following connection handlers are currently available for use in the directory server:

- **LDAP connection handler.** This connection handler is used to interact with clients using LDAP. It provides full support for LDAPv3 and limited support for LDAPv2.
- **LDAPS connection handler.** This connection handler is used to interact with clients using LDAP over SSL.
- **LDIF connection handler.** This connection handler is used to process changes in the server using internal operations.
- **JMX connection handler.** This connection handler allows interactions with clients using the Java Management Extensions (JMX) framework and the Remote Method Invocation (RMI) protocol.

● **To display all configured connection handlers, along with their basic properties, use the `dsconfig list-connection-handlers` command.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  list-connection-handlers
```

Depending on your installation, the output will be similar to the following.

```
Connection Handler : Type : enabled : listen-port : use-ssl
-------------------------:------:---------:-------------:--------
JMX Connection Handler : jmx : false : 1689 : false
LDAP Connection Handler : ldap : true : 1389 : false
LDAPS Connection Handler : ldap : true : 1636 : true
LDIF Connection Handler : ldif : true : - : -
```

Configuring the LDAP Connection Handler

The following command displays the properties of the LDAP connection handler:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  get-connection-handler-prop \
  --handler-name "LDAP Connection Handler"
```

Depending on your installation, the output will be similar to the following.

```
Property : Value(s)
----------------------:-----------
allow-ldap-v2 : true
allow-start-tls : false
allowed-client : -
denied-client : -
enabled : true
keep-stats : true
key-manager-provider : -
listen-address : 0.0.0.0
listen-port : 1389
ssl-cert-nickname : server-cert
ssl-cipher-suite : -
ssl-client-auth-policy : optional
ssl-protocol : -
trust-manager-provider : -
use-ssl : false
```

▼ To Control Which Clients Have LDAP Access to the Directory Server

You can specify a list of clients that may or may not access the directory server over LDAP. To do this, set the `allowed-client` or `denied-client` property of the LDAP connection handler. These properties take an IP address or subnetwork with subnetwork mask as values.

By default, these properties are not set and all clients are allowed access. Changes to these properties take effect immediately but do not interfere with connections that are already established.

This example permits access only to clients in the subnet mask `255.255.255.10`.

- **Run the `dsconfig` command as follows:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-connection-handler-prop \
  --handler-name "LDAP Connection Handler" --set allowed-client:255.255.255.10
```

Configuring the LDIF Connection Handler

The LDIF connection handler is disabled by default. This connection handler can be used to process changes in the server using internal operations. The changes to be processed are read from an LDIF file.

The following command displays the default properties of the LDIF connection handler:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  get-connection-handler-prop \
  --handler-name "LDIF Connection Handler"
```

Depending on your installation, the output will be similar to the following.

```
Property : Value(s)
---------------:-------------------------
allowed-client : -
denied-client : -
enabled : false
ldif-directory : config/auto-process-ldif
poll-interval : 5 s
```

The `ldif-directory` property specifies the directory in which the LDIF files are located. The connection handler checks if there are any files in this directory, at an interval specified by the `poll-interval` property. The connection handler then processes the changes contained in those files as internal operations and writes the result to an output file with comments indicating the result of the processing.

▼ To Enable the JMX Alert Handler Through the LDIF Connection Handler

This example demonstrates how to enable the JMX alert handler through the LDIF connection handler.

1. **Check the status of the JMX alert handler (disabled by default).**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  get-alert-handler-prop \
  --handler-name "JMX Alert Handler"
```

Depending on your installation, the output will be similar to the following.

```
Property            : Value(s)
--------------------:---------
disabled-alert-type : -
enabled             : false
enabled-alert-type  : -
```

2. **Create an LDIF file in the default LDIF directory that enables the JMX alert handler.**

```
$ cd ../config/
$ mkdir auto-process-ldif
$ cd auto-process-ldif/
$ cat > disable-jmx.ldif << EOM
> dn: cn=JMX Alert Handler,cn=Alert Handlers,cn=config
> changetype: modify
> replace: ds-cfg-enabled
> ds-cfg-enabled: true
> EOM
$
```

3. **After a period of time longer than `poll-interval`, recheck the status of the JMX alert handler.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  get-alert-handler-prop \
  --handler-name "JMX Alert Handler" -n

Property            : Value(s)
--------------------:---------
disabled-alert-type : -
```

```
enabled             : true
enabled-alert-type  : -
```

Configuring the JMX Connection Handler

The following command displays the default properties of the JMX connection handler:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password \
  get-connection-handler-prop \
  --handler-name "JMX Connection Handler" -n
```

Depending on your installation, the output will be similar to the following.

```
Property : Value(s)
--------------------:-----------
allowed-client : -
denied-client : -
enabled : false
key-manager-provider : -
listen-port : 1689
ssl-cert-nickname : server-cert
use-ssl : false
```

▼ To Change the Port on Which the Server Listens for JMX Connections

This example changes the port on which the server listens for JMX connections to 1789.

- **Use the `dsconfig` command as follows:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-connection-handler-prop \
  --handler-name "JMX Connection Handler" --set listen-port:1789
```

Configuring Network Groups With `dsconfig`

Network groups are the single entry point of all client requests to the Oracle Unified Directory. The network group handles all client interactions, dispatching them and delegating the treatment of the request to workflows. A client connection is associated to the network group with the highest priority and for which all the criteria are met. During installation, a default network group with a priority of 1 is created. To set request filtering policies or resource limits, you must create a network group quality of service policy.

Each network group is associated with one or more workflows. The workflows provide access to a naming context (or suffix). By associating a workflow with a network group, you indicate to the network group which naming contexts are available. Typically to create a network group, you would already have a workflow created. For information about workflows, see "Configuring Workflows With dsconfig" on page 46.

The following examples describe how to configure network groups using the dsconfig command.

All the commands in the following procedures specify the proxy hostname (-h), the proxy admin port (-p), the bind DN (-D), and the bind password (-w). The following examples use the -X option to trust all certificates.

Creating a Network Group

You can create many network groups, in which case the requests will be handled by the network group with the highest priority, for which the criteria are met. Therefore, when you create a network group, you must consider all the network groups you plan to create, and the priority of each. The priority can be 0 or above, where 0 is the highest priority.

Note – It is possible to create two network groups with the same priority. However if two or more network groups have the same priority and match the client request, the network group that will handle the request is random, among those matching the client request. Therefore, it is recommended to use a different priority for each network group created.

The default properties of a new network group are as follows.

```
Property                 Value(s)
----------------------------------------------------------------------
allowed-auth-method      All authorization methods are allowed.
allowed-bind-dn          All bind DNs are allowed.
allowed-bind-id          All bind IDs are allowed.
allowed-client           All clients with addresses that do not match
                         an address on the deny list are allowed. If
                         there is no deny list, then all clients are
                         allowed.
allowed-protocol         All supported protocols are allowed.
certificate-mapper       The global certificate mapper will be used.
denied-client            If an allow list is specified, then only
                         clients with addresses on the allow list are
                         allowed. Otherwise, all clients are allowed.
enabled                  true
generic-identity-mapper  The global generic identity mapper will be
                         used.
gssapi-identity-mapper   The global GSSAPI identity mapper will be
                         used.
is-security-mandatory    false
priority                 1
workflow                 userroot0
```

Once you have created a network group, you can associate a network group quality of service policy to it. For information on creating a quality of service policy, see “Creating a Network Group Quality of Service Policy” on page 42.

▼ To Create a Network Group

- **To create a network group, use the `dsconfig create-network-group` command.**

  For example:

  ```
  $ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
    create-network-group \
    --group-name network-group1 \
    --set enabled:true \
    --set workflow:workflow1 \
    --set priority:1
  ```

Modifying Network Group Properties

The network group properties filter the traffic and indicate how a request is directed. To modify the network group properties, use the `dsconfig` `set-network-group-prop` command. The network group properties include the properties `enabled`, associated workflow name, priority, and criteria.

To modify any of the network group properties, use the dsconfig set-network-group-prop command. For example, to modify the *priority* of the network group:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  set-network-group-prop \
  --group-name network-group1 \
  --set priority:3
```

Using the network group properties, you can set the following criteria:

- the authentication method allowed between the client and the network group (allowed-auth-method).
- the bind DN allowed to connect to the network group (allowed-bind-dn).
- the list of clients authorized to access the Oracle Unified Directory (allowed-client), expressed by the IP address or name of the client . If no allowed client list is provided, then all clients are allowed, assuming they are not listed on the denied client list.
- the protocol allowed to connect to the Oracle Unified Directory (allowed-protocol). If none is specified, all protocols are allowed.
- the name of the certificate mapper that should be used to match client certificates to user entries. (certificate-mapper). If none is specified, the global certificate mapper is used.
- the list of clients not authorized to access the Oracle Unified Directory (denied-client). If no denied client list is provided, all clients are authorized, assuming there is no limitation set by an allowed client list.
- the set of identity mappers that will be used by network group for mapping an identity while performing SIMPLE, non-GSSAPI SASL bind requests and proxy authorization controls (generic-identity-mapper).
- the set of identity mappers that will be used by network for mapping an identity while performing GSSAPI/SASL bind requests (gssapi-identity-mapper).
- whether security between the client and the Oracle Unified Directory is always required (is-security-mandatory).
- the priority for this network group (priority). A client connection is first compared against the network group with the highest priority. If the client connection does not match its connection criteria, the client connection is compared against the network group with next highest priority, and so on. If no network group is selected, the client connection is rejected.

For example, you can ensure that no connections are accepted from the IP address 208.77.188.166, by *network-group1* as follows:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  set-network-group-prop \
  --group-name network-group1 \
  --set denied-client:208.77.188.166
```

Setting an Allowed or Denied Client List

For allowed-client and denied-client lists, you must be aware of the name service configuration on the server. For example, if the name service knows the host as myclienthost.example.com, you must specify myclienthost.example.com as the value, and not just myclienthost. Similarly, if the name service knows the host as myclienthost, you must specify the value as myclienthost. If you do not know how the name service is configured, you should specify both the fully qualified domain name (for example myclienthost.sun.com) and the short name (myclienthost) of the machine. Specifying multiple values will ensure that the name is resolved correctly. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  set-network-group-prop \
  --group-name network-group1 \
  --add denied-client:myhost \
  --add denied-client:myhost.example \
  --add denied-client:myhost.example.com
```

To avoid any issues, use the IP address for clarity.

Moreover, if you use localhost or the name of the local machine when connecting to Oracle Unified Directory proxy, the IP addresses of the client will be different. If you want to forbid connections from the localhost to Oracle Unified Directory proxy, you should specify both localhost and the name of the local machine in the list of denied-clients.

Creating a Network Group Quality of Service Policy

Creating a quality of service policy is optional and associated to a network group. There are four types of quality of service policy available:

- request filtering policy
- resource limits
- affinity
- referral

To create a network group quality of service policy, use the dsconfig create-network-group-qos-policy command. You must specify the name of the network group to which the quality of service policy applies, as well as the type of quality of service policy.

Creating a Request Filtering Policy

When you create a network group request filtering policy, you can set the following properties:

- allowed-attributes: list of attributes that can be specified in the filter of a search request
- allowed-operations: type of operation accepted by the network group. For example, you can set a network group to accept only read requests.
- allowed-search-scopes: scope of a search accepted, for example one-level only.

- allowed-subtrees: list of specific sub-trees that can be specified as base DN in a search request
- prohibited-attributes: list of attributes which, if specified in the filter of a search request, will be rejected
- prohibited-subtrees: list of specific sub-tress that will not manage a request

To create a network group quality of service request filtering policy, use the dsconfig create-network-group-qos-policy command. You must state the network group to which the quality of service policy applies.

For example, if you want to ensure that users can only search and not modify data, use the following command:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  create-network-group-qos-policy \
  --group-name network-group1 \
  --type request-filtering \
  --set allowed-operations:search
```

Creating a Network Group Resource Limit

When you create a network group resource limit, you can set the following properties:

- maximum number of simultaneous operations per connection (max-concurrent-ops-per-connection). If you want your Oracle Unified Directory proxy to run in synchronous mode, set the maximum to 1.
- maximum number of operations per connection (max-ops-per-connection)
- maximum number of connections (max-connections). If you do not set a maximum number of connections, the server limit is used.
- maximum number of connections from the same IP (max-connections-from-same-ip). Set this parameter if you want to avoid Denial of Service attacks. However, this parameter should not be set if you know that the requests typically come from the same client.
- maximum number of operations (max-ops-per-interval). For example, a setting of 1,000 will limit the number of operations to 1,000 per the interval set using max-ops-interval.
- maximum interval during which the number of operations is counted (max-ops-interval). For example, an interval set to one second results in operations being counted for one second. The limit (max-ops-per-interval) is checked and enforced during each interval.
- minimum search string length (min-substring-length). The shorter the search string, the more results that need to be found and displayed. Therefore, it may be useful to set a minimum search string length in the substring search filter to limit the resources used.
- size limit (size-limit) limits the number of results of a query. It is recommended to use the default value.
- time limit (time-limit) of a connection. It is recommended to use the default value.

To create a network group quality of service resource limit policy, use the dsconfig create-network-group-qos-policy command. You must state the network group to which the quality of service policy applies.

For example, if you want to ensure that a user enters a search string of at least 5 characters, to limit the number of return values, use the following command:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  create-network-group-qos-policy \
  --group-name network-group1 \
  --type resource-limits \
  --set min-substring-length:5
```

Creating an Affinity Quality of Service Policy

In a load balancing deployment, you can use *affinity* to override the regular routing process.

When you create a network group quality of service, you can set the following affinity properties:

- affinity-policy indicates that a certain routing policy is used, regardless of the regular routing process.

  The affinity policy can take one of the following values:

  - all-requests-after-first-request
  - all-requests-after-first-write-request
  - all-write-requests-after-first-write-request
  - first-read-request-after-write-request

  Specific operations will set affinity, depending on the affinity policy. For the first policy in the previous list (all-requests-after-first-request) all operations will set affinity. For the remaining policies (all-requests-after-first-write-request, all-write-requests-after-first-write-request, and first-read-request-after-write-request) only an ADD, DELETE, MOD or MODDN operation will set affinity.
- affinity-timeout defines the duration during which the affinity applies.

Even when affinity has been set by a previous operation, the load balancing algorithm is only bypassed in specific situations, depending on the affinity policy and the current operation type. If the affinity policy is all-requests-after-first-request or all-requests-after-first-write-request, the affinity route will be used for every operation type, unless the affinity timeout has expired. If the affinity policy is all-write-requests-after-first-write, the affinity route will be used for any ADD, DELETE, MOD or MODDN operation, unless the timeout has expired. The affinity route will not be used for other operations. If the affinity policy is first-read-request-after-write-request, the affinity route will be used for all operations *except* ADD, DELETE, MOD or MODDN operations, unless the timeout has expired.

The following example sets an affinity policy that can be set by any operation and used for all operations, for a maximum of sixty seconds.

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  create-network-group-qos-policy \
  --group-name network-group1 \
  --type affinity \
  --set affinity-timeout:60s \
  --set affinity-policy:all-requests-after-first-request
```

Note – The affinity feature can be used with all load balancing algorithms except for the failover algorithm. With the failover algorithm, only one route is active at a time. The active route changes when the remote server goes down, so all connections to the remote server are broken. Affinity can therefore not apply in a failover scenario.

Creating a Referral Quality of Service Policy

You can configure the behavior of the Oracle Unified Directory proxy when a referral is received from the remote LDAP server.

Note – Referrals must be defined on the Oracle Unified Directoryserver or the Oracle Directory Server Enterprise Edition.

When you create a network group quality of service, you can set the following referral properties:

- the maximum number of hops supported (`referral-hop-limit`) when the referral policy is set to `follow`. The default is set to 5.
- define the type of referral policy (`referral-policy`), such as `discard`, `forward`, or `follow`. This defines how a referral will be treated by the network group.

For example, the referral-policy is set by default to `forward`. You can change it to `discard` or to `follow`, as follows:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  create-network-group-qos-policy \
  --group-name network-group1 \
  --type referral \
  --set referral-policy:follow
```

▼ To Modify a Network Group Quality of Service Policy

You must specify the network group name (*network-group1*) and the policy type.

- **To modify a QoS policy property, use the `dsconfig set-network-group-qos-policy-prop` command.**

  Use the `--set` argument to modify the quality of service policy. In the example below, one of the network group resource limit policies (minimum search string limit) is set.

  ```
  $ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
    set-network-group-qos-policy-prop \
    --group-name network-group1 \
    --policy-type resource-limits \
    --set min-substring-length:5
  ```

Configuring Workflows With dsconfig

A workflow is the link between the network group and the naming context (suffixes). It defines the naming context that will be accessible for a given network group, when handling a request to a load balancing or distribution configuration. To create a workflow, you must already have a load balancing or distribution workflow element created. For information on workflow elements, see "Configuring Workflow Elements With `dsconfig`" on page 48.

Oracle Unified Directory proxy automatically creates a number of private workflows. These workflows should not be modified or deleted. Privacy settings of the remote LDAP servers must be considered when configuring workflows. Privacy settings are as follows:

LDIFBackend	Privacy defined by the property `ds-cfg-is-private-backend`. This flag is set by default to private, but can be changed.
JEB backend	Always public, and contains user data.
Config File Handler backend	Always private
Backup backend	Always private
Schema backend	Always private
Tasks backend	Always private
Monitor backend	Always private
Truststore backend	Always private

The following examples describe how to configure workflows using the `dsconfig` command.

All the commands in the following procedures specify the proxy hostname (`-h`), the proxy admin port (`-p`), the bind DN (`-D`), and the bind password (`-w`). These following examples use the `-X` option to trust all certificates.

Listing Existing Workflows

To display all the workflows that are part of your Oracle Unified Directory proxy, use the `dsconfig list-workflows` command. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
list-workflows

Workflow       : Type    : enabled
---------------:---------:--------
adminRoot      : generic : true
ads-truststore : generic : true
backup         : generic : true
config         : generic : true
monitor        : generic : true
schema         : generic : true
tasks          : generic : true
workflow1      : generic : true
```

In the example above, `workflow1` is the workflow created during a basic installation using `vdp-setup`.

Note – The `adminRoot`, `ads-truststore`, `backup`, `config`, `monitor`, `schema`, and `tasks` workflows are default workflows created by the Oracle Unified Directory proxy during your installation. These workflows must not be deleted or modified, otherwise your Oracle Unified Directory proxy will no longer work.

Viewing Workflow Properties

To view the properties of a specific workflow, use the `dsconfig get-workflow-prop` command. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  get-workflow-prop \
  --workflow-name workflow1

Property         : Value(s)
-----------------:------------------
base-dn          : "ou=people,o=test"
enabled          : true
workflow-element : load-bal-we1
workflow-id      : workflow1
```

The `workflow-id` is the workflow name. The `base-dn` indicates the base DN used for the workflow, and therefore for the deployment using that workflow. The `workflow-element` property indicates the workflow element (either a load balancing workflow element or a distribution workflow element) which will process the requests.

Note – The `base-dn` and `workflow-id` properties cannot be modified.

Creating a Workflow

Each workflow is associated to a workflow element. When creating a workflow, you must specify the associated workflow element name (`--set workflow-element`). In other words, you must already have created the load balancing or distribution workflow element. See "Configuring Workflow Elements With `dsconfig`" on page 48.

To create a workflow, use the `dsconfig create-workflow` command. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  create-workflow \
  --workflow-name workflow1 \
  --set base-dn:ou=people,o=test \
  --set enabled:true \
  --set workflow-element:load-bal-we1
```

Configuring Workflow Elements With `dsconfig`

Workflow elements are part of a routing structure, and are linked to workflows. There are different types of workflow elements within Oracle Unified Directory proxy:

- LDAP proxy workflow elements, which connect to the remote LDAP servers
- load balancing workflow elements (load balancing connectors)
- distribution workflow elements (distribution connectors)
- DN renaming workflow elements, which transform the entry DN and DN type attributes

In your Oracle Unified Directory proxy deployment, you must have LDAP proxy workflow elements and either a load balancing or distribution workflow element.

The following examples describe how to configure workflow elements using the `dsconfig` command.

All the commands in the following procedures specify the Oracle Unified Directory proxy hostname (`-h`), the Oracle Unified Directory proxy admin port (`-p`), the bind DN (`-D`), and the bind password (`-w`). The following examples use the `-X` option to trust all certificates.

Listing Workflow Elements

To display all the workflow elements that are part of your Oracle Unified Directory proxy, use the `dsconfig list-workflow-elements` command. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
list-workflow-elements

Workflow Element : Type           : enabled
-----------------:----------------:--------
adminRoot        : local-backend  : true
ads-truststore   : local-backend  : true
backup           : local-backend  : true
config           : local-backend  : true
load-bal-we1     : load-balancing : true
monitor          : local-backend  : true
proxy-we1        : proxy-ldap     : true
proxy-we2        : proxy-ldap     : true
schema           : local-backend  : true
tasks            : local-backend  : true
```

In the example above, the workflow elements listed are the ones created by default when deploying a simple load balancing configuration using `vdp-setup`. The `proxy-we1` and `proxy-we2` are the LDAP proxy workflow elements. A load balancing workflow element (`load-bal-we1`) is also created. All other workflow elements are default workflow elements and should not be modified or deleted.

Creating Workflow Elements

To create workflow elements in interactive mode, use the `dsconfig create-workflow-element` command. If you have configured your Oracle Unified Directory proxy using `vdp-setup`, then the basic workflow elements required will already be created.

You can create the following types of workflow elements:

- proxy LDAP. For more information, see "Creating a Proxy LDAP Workflow Element" on page 82
- load balancing. For more information, see "Creating a Load Balancing Workflow Element" on page 89
- distribution. For more information, see "Creating a Distribution Workflow Element" on page 97
- DN renaming. For more information, see "To Configure DN Renaming" on page 49

To Configure DN Renaming

To configure DN renaming, you must create a DN renaming workflow element.

- **To create a DN renaming workflow element, use the `dsconfig create-workflow-element` command.**

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
 create-workflow-element \
 --type dn-renaming \
 --element-name RenameorgDN \
 --set client-base-dn:ou=myorg,dc=example,dc=com \
 --set next-workflow-element:load-bal-we1 \
 --set source-base-dn:ou=people,dc=example,dc=com \
 --set enabled:true
```

- `--set client-base-dn` indicates the client base DN, which is the workflow entry point
- `--set source-base-dn` indicates the base DN which the entries should have after transformation, which is the workflow exit point.
- `--set next-workflow-element` indicates the workflow element that will follow the DN renaming workflow element in the proxy architecture. This can be any type of workflow element.

Modifying Workflow Elements

Once you have created a workflow element, you can modify some of the properties using the `dsconfig set-workflow-element-prop` command.

▼ To Modify DN Renaming Properties

Once you have configured DN renaming, you can modify the following DN renaming properties:

- client base DN
- source base DN
- next workflow element
- black list attributes
- white list attributes

1 **(Optional) To view the current DN renaming properties, use the `dsconfig get-workflow-element-prop` command.**

2 **To modify a DN renaming property, use the `dsconfig set-workflow-element-prop` command.**

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
 set-workflow-element-prop \
 --element-name RenameorgDN \
 --set source-base-dn:ou=admin,dc=example,dc=com
```

In the example above, only the source-base-dn is modified. There is no need to specify the old source base DN. Only the new one is required.

- **To create a black list of DN attributes that should not be renamed, use the `dsconfig set-workflow-element-prop` command.**

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
 set-workflow-element-prop \
 --element-name RenameorgDN \
 --set black-list-attributes:manager
```

The attribute must have a DN type.

Configuring Plug-Ins With `dsconfig`

Plug-ins are responsible for providing custom logic in the course of processing an operation or at other well-defined points within the directory server. The `dsconfig` command is used to manage the configuration of the directory server. For information about using `dsconfig`, see "Managing the Server Configuration With `dsconfig`" on page 25.

Overview of Plug-In Types

The `dsconfig` `plugin-type` property can be used to configure a plug-in to use one or more of the numerous plug-in types supported by the server. Usually a plug-in was written to perform a specific processing action for each of its default plug-in types. For this reason, a new default plug-in type cannot be added to a plug-in's configuration without changing the plug-in's underlying source code to add support for that plug-in type. A well-written plug-in checks the plug-in types passed to it from the configuration manager when it is enabled, and fails to start if it sees a plug-in type that it does not support.

Therefore, you can only remove one or more of the default plug-in type values from a plug-in's configuration. Care should be taken when doing this, because usually a plug-in has been engineered to support its default plug-in types for a reason. Removing one or more plug-in types might endanger the safe operation of the directory server.

Most of the plug-ins support more than one type, and multiple plug-ins are sometimes defined with the same plug-in type. The order in which these plug-ins are invoked during processing is undefined. If a specific order is required (for example, if the processing performed by one plug-in depends on the result of another), you can specify the order in which the plug-ins are invoked. For more information, see "To Configure Plug-In Invocation Order" on page 54.

Modifying the Plug-In Configuration

The following sections show various examples of managing plug-in configuration using `dsconfig`. `dsconfig` uses the administration connector to access the server. All of the examples in this section assume that the administration connector is listening on the default port (4444) and that the command is accessing the server running on the local host. If this is not the case, the `--port` and `--hostname` options must be specified.

`dsconfig` always accesses the server over a secured connection with certificate authentication. If you run `dsconfig` in interactive mode, you are prompted as to how you want to trust the certificate. If you run `dsconfig` in non-interactive mode (that is, with the `-n` option) you must specify the `-X` or `--trustAll` option, otherwise the command will fail.

▼ To Display the List of Plug-Ins

This example shows a directory server configured with the current supported plug-ins. For a description of these plug-ins and their purpose, see “The Plug-In Configuration” in .

- **Use `dsconfig` to display the list of plug-ins that are currently configured.**

```
$ dsconfig -h localhost -p 4444 -D cn="Directory Manager" -w password -n \
  list-plugins
```

Depending on your installation, the output will be similar to the following.

```
Plugin                         : Type                             : enabled
-------------------------------:----------------------------------:--------
7-Bit Clean                    : seven-bit-clean                  : false
Entry UUID                     : entry-uuid                       : true
LastMod                        : last-mod                         : true
LDAP Attribute Description List : ldap-attribute-description-list : true
Password Policy Import         : password-policy-import           : true
Profiler                       : profiler                         : true
Referential Integrity          : referential-integrity            : false
UID Unique Attribute           : unique-attribute                 : false
```

The output of the command shows (from left to right):

- **Plug-in.** The name of the plug-in, usually descriptive of what it does.
- **Type.** The type of plug-in. It is possible to have more then one plug-in of a specific type.
- **Enabled.** Plug-ins can either be enabled of disabled. Disabled plug-ins remain in the server configuration but do not perform any processing.

▼ To Create a New Plug-In

The easiest way to configure plug-ins is to use `dsconfig` in interactive mode. Interactive mode walks you through the plug-in configuration, and is therefore not documented here.

This example creates a new Password Policy Import Plug-in by using `dsconfig` in non-interactive mode.

- **Run the `dsconfig` command to create and enable a new Password Policy Import plug-in.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
 create-plugin \
  --type password-policy-import --plugin-name "My Password Policy Import Plugin" \
  --set enabled:true
```

▼ To Enable or Disable a Plug-In

You can enable or disable a plug-in by setting the `enabled` property to `true` or `false`. This example disables the Password Policy Import plug-in created in the previous example.

- **Run the `dsconfig` command to disable the new Password Policy Import plug-in.**

```
$ dsconfig -h localhost -p 4444 -D cn="Directory Manager" -w password -n \
  set-plugin-prop \
  --plugin-name "My Password Policy Import Plugin" --set enabled:false
```

▼ To Display and Configure Plug-In Properties

To display the properties of a plug-in, use the `get-plugin-prop` subcommand. To change the properties of a plug-in, use the `set-plugin-prop` subcommand. This example displays the properties of the plug-in created in the previous example, then enables the plug-in and sets the default authentication password storage scheme to Salted SHA-512.

1. **Display the plug-in properties.**

```
$ dsconfig -h localhost -p 4444 -D cn="Directory Manager" -w password -n \
  get-plugin-prop \
  --plugin-name "My Password Policy Import Plugin"
```

Depending on your installation, the output will be similar to the following.

```
Property                             : Value(s)
-------------------------------------:---------
default-auth-password-storage-scheme : -
default-user-password-storage-scheme : -
enabled                              : false
```

2. **Enable the plug-in and set the default authentication password storage scheme to Salted SHA-512.**

```
$ dsconfig -h localhost -p 4444 -D cn="Directory Manager" -w password -n \
  set-plugin-prop \
  --plugin-name "My Password Policy Import Plugin" --set enabled:true\
  --set default-auth-password-storage-scheme:"Salted SHA-512"
```

3. **(Optional) Display the plug-in properties again to verify the change.**

```
$ dsconfig -h localhost -p 4444 -D cn="Directory Manager" -w password -n \
  get-plugin-prop \
  --plugin-name "My Password Policy Import Plugin"

Property                             : Value(s)
```

```
-----------------------------------:--------------
default-auth-password-storage-scheme : Salted SHA-512
default-user-password-storage-scheme : -
enabled                              : true
```

▼ To Configure Plug-In Invocation Order

By default, the order in which plug-ins are invoked is undefined. You can specify that plug-ins be invoked in a specific order by using the `set-plugin-root-prop --set` *plugin-type*`:`*value* subcommand. The *value* in this case is the plug-in order, expressed as a comma-delimited list of plug-in names. The plug-in order string should also include a single asterisk element, which is a wildcard that will match any plug-in that is not explicitly named.

This example specifies that the Entry UUID plug-in should be invoked before any other pre-operation add plug-ins.

1. **(Optional) Display the current plug-in invocation order.**

```
$ dsconfig -h localhost -p 4444 -D cn="Directory Manager" -w password -n \
  get-plugin-root-prop

Property                                      : Value(s)
----------------------------------------------:---------
plugin-order-intermediate-response            : -
plugin-order-ldif-export                      : -
plugin-order-ldif-import                      : -
plugin-order-post-connect                     : -
...
```

2. **Set the plug-in order.**

```
$ dsconfig -h localhost -p 4444 -D cn="Directory Manager" -w password -n \
  set-plugin-root-prop \
  --set plugin-order-pre-operation-add:"Entry UUID,*"
```

Note – Plug-in order values are not validated. Values that do not match defined plug-ins are ignored.

Managing the Server Configuration With Oracle Directory Services Manager

The Configuration tab of each server instance in ODSM enables you to modify elements of the server configuration. For additional information about managing the configuration that is specific to a proxy server instance, see “Managing the Proxy Configuration With ODSM” on page 117.

Select a Configuration View

The Configuration tab presents two separate views of the server configuration. To select a configuration view, click the **Select type of view** icon and select one of the following:

- **Configuration Tree.** This is the default view that is displayed and shows all of the server configuration objects for that particular server instance.
- **All Configuration Objects.** This view shows all possible configuration objects for any kind of server instance.

Display Suffix Properties

In the Configuration Tree view, the Configuration tab displays all of the suffixes that have been configured on the server. You cannot edit a suffix in this view but you can see the list of network groups and workflows that expose that suffix.

You can display suffix properties as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Configuration** tab.
3. Expand the **Core Configuration** element.
4. Click on the suffix whose properties you want to display.

   The suffix properties are displayed in the right hand pane.

For more information about network groups and workflows, and how they relate to the configured suffixes, see Chapter 1, "Overview of Oracle Unified Directory," in *Oracle Fusion Middleware Deployment Planning Guide for Oracle Unified Directory*.

Modify a Network Group

Network groups are the entry point of all client requests that are handled by the Oracle Unified Directory. The properties of a network group indicate how client requests are directed.

You can modify the properties of a network group, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Configuration** tab.
3. Expand the **Core Configuration** element.
4. Expand the suffix whose network group you want to modify.

5. Click on the network group.

   The properties of the network group are displayed in the right hand pane
6. You can modify the following properties of the network group:
   - **Enabled.** Select or deselect this check box to enable or disable the network group. If you disable a network group, no client requests can be handled by that network group. If you disable the only configured network group, you effectively stop client applications from accessing the backend.
   - **Security Mandatory.** Select this option if you require clients to use a secure connection to access this network group. By default, a secure connection is not required.
   - **Priority.** In the event of multiple network groups, set priority for this network group. Client requests are handled by the network group with the highest priority, for which the criteria are met. The highest priority a network group can have is 0.
   - **Allowed auth method.** Specify the authentication method/s that are allowed between the client and the network group.
   - **Allowed protocol.** Specify the protocol/s that are allowed for client connections. If you do not specify a protocol, all protocols are allowed.
   - **Allowed BindDN.** Click the Add icon to add one or more bind DNs that are allowed to connect to this network group. Click the Delete icon to remove the bind DNs that should not be accepted by the network group.
   - **Allowed Client.** Click the Add icon to add one or more clients that are authorized to access this network group. Clients can be expressed by their IP addresses or their names. If no allowed client list is provided, all clients are allowed, unless they are specifically listed on the denied client list.
   - **Denied Client.** Click the Add icon to add one or more clients that are prohibited from accessing this network group. Clients can be expressed by their IP addresses or their names. If no denied client list is provided, all clients are allowed, unless a limitation is set by using the allowed client list.
   - **Workflow.** Click the Add icon to add one or more workflows that can be accessed through this network group.
   - **QoS Policy.** Select a quality of service policy for this network group. For more information, see “Creating a Network Group Quality of Service Policy” on page 42.

For more information about network groups and workflows, and how they relate to the configured suffixes, see Chapter 1, “Overview of Oracle Unified Directory,” in *Oracle Fusion Middleware Deployment Planning Guide for Oracle Unified Directory*.

Modify a Workflow Element

A workflow element is the key building block of a workflow process. Workflow elements define how client requests that are sent to the server are treated. In a deployment that includes a proxy server, workflow elements are configured for load balancing or distribution. In a deployment that does not include a proxy server, workflow elements are configured directly for each backend.

You can modify the properties of an existing workflow element, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Configuration** tab.
3. Expand the **Core Configuration** element.
4. Expand the suffix whose workflow element you want to modify.
5. Expand the network group whose workflow element you want to modify.
6. Click on the workflow element, for example `userRoot`, `distrib-we`, or `load-bal-we1`.

   The properties of the workflow element are displayed in the right hand pane
7. The properties that you can edit depend on the type of workflow element that is configured.

   For a backend workflow element, you can modify the following basic properties:

   - **Enabled.** Select or deselect this check box to enable or disable the workflow element. If you disable a workflow element, you effectively stop client applications from accessing that backend.
   - **Writability Mode.** Select **Enabled** if you want clients to be able to write to the backend. Select **Disabled** if you do not want clients to be able to write to the backend. Select **Internal Only** if you want replication changes and internal operations to be written to the backend, but you do not want client applications to write to the backend directly.
   - **Base DN.** Specify the base DN(s) for the data that the backend handles. A single backend can be responsible for more than one base DN.

   You can also modify the properties of the database and its associated indexes. For a comprehensive list of all configurable properties, and their allowed values, see the *Oracle Fusion Middleware Configuration Reference for Oracle Unified Directory*.

   For a distribution workflow element, you can modify the following properties:

   - **Enabled.** Select or deselect this check box to enable or disable the workflow element. If you disable a workflow element, you effectively stop client applications from accessing all partitions that are handled by that distribution element.
   - **Distribution Attribute.** Enter the name of the attribute by which you want client requests to be distributed.

- **Force DN Modify.** Specifies whether a modify DN operation is always accepted by the server. If this option is selected, you must configure distribution with a global index catalog because when entries are "moved" the distribution algorithm might not be able to locate them properly.
- **Global Index Catalog.** Select the global index catalog that you want to use with this distribution element. The referenced global index catalog must be enabled before it appears for selection.

For a load balancing workflow element, you can modify the following properties:

- **Enabled.** Select or deselect this check box to enable or disable the workflow element. If you disable a workflow element, you effectively stop client applications from accessing all partitions that are handled by that load balancing element.
- **Routes.** Click the Add icon to add a new load balancing route. For information about configuring the specific route properties, see the *Oracle Fusion Middleware Configuration Reference for Oracle Unified Directory*.

Modify the General Server Configuration

Certain elements of the general server configuration can be modified by using ODSM. In the Configuration Tree view, the Configuration tab displays all of the suffixes that have been configured on the server. You cannot edit a suffix in this view but you can see the list of network groups and workflows that expose that suffix.

You can modify the server configuration by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in “Connecting to the Server From Oracle Directory Services Manager” on page 188.
2. Select the **Configuration** tab.
3. Expand the **General Configuration** element.
4. Click on the Server whose properties you want to modify.

   The properties are displayed in the right hand pane.
5. You can modify the following properties:
   - **Default Password Policy**
   - **Etime Resolution**
   - **Idle Time Limit**
   - **Max Allowed Client Connections**
   - **Reject Unauthenticated Requests**
   - **Size Limit**
   - **Writability Mode**
   - **Work Queue Properties**

- **Number of Worker Threads**
- **Maximum Work Queue Capacity**

For a comprehensive list of all configurable properties, and their allowed values, see the *Oracle Fusion Middleware Configuration Reference for Oracle Unified Directory*.

Modify a Connection Handler

Connection handlers are responsible for accepting connections from clients, reading and parsing requests submitted by the clients, ensuring that they are processed by the server, and sending the corresponding responses back to the client. The connection handler manages all communication with the client and therefore needs to implement support for the associated protocol.

You can configure all of the connection handler properties by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Configuration** tab.
3. Expand the **General Configuration** element.
4. Expand the Connection Handlers element.
5. Click on the connection handler whose properties you want to modify.

   The properties are displayed in the right hand pane.

For a comprehensive list of all configurable properties, and their allowed values, see the *Oracle Fusion Middleware Configuration Reference for Oracle Unified Directory*.

Modify Logger Properties

Oracle Unified Directory provides several log publishers, or loggers, by default. Any number of loggers of any type can be defined and active at any time. This means that you can log to different locations or different types of repositories and that you can specify various sets of criteria for what to include in the logs.

You cannot create a new log publisher with ODSM, but you can modify the properties of an existing log publisher.

To configure logger properties by using ODSM, complete the following steps:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Configuration** tab.

3. Expand the **General Configuration** element.
4. Expand the **Logging** element.
5. Expand the **Loggers** element and click on the logger whose properties you want to modify.

   The properties of the logger are displayed in the right hand pane. The configurable properties will depend on the type of logger that you have selected. For a comprehensive list of all configurable properties and their allowed values, see the *Oracle Fusion Middleware Configuration Reference for Oracle Unified Directory*.

Modify Log Rotation Policies

Log rotation policies dictate how often log files are rotated, that is to say, how long log files are kept based on various criteria.

Oracle Unified Directory provides the following four log rotation policies:

- 24 Hours time limit rotation policy. By default, this policy sets the rotation interval to one day. Time of day can be configured.
- 7 Days time limit rotation policy. By default, this policy sets the rotation interval to one week. Time of day can be configured.
- Fixed time limit rotation policy. By default, this policy sets the time of day that log files are to be rotated, to one minute before midnight.
- Size time limit rotation policy. By default, this policy sets a maximum size that log files can reach to 100 Mb, before the log file is rotated.

The type of log rotation policy that is enabled by default depends on the logger type.

You can configure log rotation policies by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Configuration** tab.
3. Expand the **General Configuration** element.
4. Expand the **Logging** element.
5. Select the **Rotation Policies** element and modify the required properties.

You can also add a new rotation policy or delete an existing rotation policy by clicking the Add or Delete icons on this page, and completing the required information.

Modify Log Retention Policies

Log retention policies dictate size and space limits for log files. Oracle Unified Directory provides the following three log retention policies by default:

- File count retention (file-count). By default, this policy sets the maximum number of log files to 10, for a specified type of log file.
- Free disk space retention (free-disk-space). By default, this policy sets a minimum remaining free disk space limit to 500 Mb, for a specified type of log file.
- Size limit retention (size-limit). By default, this policy sets the disk spaced used to a maximum of 500 Mb, for a specified type of log file. By default, the log retention policy enabled is File count retention.

You can configure log retention policies by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Configuration** tab.
3. Expand the **General Configuration** element.
4. Expand the **Logging** element.
5. Select the **Retention Policies** element and modify the required properties.

You can also add a new retention policy or delete an existing retention policy by clicking the Add or Delete icons on this page, and completing the required information.

Configure Alerts

Oracle Unified Directory provides mechanisms for transmitting alert and account status notifications by means of JMX extensions or SMTP extensions. You can configure the directory server to send alert notifications when an event occurs during processing. Typical server events include server starts and shut downs, or problems that are detected by the server, such as an attempt to write to the configuration file. You can also receive account status notifications when an event occurs during password policy processing, such as when accounts are locked out, accounts expire, passwords expire, and so on.

You can use ODSM to configure the JMX alert handler, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Configuration** tab.
3. Expand the **General Configuration** element.
4. Expand the **Alert Handlers** element.
5. Select the **JMX Alert Handler** element and modify the required properties.

Managing Administration Traffic to the Server

The administration connector is based on the LDAP protocol and uses LDAP over SSL by default. All command-line utilities that access the administrative suffixes use the administration connector. This includes the following commands:

- `backup`
- `dsconfig`
- `dsreplication`
- `export-ldif`
- `import-ldif`
- `manage-account`
- `manage-tasks`
- `restore`
- `status`
- `stop-ds`
- `uninstall`
- `vdp-uninstall`

The administration connector is always present and enabled. You cannot disable or delete the connector but you can use `dsconfig` to manipulate the following properties of the connector:

- `listen-address`. The address on which the server listens for administration traffic.
- `listen-port`. The default port of the administration connector is 4444. You can change this port during setup if required. If you use the default port, you do not need to specify a port when running the administration commands (the default port is assumed). If you change the port, you must specify the new port when running the administration commands.
- **Security-related properties.** Traffic using the administration connector is always secured. As with the LDAPS connection handler, the administration connector is configured with a self-signed certificate during server setup. This self-signed certificate is generated the first time the server is started. You can manage the administration connector certificate using external tools, such as `keytool`.

  The security-related properties include the following:

  - `ssl-cert-nickname`
  - `key-manager-provider`
  - `trust-manager-provider`

  When you run the administration commands, you are prompted as to how you want to trust the certificate. If you run the administration commands in non-interactive mode, you must specify the `-X` or `--trustAll` option to trust the certificate, otherwise the command will fail.

Accessing Administrative Suffixes

The *administrative suffixes* include the following:

- `cn=config`
- `cn=monitor`
- `cn=tasks`
- `cn=backups`
- `cn=ads-truststore`
- `cn=schema`
- `cn=admin data`

In general, direct LDAP access to the administrative suffixes (using the `ldap*` utilities) is discouraged, with the exception of the `cn=monitor` suffix. In most cases, it is preferable to use the dedicated administrative command-line utilities to access these suffixes.

If you must use the `ldap*` commands to access the administrative suffixes, you should use the administration connector port (with the `--useSSL` or `-Z` option). Using the administration connector ensures that monitoring data is not polluted and that server administration takes precedence over user traffic. The same recommendations apply if you are accessing the administrative suffixes using an LDAP browser.

▼ To Configure the Administration Connector

This example displays the default properties of the administration connector, and changes the listen port of the connector to `5555`.

1 **View the default properties of the administration connector, using the `dsconfig` command.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
get-administration-connector-prop
```

The output is similar to the following.

```
Property                : Value(s)
------------------------:---------------
key-manager-provider    : Administration
listen-address          : 0.0.0.0
listen-port             : 4444
ssl-cert-nickname       : admin-cert
trust-manager-provider  : Administration
```

2 **Change the listen port, using the `dsconfig` command.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
 set-administration-connector-prop --set listen-port:5555
```

Note – You must restart the server for changes to this property to take effect.

Configuring Commands As Tasks

Certain command-line utilities can be used to schedule tasks to run within the directory server as well as to perform their functions locally. Tasks that can be scheduled support the options used to connect to the directory server to interact with the task back end.

Commands That Can Schedule Tasks

The following utilities can schedule tasks:

- `import-ldif`
- `export-ldif`
- `backup`
- `restore`
- `stop-ds`
- `stop-ds --restart`
- `rebuild-index`
- `dsreplication purge-historical`

For Oracle Unified Directory proxy, only the `stop-ds` command can be scheduled to run as a task.

Controlling Which Tasks Can Be Run

You can control the tasks that can be run by setting the `allowed-tasks` advanced global configuration property. By default, all tasks supported by the tasks back end are allowed. To prevent a task from being run, remove its value from the `allowed-tasks` property. For example, to prevent the server from being stopped using a task, run the following command:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-global-configuration-prop \
  --remove allowed-task:org.opends.server.tasks.ShutdownTask
```

Scheduling and Configuring Tasks

The procedures in this section indicate how to schedule a task, how to configure task notification, and how to configure task dependencies. All of the examples in this section assume that the commands are being run on the local host, using the default administration port (4444), and the local certificate configuration. If you are running the commands remotely, you might need to specify the certificate parameters. For more information, see "Managing Administration Traffic to the Server" on page 62.

▼ To Schedule a Task

To schedule a task, invoke the required utility with the options used to connect to the directory server, an optional start time, and any options that will be used as arguments for the task execution.

If the `-t` or `--start` option is provided, the utility exits immediately after scheduling the task. To schedule a task for immediate execution and have the utility exit immediately after scheduling the task, specify `0` as the value for the start time.

If the `-t` or `--start` option is omitted, the utility schedules the task for immediate execution and tracks the task's progress, printing log messages as they are available and exiting when the task has completed.

● **Schedule the `export-ldif` task to start at 12:15 on September 24th, 2009.**

```
$ export-ldif -D "cn=directory manager" -w password \
  -l /ldif-files/example.ldif --start 20090924121500 -n userRoot
```

▼ To Schedule a Recurring Task

To schedule a recurring task, invoke the required utility with the options used to connect to the directory server, specifying the recurring task schedule, and any options that will be used as arguments for the task execution. The following commands can be scheduled as recurring tasks:

- `import-ldif`
- `export-ldif`
- `backup`
- `restore`
- `rebuild-index`
- `dsreplication purge-historical`

The `--recurringTask` option specifies a recurring task schedule that is used by the task scheduler to determine when and how often a recurring task should run. The pattern used to specify the schedule is based on UNIX `crontab`(5) scheduling patterns and rules and includes the following five integer pattern fields, separated by blank spaces:

- Minute [0,59]
- Hour [0,23]
- Day of the month [1,31]
- Month of the year [1,12]
- Day of the week [0,6] (with 0=Sunday)

Each of these patterns can be either an asterisk (meaning all valid values), an element, or a list of elements separated by commas. An element is either a number or two numbers separated by a dash (meaning an inclusive range).

The task scheduler spawns regular task iterations according to the specified schedule.

- **Schedule the task using the `--recurringTask` option.**

  The following command schedules a backup task to execute at the beginning of every hour.

```
$ backup -D "cn=directory manager" -w password --recurringTask \
  "00 * * * *" --backupDirectory /example/backup --backUpAll --backupID "Hourly Backup"
```

Example 2–1 Recurring Task Example

This example shows an export task that is scheduled to run every 15 minutes, every Sunday.

```
$ export-ldif -D "cn=directory manager" -w password --recurringTask \
  "0,15,30,45 * * * 0" -l PATH/export-recurring.ldif -n userRoot
Recurring Export task  ExportTask-a614e45d-6ba5-4c29-a8e1-d518c20e46ab scheduled
successfully
```

▼ To Configure Task Notification

The task scheduling options of a utility enable you to notify an administrator when a task completes or if an error occurs during the task's execution. To use the notification facility, an SMTP server must be configured for the directory server.

1. **Specify an SMTP server by setting the `smtp-server` global configuration property.**

   The following command configures the SMTP server named `mailserver.example.com`:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-global-configuration-prop \
  --set smtp-server:mailserver.example.com
```

2. **Use the `completionNotify` and `errorNotify` options to specify the email address to which the task notification should be sent.**

   The following command schedules a `backup` task and specifies that `admin@example.com` should be notified when the task completes, or when an error occurs:

```
$ backup -D "cn=directory manager" -w password -a -d /tmp/backups \
  --start 20080924121500 --completionNotify admin@example.com \
  --errorNotify admin@example.com
Backup task 20080924121500 scheduled to start Sep 24, 2008 12:15:00 PM SAST
```

▼ To Configure Task Dependencies

Certain tasks might require that another task be completed before the task begins. The task dependency options of a utility enable you to specify that the task depends on another task, and what the task should do should the other task fail.

- **Schedule the task and specify the `dependency` and `failedDependencyAction`.**

  The following example schedules a backup task that depends on another task, and specifies that the backup should be canceled should the other task fail:

  ```
  $ backup -D "cn=directory manager" -w password -a -d /tmp/backups \
    --start 2008102914530410 --dependency 20080924121500 \
    --failedDependencyAction cancel
  Backup task 2008102914530410 scheduled to start Oct 29, 2008 14:53:04 PM SAST
  ```

Managing and Monitoring Scheduled Tasks

The `manage-tasks` utility can be used to obtain a list of scheduled tasks, to display task status, and to cancel scheduled tasks. The following procedures provide examples of managing scheduled tasks. For more information, see "manage-tasks" in *Oracle Fusion Middleware Command-Line Usage Guide for Oracle Unified Directory*.

▼ To Obtain Information About Scheduled Tasks

1 Display a summary of all scheduled tasks.

```
$ manage-tasks -D "cn=directory manager" -w password -n -s
ID                Type    Status
------------------------------------------------
2008100912550010  Backup  Completed successfully
2008100912554710  Backup  Completed successfully
2008100912560510  Backup  Waiting on start time
2008100912561410  Backup  Waiting on start time
```

2 Display additional information on a particular task, specified by its task ID.

```
$ manage-tasks -D "cn=directory manager" -w password -n -i 2008100912550010

Task Details
------------------------------------------------------
ID                          2008100912550010
Type                        Backup
Status                      Completed successfully
Scheduled Start Time        Immediate execution
Actual Start Time           Oct 9, 2008 12:55:00 PM SAST
Completion Time             Oct 9, 2008 12:55:01 PM SAST
Dependencies                None
Failed Dependency Action    None
Email Upon Completion       None Specified
Email Upon Error            None Specified

Backup Options
----------------------------
Backup All        true
Backup Directory  ../backups

Last Log Message
------------------------------------------------------------------------------
```

```
[09/Oct/2008:12:55:01 +0200] severity="NOTICE" msgCount=4 msgID=10944795
message="The backup process completed successfully"
```

▼ To Cancel a Scheduled Task

● **Run the `manage-tasks` utility with the `-c` or `--cancel` option.**

The following command cancels a particular task, specified by its task ID:

```
$ manage-tasks -D "cn=directory manager" -w password -n -c 2008100912561410
```

▼ To Cancel a Recurring Task

You can cancel an entire recurring task, in which case both the recurring task and its next scheduled iteration are canceled. Alternatively, you can cancel only the next scheduled task iteration, in which case future recurring task iterations will be spawned by the task scheduler.

1 **Use the manage-tasks command to display the summary of scheduled tasks.**

```
$ manage-tasks -D "cn=directory manager" -w password -n -s

 ID                                              Type    Status

----------------------------------------------------------------------------
 Hourly Backup                                   Backup  Recurring
 Hourly Backup - Wed Jan 14 13:00:00 SAST 2009  Backup  Waiting on start time
```

2 **Run the `manage-tasks` utility with the `-c` or `--cancel` option.**

- **Cancel the entire recurring task by specifying its task ID.**

  ```
  $ manage-tasks -D "cn=directory manager" -w password -n -c "Hourly Backup"
  Task Hourly Backup canceled
  ```

- **Cancel the next scheduled task by specifying its task ID.**

  ```
  $ manage-tasks -D "cn=directory manager" -w password -n \
    -c "Hourly Backup - Wed Jan 14 13:00:00 SAST 2009 "
  Task Hourly Backup - Wed Jan 14 13:00:00 SAST 2009  canceled
  ```

Deploying and Configuring the DSML Gateway

The Directory Services Markup Language (DSML) is a SOAP-based mechanism that can communicate with directory servers using an XML-based representation instead of the LDAP protocol. Oracle Unified Directory 11g Release 1 (11.1.1) supports the use of DSML through a web application that acts as a DSML-to-LDAP gateway, in which clients communicate with the gateway using DSML, but the gateway communicates with the directory server through LDAP.

Deploying the DSML Gateway

The DSML gateway can be deployed like any other web application, in most common application containers. The following section describes how to deploy the DSML gateway in Oracle WebLogic Server 10.3.5, on a UNIX system.

Deploying the DSML Gateway in Oracle WebLogic Server

This section assumes that you have Oracle WebLogic Server installed. If you do not, install Oracle WebLogic Server, as described in “Installing Oracle WebLogic Server” in *Oracle Fusion Middleware Installation Guide for Oracle Unified Directory*.

Configuring WebLogic Server for the DSML Gateway

1. Run the configuration wizard from the following location:

   ```
   $ /OUD Base Location Home/oracle_common/common/bin/config.sh
   ```
2. On the Welcome screen, select **Create a new WebLogic domain** and click **Next**.
3. On the Select Domain Source screen, accept the default selection (**Basic WebLogic Server Domain**) and click **Next**.
4. On the Specify Domain Name and Location screen, type a domain name and specify its location.

   A new WebLogic domain is created in this location. The DSML gateway will be deployed into this domain.
5. On the Configure Administrator User Name and Password screen, type a name and password for the user who will administer this domain.

   The password must be at least eight characters and must contain at least one number or special character. Confirm the password and click Next.

   Make a note of these details as you will need them to start or restart the WebLogic domain.
6. On the Configure Server Start Mode screen, select Production Mode.

   Select a valid JDK (at least Java 1.6) and click Next.
7. On the Optional Configuration screen, click Next.
8. On the Configuration Summary screen, verify the domain details and click Create.
9. On the Creating Domain Screen, click Done.
10. Set the Java options for the WebLogic Server.

```
$ export JAVA_OPTIONS=-Djavax.xml.soap.MessageFactory=weblogic.xml.saaj.MessageFactoryImpl
```

   If you do not set the Java options, an error will be returned.

11. Set the `enforce-valid-basic-auth-credentials` flag in the configuration file of the WebLogic domain (*domain-home*`/config/config.xml`, where *domain-home* is the domain that you created in Step 4).

    For example, edit the file *OUD-Base-Location-Home*`/user_projects/domains/base_domain/config/config.xml` by adding the following line to the `security-configuration` element:

    ```
    <enforce-valid-basic-auth-credentials>false</enforce-valid-basic-auth-credentials>
    ```

    For more information, see `http://download.oracle.com/docs/cd/E12840_01/wls/docs103/security/thin_client.html#understanding_basic_atn`.

12. Start the WebLogic Server by running *domain-home*`/bin/startWebLogic.sh` (where *domain-home* is the domain that you created in Step 4.

    For example:

    ```
    $ OUD-Base-Location-Home/user_projects/domains/base_domain/bin/startWebLogic.sh
    ```

13. Deploy the DSML Gateway WAR file, as described in the following section.

Deploying the DSML Gateway WAR File

1. Create a `DSML` directory in the `addons` directory and change to that directory.

    ```
    $ cd OUD-Base-Location-Home/ORACLE_HOME/addons
    $ mkdir DSML
    $ cd DSML
    ```

2. Explode the DSML gateway WAR file.

    ```
    $ jar xvf ../DSML.war
    ```

3. Edit the DSML configuration, if required.

    The `WEB-INF/web.xml` file includes initialization parameters that can be used to specify the address (in the `ldap.host` parameter) and port number (in the `ldap.port` parameter) of the directory server to which DSML requests should be forwarded.

    By default, the DSML gateway is configured to communicate with a directory server on the same system, that is, `localhost`) on port `389`. If you need to change the host address and port number, edit the `web.xml` file and restart the web container.

4. In a browser window, connect to the WebLogic Administration Console (for example `http://`*hostname*`:7001/console`), where *hostname* is the host on which WebLogic Server is running.

    Use the administrator user name and password that you established in Step 5 of the previous procedure.

5. Follow the WebLogic Server Documentation to install a web application (`http://download.oracle.com/docs/cd/E12840_01/wls/docs103/ConsoleHelp/taskhelp/web_applications/InstallWebApplications.html`).
   - In step 4 of the procedure, provide the path to the exploded application (*OUD-Base-Location-Home*/*ORACLE_HOME*/`addons/DSML`).
   - In step 6 of the procedure, select **Install this deployment as an application**.
   - Accept the default values for the other steps.
6. On the left panel of the Administration Console, click **Deployments**.
7. Select the checkbox next to the DSML application and click **Start** then **Servicing all requests**.
8. On the Start Deployments panel, click **Yes**.
9. The DSML application is now deployed and available for use.

Confirming the DSML Gateway Deployment

After the DSML gateway has been deployed and configured, you can communicate with it by using any DSMLv2 client. The following sections describe two ways to accomplish this:

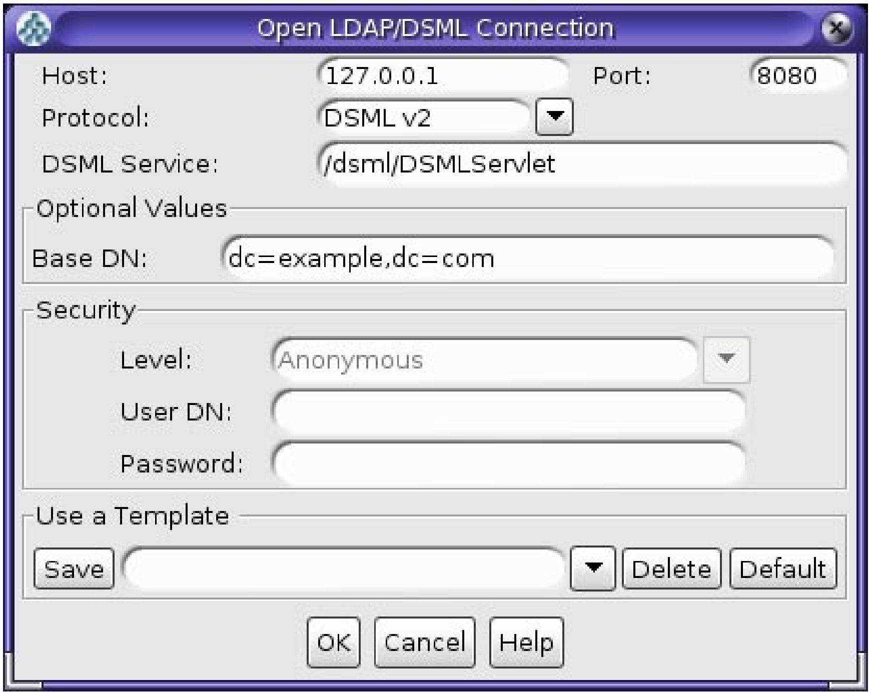
- "To Confirm the DSML Gateway Deployment with JXplorer" on page 71
- "Confirming the DSML Gateway Deployment with the Directory Server Resource Kit" on page 73

▼ To Confirm the DSML Gateway Deployment with JXplorer

The JXplorer tool is a Java-based LDAP browser that can be used to browse, search, and edit the contents of an Oracle Unified Directory instance. This tool can communicate using both LDAP and DSML. Although JXplorer's DSML support does not allow authentication (and therefore is restricted to the set of operations available to anonymous users), it is still possible to use it to verify that the DSML gateway is functioning as expected.

1 **Start JXplorer and chose the Connect option from the File menu.**

The Open LDAP/DSML Connection window opens with fields for connection information. The following figure shows typical entries.



Host: 127.0.0.1

Port: 8080

Protocol: DSML v2

DSML Service: /dsml/DSMLServlet

Base DN: dc=example,dc=com

Level: Anonymous

User DN:

Password:

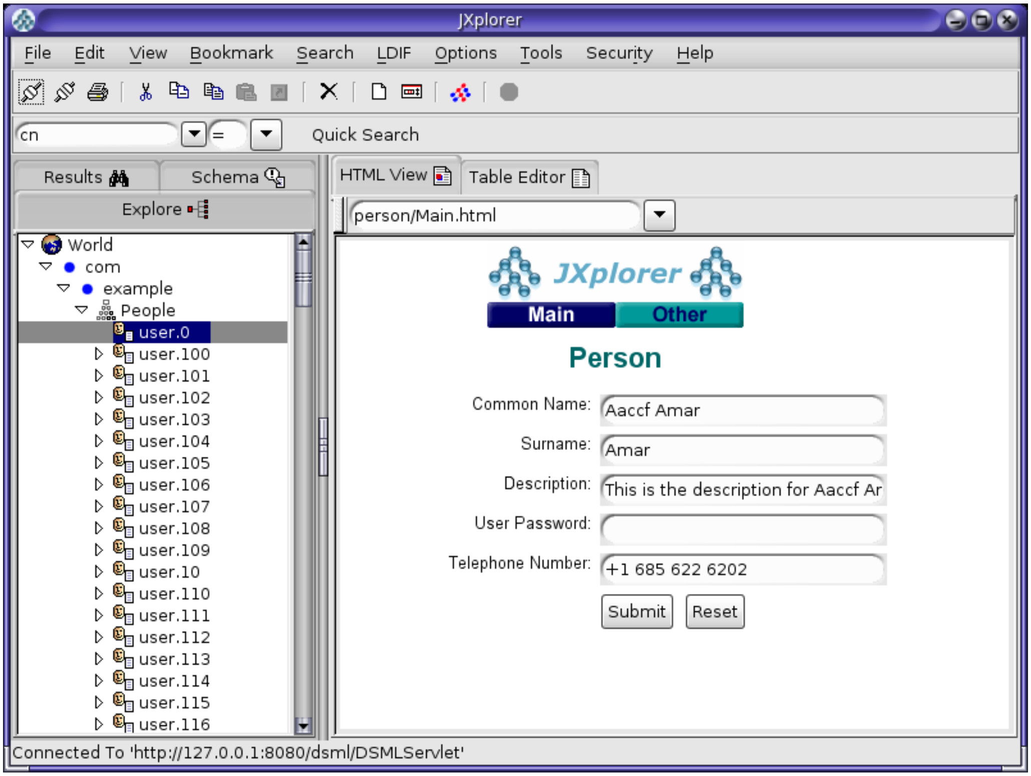
2 **Enter the address and port number of the Web application on which the DSML gateway is running.**

3 **Choose `DSMLv2` from the Protocol list.**

4 **Specify the path to the DSMLServlet in the DSML Service field.**

5 **Provide an appropriate base DN value for your directory.**

6 **Click the OK button to connect the directory server and display a JXplorer window where you can search and browse the tree (with the limitations imposed for anonymous users).**



Common Name: Aaccf Amar

Surname: Amar

Description: This is the description for Aaccf Ar

User Password:

Telephone Number: +1 685 622 6202

Connected To 'http://127.0.0.1:8080/dsml/DSMLServlet'

Confirming the DSML Gateway Deployment with the Directory Server Resource Kit

The Directory Server Resource Kit (DSRK) is a collection of utilities that may be used in conjunction with directory servers. It is originally intended for use with Oracle Directory Server Enterprise Editionr, but in most cases the applications also work with Oracle Unified Directory. The most recent version of the DSRK is included as part of DSEE 6.0, and it contains `dsmlsearch` and `dsmlmodify` tools that can interact with a directory server using DSML rather than LDAP.

Note that even though an older version of these DSML tools was provided with earlier versions of the Directory Server Resource Kit, the version provided with DSEE 6 is strongly recommended because it is easier to use.

Using the dsmlsearch Command

The `dsmlsearch` command is a DSML-based counterpart to the `ldapsearch` command. `dsmlsearch` operates in a similar manner to `ldapsearch` but there are certain key differences. To see usage information, invoke the command with no arguments, as in the following example:

```
$ ./dsmlsearch
usage: dsmlsearch -h http://host:port -b basedn [options] filter [attributes...]
where:
-h hostURL URL of the directory server
-b basedn  base dn for search
-D binddn  bind dn
-w passwd  bind password (for simple HTTP authentication)
use "-w - " to prompt for a password
-j pwfile  file where password is stored
-s scope   specify the scope of the search
baseObject - For searching only the base entry
singleLevel - For searching only the children
wholeSubtree - For searching the base entry and all childrens
-a deref   specify how aliases are deferenced
neverDerefAliases - Aliases are never dereferenced
derefFindingBaseObj - Dereferenced when finding the base DN
derefAlways - Dereferenced when finding below the base DN
-l seconds specify the maximum number of seconds to wait for the search
-z number  specify the maximum number of entries to return for the search
-f file    specify the name of the file containing the search filter
```

The `dsmlsearch` command differs in usage from `ldapsearch`:

- The `-h` argument is used to provide a URL to use to access the server. It should include the host and port number, as well as the URI for the gateway servlet (for example, `http://127.0.0.1:8080/dsml/DSMLServlet`).
- The `-b` argument is used to specify the search scope, but note that the values you provide are different (`baseObject`instead of `base`, `singleLevel`instead of `one`, and `wholeSubtree`instead of `sub`).
- The results are output in DSML format, which is not as user-friendly or human-readable as the LDIF output provided by `ldapsearch`.

An example usage of this tool is as follows. Note that the DSML output does not contain any line breaks, but line breaks are added here for readability.

```
$ ./dsmlsearch -h http://127.0.0.1:8080/dsml/DSMLServlet \
-b "dc=example,dc=com" -s baseObject \"(objectClass=*)"
<SOAP-ENV:Envelope xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/">
<SOAP-ENV:Body><dsml:batchResponse xmlns:dsml="urn:oasis:names:tc:DSML:2:0:core">
<dsml:searchResponse><dsml:searchResultEntry dn="dc=example,dc=com"><dsml:attr
name="objectClass"><dsml:value>domain</dsml:value><dsml:value>top</dsml:value>
</dsml:attr><dsml:attr name="dc"><dsml:value>example</dsml:value></dsml:attr>
</dsml:searchResultEntry><dsml:searchResultDone><dsml:resultCode code="0"/>
```

```
</dsml:searchResultDone></dsml:searchResponse></dsml:batchResponse>
</SOAP-ENV:Body></SOAP-ENV:Envelope>
```

Using the dsmlmodify Utility

dsmlmodify utility is a DSML-based counterpart to the ldapmodify command, and it can perform add, delete, modify, and modify DN operations over DSML. To see the usage information for this tool, run it with no arguments, as shown in this example:

```
$ ./dsmlmodify
usage: dsmlmodify -h http://host:port [options] -f file
where:
-h hostURL URL of the directory server
-D binddn  bind dn
-w passwd  bind password (for simple HTTP authentication)
use "-w - " to prompt for a password
-j pwfile  file where password is stored
-f file    specify the name of the file containing
the modifications
```

As with the dsmlsearch utility, the -h argument specifies a URL, and the output is returned in DSML form. Unlike ldapmodify, the dsmlmodify tool does not accept the changes through standard input. Changes must be specified in a file, and that file must be in DSML format instead of than LDIF, and the changes cannot contain an outer batchRequest wrapper. The following example shows a typical input file.

```
<addRequest dn="uid=test.user,dc=example,dc=com">
<attr name="objectClass">
<value>top</value>
<value>person</value>
<value>organizationalPerson</value>
<value>inetOrgPerson</value>
</attr>
<attr name="uid">
<value>test.user</value>
</attr>
<attr name="givenName">
<value>Test</value>
</attr>
<attr name="sn">
<value>User</value>
</attr>
<attr name="cn">
<value>Test User</value>
</attr>
<attr name="userPassword">
<value>password</value>
</attr>
</addRequest>
<modifyRequest dn="uid=test.user,dc=example,dc=com">
<modification name="description" operation="replace">
<value>This is the new description</value>
</modification>
</modifyRequest>
```

```
<modDNRequest dn="uid=test.user,dc=example,dc=com" newrdn="cn=Test User"
 deleteoldrdn="false" newSuperior="ou=People,dc=example,dc=com" />
<delRequest dn="cn=Test User,ou=People,dc=example,dc=com" />
```

The following example shows the output from applying these changes. Line breaks have been added to the output to make it more readable:

```
$ dsmlmodify -h http://127.0.0.1:8080/dsml/DSMLServlet \
  -D "cn=Directory Manager" -w password -f /tmp/test.dsml
<SOAP-ENV:Envelope xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/">
<SOAP-ENV:Body><dsml:batchResponse xmlns:dsml="urn:oasis:names:tc:DSML:2:0:core">
<dsml:addResponse><dsml:resultCode code="0"/></dsml:addResponse>
<dsml:modifyResponse><dsml:resultCode code="0"/></dsml:modifyResponse>
<dsml:modDNResponse><dsml:resultCode code="0"/></dsml:modDNResponse>
<dsml:delResponse><dsml:resultCode code="0"/><dsml:errorMessage>The number of
entries deleted was 1</dsml:errorMessage></dsml:delResponse></dsml:batchResponse>
</SOAP-ENV:Body></SOAP-ENV:Envelope>

$ dsmlmodify -h http://localhost:8080/dsml/DSMLServlet \
  -D "cn=directory manager" -w password -f /tmp/dsml.ldif
<SOAP-ENV:Envelope xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/">
<SOAP-ENV:Body><batchResponse xmlns="urn:oasis:names:tc:DSML:2:0:core">
<addResponse><resultCode code="0"/></addResponse>
<modifyResponse><resultCode code="0"/></modifyResponse>
<modDNResponse><resultCode code="0"/></modDNResponse>
<delResponse><resultCode code="0"/></delResponse></batchResponse>
</SOAP-ENV:Body></SOAP-ENV:Envelope>
```

CHAPTER 3

Configuring the Proxy Components

This chapter describes how to configure those server elements that are specific to an Oracle Unified Directory proxy server instance, by using either the `dsconfig` command or the Oracle Directory Services Manager (ODSM) interface. The chapter covers the following topics:

- "Managing the Proxy Configuration With `dsconfig`" on page 77
- "Managing the Proxy Configuration With ODSM" on page 117

For more information about the `dsconfig` command, see "Managing the Server Configuration With `dsconfig`" on page 25.

For more information about ODSM, see Chapter 6, "Managing Oracle Unified Directory With Oracle Directory Services Manager."

Managing the Proxy Configuration With `dsconfig`

Configuring an LDAP Proxy

In order to connect to a remote LDAP directory server, the Oracle Unified Directory proxy needs to have the following two elements configured:

- LDAP server extension
- LDAP proxy workflow element

This topic covers all the administration tasks possible for a proxy LDAP workflow element and LDAP server extension once a Oracle Unified Directory proxy is installed.

The following examples describe how to configure the LDAP server extensions using the `dsconfig` command.

All the commands in the following procedures specify the proxy hostname (-h), the proxy admin port (-p), the bind DN (-D), and the bind password (-w). The following examples use the -X option to trust all certificates.

Listing LDAP Proxy Elements

You can list the following LDAP proxy elements:

- LDAP server extensions. See "Listing LDAP Server Extensions" on page 78.
- LDAP proxy workflow element. See "Listing Proxy Workflow Elements" on page 78.

Listing LDAP Server Extensions

To display all the LDAP server extensions associated to your deployment, use the dsconfig list-extensions command. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  list-extensions
```

The extensions will be listed, along with the extension type.

```
Extension  : Type
-----------:--------------------
gi-catalog : global-index-catalog
proxy1     : ldap-server
proxy2     : ldap-server
```

The extensions with type ldap-server are the LDAP server extensions. You should have one LDAP server extension for each remote LDAP server configured with Oracle Unified Directory proxy.

Listing Proxy Workflow Elements

To display all the proxy workflow elements associated to your deployment, use the dsconfig list-workflow-elements command. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  list-workflow-elements
```

The proxy workflow elements are the ones with the type proxy-ldap.

Viewing LDAP Proxy Element Properties

You can view the properties of the following LDAP proxy elements:

- LDAP server extensions. See "Viewing LDAP Server Extension Properties" on page 79.
- LDAP proxy workflow elements. See "Viewing Proxy Workflow Element Properties" on page 80.

Viewing LDAP Server Extension Properties

To view the LDAP server extensions properties, use the `dsconfig get-extension-prop` command. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  get-extension-prop \
  --extension-name proxy1
```

Properties similar to the following are displayed.

```
        Property                    Value(s)
        ------------------------------------
    1)  enabled                     true
    2)  monitoring-bind-dn          -
    3)  monitoring-bind-password    -
    4)  remote-ldap-server-address  DS-proxy1
    5)  remote-ldap-server-port     3389
```

By viewing the LDAP server extension properties, you can gather the following information:

`enabled`
: indicates if the LDAP server extension is enabled (`true`) or not (`false`)

`remote-ldap-server-address` and `remote-ldap-server-port`
: indicate the address and port of the remote LDAP server that the LDAP server extension will forward requests to

`monitoring-bind-dn` and `monitoring-bind-password`
: are the credentials of the user that the extension will use to perform monitoring of the data source. If blank, the monitoring will be performed anonymously, which is the default

To configure these properties, see "Monitoring the Server With LDAP" on page 474.

Viewing Advanced LDAP Server Extension Properties

To view all the LDAP server extensions properties, use the `dsconfig --advanced get-extension-prop` command. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  --advanced get-extension-prop \
  --extension-name proxy1
```

Properties similar to the following are displayed.

```
         Property                            Value(s)
         ----------------------------------------------------------------------
    1)   enabled                             true
    2)   java-class                          com.sun.dps.server.workflowelement
                                             .proxyldap.LDAPServerExtension
    3)   monitoring-base-dn                  ""
    4)   monitoring-bind-dn                  -
    5)   monitoring-bind-password            -
    6)   monitoring-check-interval           30000
    7)   monitoring-connect-timeout          5000
    8)   monitoring-inactivity-timeout       120000
    9)   monitoring-search-filter            (|(objectClass=*)(objectClass=ldap
                                             SubEntry))
    10)  monitoring-search-timeout           5000
    11)  pool-increment                      5
    12)  pool-initial-size                   10
    13)  pool-max-size                       25
    14)  pool-max-write                      0
    15)  pool-release-connection-interval    300000
    16)  pool-use-max-write                  false
    17)  proxied-auth-use-v1                 false
    18)  remote-ldap-server-address          DS-proxy1
    19)  remote-ldap-server-connect-timeout  10000
    20)  remote-ldap-server-port             3389
    21)  remote-ldap-server-read-only        false
    22)  remote-ldap-server-read-timeout     10000
    23)  remote-ldap-server-ssl-policy       never
    24)  remote-ldap-server-ssl-port         636
    25)  saturation-precision                5
    26)  ssl-client-alias                    -
    27)  ssl-key-manager-provider            -
    28)  ssl-trust-all                       false
    29)  ssl-trust-manager-provider          -
```

Note – Most of the advanced properties (except SSL properties) are set by default when the LDAP server extensions are created.

To modify these values, see "Modifying LDAP Server Extension Properties" on page 84.

For information about the monitoring properties, see "LDAP Data Source Monitoring Connection Properties" on page 87. For information about the SSL (security) properties, see Chapter 5, "Configuring Security Between the Proxy and the Data Source."

Viewing Proxy Workflow Element Properties

To view the proxy workflow element properties, use the dsconfig get-workflow-element-prop command. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  get-workflow-element-prop \
  --element-name proxy-we1
```

Properties similar to the following are displayed.

```
        Property                                Value(s)
        ----------------------------------------------------------
    1)  client-cred-mode                        use-client-identity
    2)  enabled                                 true
    3)  ldap-server-extension                   proxy1
    4)   remote-ldap-server-bind-dn              -
    5)   remote-ldap-server-bind-password-file   -
    6)   workflow-element-id                     proxy-we1
```

With the proxy workflow element properties you can see the following information:

`client-cred-mode`
: indicates how the proxy connects to the remote LDAP server. In this example, the status is `use-client-identity`, which means that the proxy will connect to the remote LDAP server with the same credentials that the client used to connect to the proxy. This is the default mode.

  For more information, see Chapter 5, "Configuring Security Between the Proxy and the Data Source."

`enabled`
: indicates if the LDAP server extension is enabled (`true`) or not (`false`)

`ldap-server-extension`
: the name of the LDAP server extension that the workflow element is associated to

`remote-ldap-server-bind-dn` and `remote-ldap-server-bind-password-file`
: are the credentials of the user that Oracle Unified Directory proxy uses to connect to the remote LDAP server when `client-cred-mode` is `use-specific-identity` or `use-proxy-auth`. When using `--advanced`, you can also see `remote-ldap-server-bind-password`.

Note – To view the `remote-ldap-server-bind-password` you must use `dsconfig get-workflow-element-prop --advanced` command.

Adding an LDAP Proxy

To add an LDAP proxy you must create:

- first an LDAP server extension for each remote LDAP server used in the deployment. See "Creating an LDAP Server Extension" on page 82.
- secondly, a proxy LDAP workflow element, associated to an LDAP server extension. See "Creating a Proxy LDAP Workflow Element" on page 82.

Creating an LDAP Server Extension

To create an LDAP server extension, use the `dsconfig` `create-extension` command. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  create-extension \
  --extension-name DS-proxy5 \
  --type ldap-server \
  --set enabled:true \
  --set remote-ldap-server-address:DS5-hostname
```

To create an LDAP server extension, the type must be `ldap-server`. The name of the new extension is defined by `extension-name`, in this example `DS-proxy5`.

You must also specify the name of the remote LDAP server that this extension is associated to, in the option `--set` `remote-ldap-server-address`. You can specify either the hostname or the IP address of the remote LDAP server.

If you do not specify the port, as in the example above, the port 389 will be used by default. If you want to use a different port, then specify `-–set` `remote-ldap-server-port` with the correct port address.

Creating a Proxy LDAP Workflow Element

You must have an existing LDAP server extension before creating a proxy LDAP workflow element.

To create a proxy LDAP workflow element, use the `dsconfig` `create-workflow-element` command. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  create-workflow-element \
  --element-name proxy-we5 \
  --type proxy-ldap \
  --set enabled:true \
  --set client-cred-mode:use-client-identity \
  --set ldap-server-extension:DS-proxy5
```

To create a proxy LDAP workflow element, the type must be `proxy-ldap`. The name of the new proxy LDAP workflow element is defined by `element-name`, in this example `proxy-we5`.

You must also set the client credential mode. The client credential mode indicates how the proxy will connect to the remote LDAP server. In this example, the status is `use-client-identity`, which means that the proxy will connect to the remote LDAP server with the same credentials that the client used to connect to the proxy. This is the default mode.

Note – If you use Oracle Unified Directory remote LDAP servers and the client credential mode is set to `use-proxy-auth`, the user as which you are connecting *must* exist on the remote LDAP server. If the user does not exist, requests will be rejected. If you cannot guarantee that the users exists on the remote LDAP server, rather set the client credential mode to `use-specific-identity`.

For more information, see Chapter 5, "Configuring Security Between the Proxy and the Data Source."

Modifying an LDAP Proxy

You can modify the following elements:

- The proxy LDAP workflow element properties. See "Modifying Proxy LDAP Workflow Element Properties" on page 83.
- The LDAP server extension properties. See "Modifying LDAP Server Extension Properties" on page 84.

  For information about advanced LDAP server extension properties, see "Modifying LDAP Server Extension Advanced Properties" on page 84.

Modifying Proxy LDAP Workflow Element Properties

To modify the proxy LDAP workflow element properties, use the `set-workflow-element-prop` command.

You can modify the following properties:

- Set whether the proxy LDAP workflow element is enabled (`true`) or not (`false`)
- Set the client credential mode that is used (`client-cred-mode`)
- Associate an LDAP server extension, to indicate which remote LDAP server to use (`ldap-server-extension`)
- Set the credentials of the user that Oracle Unified Directory proxy uses to connect to the remote LDAP server (`remote-ldap-server-bind-dn`, `remote-ldap-server-bind-password`, and/or `remote-ldap-server-bind-password-file`)

For example, if you want to modify the LDAP server extension used by the workflow element in order to use a different remote LDAP server, do the following:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  set-workflow-element-prop --advanced \
  --element-name proxy-we5 \
  --set remote-ldap-server-bind-dn:uid=Specific\ User,dc=example,dc=com \
  --set remote-ldap-server-bind-password:password \
  --set ldap-server-extension:DS-proxy3 \
  --set client-cred-mode:use-specific-identity
```

Modifying LDAP Server Extension Properties

To modify the LDAP server extension properties, use the `set-extension-prop` command.

You will be able to:

- set whether the LDAP server extension is enabled (`true`) or not (`false`)
- modify the remote LDAP directory server address and port (`remote-ldap-server-address` and `remote-ldap-server-port`)
- set the credentials of the user that the extension will use to perform monitoring of the data source (`monitoring-bind-dn` and `monitoring-bind-password`). If left blank, the monitoring will be performed anonymously, which is the default.

For example, a typical operation would be to change the remote LDAP server used. To do so, you need to set the new remote LDAP server address and port, as follows:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  set-extension-prop \
  --extension-name DS-proxy5 \
  --set remote-ldap-server-address:DS5-hostname \
  --set remote-ldap-server-port:3388
```

To modify advanced LDAP server extension properties, see "Modifying LDAP Server Extension Advanced Properties" on page 84.

Modifying LDAP Server Extension Advanced Properties

You can configure the following advanced properties:

`pool-increment`

The increment by which the size of a connection pool is increased or decreased. If the `remote-ldap-server-ssl-policy` property is set to `user`, two pools of connections are created and the incremental change in size of each pool is set to `pool-increment`.

The default value is 5 connections.

pool-initial-size

The initial size of a connection pool. This is the initial number of connections to be created when a pool is initialized. Note that pool-initial-size is also minimum size of a pool.

The default value is 10 connections.

If the remote-ldap-server-ssl-policy property is set to user, two pools of connections are created and the initial size, and minimum size, of each pool is set to pool-initial-size. Therefore there can initially be twice the total number of connections indicated in pool-initial-size. For details, see "Modes of Secure Connection" on page 178.

pool-max-size

The maximum size of a connection pool. This is the maximum number of connections that a pool can allocate. If the remote-ldap-server-ssl-policy property is set to user, two pools of connections are created and the maximum size of each pool is set to pool-max-size.

The default value is 1000 connections.

pool-max-write

The maximum number of write connections that a connection pool can allocate at the same time. This is an integer. This parameter is taken into account only if the pool-use-max-write parameter is set to true.

The default value is 0 connections.

pool-release-connection-interval

The time after which a connection is considered by the Oracle Unified Directory proxy to be unused if no traffic has been sent on it. This reduces the size of the pool of connections, if the pool has been previously increased. If the number of unused connections is greater than pool-increment, then the size of the pool is reduced by pool-increment. This means that unused connections are closed and are removed from the pool.

The default value is 300 000 milliseconds (5 minutes).

`pool-use-max-write`

If this boolean is set to true, the `pool-max-write` parameter is taken into account, otherwise it is not. By default, `pool-use-max-write` is set to false.

`proxied-auth-use-v1`

When using the proxy authorization control mode, the default version of the control is v2. To use an older version for compatibility reasons, set `proxied-auth-use-v1` to true. By default, `proxied-auth-use-v1` is set to false. For more information about controls, see “Supported LDAP Controls” in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

`remote-ldap-server-read-timeout`

The timeout for reads. If the timeout is reached before the remote LDAP server sends back a response, an error is returned by Oracle Unified Directory proxy to the client. By default, this value is 10 000 milliseconds.

`saturation-precision`

The saturation precision is used in calculating the saturation threshold. Since the saturation limit can vary as requests are sent and received, the saturation precision indicates the buffer before the saturation is taken into account. In other words, by default the saturation can vary by 5% before it is taken into account.

The monitoring properties are described in “LDAP Data Source Monitoring Connection Properties” on page 87.

The SSL properties are security features. For information on these properties, see Chapter 5, “Configuring Security Between the Proxy and the Data Source.”

To modify the advanced LDAP server extension properties, use the `set-extension-prop --advanced` command.

Note – These advanced properties are set by default and typically are not modified.

An example of an advanced property that you may want to change is the `pool-max-size`. If you have a powerful remote LDAP server and you have configured your Oracle Unified Directory proxy so that it receives a maximum of requests, then you can increase the `pool-max-size` as follows:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  set-extension-prop --advanced \
  --extension-name DS-proxy5 \
  --set pool-max-size:500
```

LDAP Data Source Monitoring Connection Properties

Using the `dsconfig --advanced` command for the LDAP server extension, you can view or change the following monitoring properties.

Note – All properties relate to proactive monitoring unless otherwise specified.

`monitoring-base-dn`
The search base DN used by the monitoring functionality of the proxy to perform searches on remote LDAP servers. The default value is "".

`monitoring-bind-dn`
The bind DN of the user who wants to manage monitoring of the remote LDAP server. By default this value is undefined, which provides for anonymous access.

`monitoring-bind-password`
The password of the user who wants to manage monitoring of the remote LDAP server.

`monitoring-check-interval`
The monitoring check interval. This is the interval at which the proxy proactive monitoring checks the data source. The default value is 30000 milliseconds.

`monitoring-connect-timeout`
The maximum time after which the proactive monitoring facility will stop attempting to connect to the remote LDAP server. The default value is 5000 milliseconds. 0 means unlimited.

`monitoring-inactivity-timeout`
The time interval after which an idle connection is regularly checked to avoid connection closure by the remote server. The value of this parameter must be superior to the `monitoring-check-interval`. The default value is 120000 milliseconds.

`monitoring-search-filter`
The search filter that the proactive monitoring facility uses to perform searches on the remote LDAP server. The default value is `(|(objectClass=*)(objectClass=ldapSubEntry))`

`monitoring-search-timeout`
The maximum time during which the proactive monitoring facility attempts to retrieve the entry in a search operation. The default value is 5000 milliseconds.

`remote-ldap-server-read-timeout`
The maximum time during which the LDAP Server Extension waits for a response from the remote server before the connection is regarded as having failed. 0 means unlimited. This is a reactive monitoring property.

`remote-ldap-server-connect-timeout`
The maximum time during which monitoring attempts to connect to the remote server before the connection is regarded as having failed. 0 means unlimited. The default is 10 000 milliseconds. This is a reactive monitoring property.

Configuring Load Balancing With `dsconfig`

In order to forward the client requests to the remote LDAP server using load balancing feature of the Oracle Unified Directory proxy, you need the following elements:

- a load balancing workflow element.
- a load balancing algorithm
- a load balancing route, for each remote LDAP server

A load balancing workflow element can only have one load balancing algorithm. However, the same load balancing algorithm is used by all the load balancing routes in the deployment.

This topic covers all the administration tasks related to load balancing. For information about setting up a load balancing deployment during installation, see “To Configure Simple Load Balancing” in *Oracle Fusion Middleware Installation Guide for Oracle Unified Directory*.

The following examples describe how to configure load balancing using the `dsconfig` command. All of the examples specify the proxy hostname (`-h`), the proxy admin port (`-p`), the bind DN (`-D`), and the bind password (`-w`), and use the `-X` option to trust all certificates.

▼ To Configure Load Balancing

1. **Create a load balancing workflow element.**

   See "Creating a Load Balancing Workflow Element" on page 89.

2. **Create a load balancing algorithm.**

   See "Creating a Load Balancing Algorithm" on page 89.

3. **Create one load balancing route for each load balancing workflow element.**

   See "Creating Load Balancing Routes" on page 90.

Creating a Load Balancing Workflow Element

To configure load balancing, you must create a load balancing workflow element using the `dsconfig create-workflow-element` command. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  create-workflow-element \
  --element-name load-bal-we1 \
  --type load-balancing \
  --set enabled:true
```

To create a load balancing workflow element, the type must be `load-balancing`. The name of the workflow element is defined by `element-name`, in this example `load-bal-we1`.

Creating a Load Balancing Algorithm

In order to determine how the requests will be forwarded in a load balancing deployment, you must configure the load balancing algorithm. The load balancing algorithm set determines how client requests will be dispatched across the pool of remote LDAP servers. The possible load balancing types are: `failover`, `optimal`, `proportional`, or `saturation`.

To create the load balancing algorithm, you must have a load balancing workflow element. See "Creating a Load Balancing Workflow Element" on page 89.

Create a load balancing algorithm using the `dsconfig create-load-balancing-algorithm` command. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  create-load-balancing-algorithm \
  --element-name load-bal-we1 \
  --type failover
```

To create a load balancing algorithm, the you must indicate the type as `proportional`, `optimal`, `failover`, or `saturation`. The name of the workflow element is defined by `element-name`, in this example `load-bal-we1`.

Creating Load Balancing Routes

You should have one load balancing route per data source used in your deployment.

To create the load balancing routes, the load balancing workflow element and load balancing algorithm must already be created.

To create a load balancing route, use the `dsconfig` `create-load-balancing-route` command. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  create-load-balancing-route \
  --element-name load-bal-we1 \
  --route-name load-bal-route1 \
  --type failover \
  --set workflow-element:proxy-we1 \
  --set add-priority:1 \
  --set bind-priority:2 \
  --set compare-priority:2 \
  --set delete-priority:1 \
  --set extended-priority:2 \
  --set modify-priority:1 \
  --set modifydn-priority:1 \
  --set search-priority:2
```

In this example, `load-bal-route1` is the name of the new load balancing route, `load-bal-we1` is the name of the existing load balancing workflow element, and `proxy-we1` is the name of the LDAP proxy workflow element. The type must be the same as the one defined by the load balancing algorithm associated, in this case `failover`.

The properties set (in this case priority) are related to the type of load balancing created. For more information about the properties of the routes, linked to the algorithm type see "Modifying Load Balancing Properties" on page 90.

Modifying Load Balancing Properties

After a load balancing deployment has been set up, you can modify certain properties, such as the priority, weight, and saturation threshold. Most of these properties are changed at the load balancing route level.

You can modify the following load balancing properties, depending on the load balancing algorithm:

Failover	Optimal	Proportional	Saturation	Search Filter
add-priority	alert-threshold	add-weight	alert-threshold	priority
bind-priority	saturation-precision*	bind-weight	priority	allowed-attributes

Failover	Optimal	Proportional	Saturation	Search Filter
compare-priority	workflow-element	compare-weight	threshold	prohibited-attributes
delete-priority		delete-weight	saturation-precision*	workflow-element
extended-priority		extended-weight	workflow-element	
modify-priority		modify-weight		
modifydn-priority		modifydn-weight		
search-priority		search-weight		
workflow-element		workflow-element		
switch-back flag				

* saturation precision is a property of the LDAP server extension.

To modify load balancing route properties, use the `dsconfig set-load-balancing-route-prop` command.

New routes can be added on a running algorithm, or routes can be deleted or have their priorities modified without the need to restart the server.

Note – You cannot modify the load balancing algorithm type.

To change a failover load balancing deployment to a proportional one, for example, you must create a new load balancing deployment. See "Configuring Load Balancing With `dsconfig`" on page 88.

Setting the Priority in Failover Algorithm

Once you have created a load balancing deployment using the failover algorithm, you can modify the proxy workflow element to change the route used, as well as the priority of the route for a given operation type.

In a failover algorithm, a priority of 1 is the highest priority and indicates the main route that will be used for a specific operation type, while the route with priority 2 (or more) is the secondary route used in case of failure on the primary route. The priority must be set for each operation type. This means that the route that has a priority of 1 for Add operations, could have a priority of 2 for Bind and Search operations.

For example, if the route load-bal-route1 was initially set as the main route with a priority set to 1 for Add operations, but you now want to make it the backup route, you can set the priority to 2 using the following command line.

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  set-load-balancing-route-prop \
  --element-name load-bal-we1 \
  --route-name load-bal-route1
  --set add-priority: 2
```

Note – If two routes have the same priority for a given operation type, the choice of the active route which treats the request is not deterministic.

Setting the switch-back Flag

After failover in a load balancing deployment, the route with the backup route continues to handle all incoming requests, even once the priority server which had failed becomes available again. Switch-back to the primary route does not automatically occur unless the switch-back flag has been set to true. By default, the switch-back flag is set to false.

The switch-back flag is an advanced property. To set the switch-back flag to true, do the following:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  --advanced set-load-balancing-algorithm-prop \
  --element-name load-bal-we1 \
  --set switch-back:true
```

Setting the Saturation Precision for the Optimal or Saturation Algorithm

When you set load balancing to use the optimal or the saturation algorithm, you can set the saturation precision level. The saturation precision is the delta between two saturation levels which is used to determine the route with the lowest saturation level. By default, the saturation precision level is set to 5.

If you find that the saturation precision level is too low, and that the routes are changing too frequently, you can modify the saturation precision level as follows:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  --advanced set-extension-prop \
  --extension-name proxy1 \
  --set saturation-precision:10
```

Setting the Weight of a Proportional Algorithm

Once you have created a load balancing deployment using the proportional algorithm, you can modify the proxy workflow element to change the route used, as well as the weight of a route. The weight can be different for each operation type. The value of the weight should be 0 or more, were 0 indicates that the route will not be used for the specified operation.

Using the interactive mode of `dsconfig`, you can see that the following properties can be modified:

```
>>>> Configure the properties of the Proportional Load Balancing Route

        Property          Value(s)
        ---------------------------
    1)  add-weight        1
    2)  bind-weight       1
    3)  compare-weight    1
    4)  delete-weight     1
    5)  extended-weight   1
    6)  modify-weight     1
    7)  modifydn-weight   1
    8)  search-weight     1
    9)  workflow-element  proxy-we1
```

For example, if you initially set all your routes to a weight of 1 on all operations, then all the servers will handle an equal ratio of operations. However, if you want a remote LDAP server to handle more search requests than the other servers in the deployment, then you can set its `search-weight` to a higher value, such as 5. To do so, use the following command:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  set-load-balancing-route-prop \
  --element-name load-bal-we1 \
  --route-name load-bal-route1 \
  --set search-weight:5
```

Note – If you want to modify the weight for all the operations, you will have to modify the weight for each operation.

If you want to modify `load-bal-route1` to handle twice the operations as your other route, then you would need to set the weight of all operations to `2` (assuming the weight on the other route is set to `1`). In other words, run the command as follows:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  set-load-balancing-route-prop \
  --element-name load-bal-we1 \
  --route-name load-bal-route1 \
  --set add-weight:2 \
  --set bind-weight:2 \
  --set compare-weight:2 \
  --set delete-weight:2 \
  --set extended-weight:2 \
  --set modify-weight:2 \
  --set modifydn-weight:2 \
  --set search-weight:2
```

If you set the weight to `0` for any of the operations, then the route will not perform the specified operation. For example, if you set `add-weight` to `0`, as follows, then `load-bal-route1` will not forward any add requests to the associated remote LDAP server. Moreover, if all the routes indicate a weight of `0` for a specific operation, then that operation will not be supported.

Setting the Threshold for a Saturation Algorithm

Once you have created a load balancing deployment using the saturation algorithm, you can modify the proxy workflow element used, the priority of the route, the saturation threshold, and the saturation threshold alert.

With a saturation algorithm, requests are distributed based on two criteria: the priority of the server and the saturation threshold of the server. The saturation threshold is the limit at which the server is considered “maximized” and service may become degraded. In a load balancing deployment with saturation algorithm, requests are sent to the server with the highest priority (1) until the server reaches the saturation threshold indicated.

For example, if you indicate `load-bal-route1` as the server with the highest priority, with a threshold of 80%, all requests will be sent to `load-bal-route1` until its saturation threshold goes over 80%. Once it exceeds 80%, then requests are routed to the next server in the priority list.

```
>>>> Configure the properties of the Saturation Load Balancing Route

        Property          Value(s)
        ---------------------------
    1)  alert-threshold   85
    2)  priority          1
    3)  threshold         80
    4)  workflow-element  proxy-we1
```

To modify the saturation threshold, use the following command:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  set-load-balancing-route-prop \
  --element-name load-bal-we1 \
  --route-name load-bal-route1 \
  --set threshold:90
```

In this example, the saturation threshold has been set to 90%.

Setting the Saturation Threshold Alert

The saturation threshold alert is used to set at which point a notification will be sent to the system administrator to indicate that the server has passed the saturation limit. Generally, the saturation threshold alert is set higher than the saturation limit, in order to indicate if the saturation continues to increase past the saturation threshold (which may indicate a problem). The alert should bet set with an acceptable buffer, as there may be a short delay in which saturation continues to increase slightly before requests are forwarded to another route.

To modify the saturation threshold, use the following command:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  set-load-balancing-route-prop \
  --element-name load-bal-we1 \
  --route-name load-bal-route1 \
  --set alert-threshold:85
```

You can set the saturation threshold alert to a value lower than the saturation threshold, in order to perform preventative actions. This may imply receiving notifications even in cases where the saturation threshold is not reached. That is, a saturation threshold alert is sent, but the saturation limit drops and does not reach the saturation threshold. However, the requests will only be sent to the next priority route when the saturation threshold is reached.

For more information on setting the notification message, see “Configuring Alerts and Account Status Notification Handlers” on page 466.

Setting Client Connection Affinity

When client connection affinity is defined, requests from a specified client connection are distributed to the same server, bypassing the load balancing algorithm that has been set. Client connection affinity is set at the network group level.

To set client connection affinity, use the `dsconfig create-network-group-qos-policy` command. For more information, see “Creating a Network Group Quality of Service Policy” on page 42.

EXAMPLE 3–1 Example of Client Connection Affinity Rejected

When client connection affinity is set, the load balancing algorithm is bypassed as long as the constraints of the weights that have been defined are respected.

For example, assume that the following routes are set with the following weights:

- `LB-route1: add=10, search= 0`
- `LB-route2: add=0, search=10`

It is clear that `LB-route1` receives all the add requests, and `LB-route2` receives all the search requests.

Assume that the load balancing deployment in this example is set with a client connection affinity of `all-requests-after-first-write-request`. If the load balancing deployment receives the following string of requests: Add, Search, Add, typically, the client connection affinity would send the Search request to the same route (`LB-route1`) as the first Add request. However, in this case, since Search requests are not allowed on `LB-route1`, the load balancing algorithm is *not* bypassed by the client affinity.

Deleting Load Balancing Elements

If you want to delete a complete load balancing workflow (workflow element, algorithm, and routes), then you only need to delete the load balancing workflow element. When you delete a load balancing workflow element, the associated load balancing algorithm and routes are silently deleted.

Configuring Distribution With `dsconfig`

In order to forward the client requests to the remote LDAP server using the distribution feature of the Oracle Unified Directory proxy, you need:

- a distribution workflow element
- a distribution algorithm
- one or more distribution partitions (typically one per remote LDAP server)

A distribution workflow element can only have one distribution algorithm, which defines how data is distributed. On the other hand, one distribution algorithm can use many partitions.

This topic covers all the administration tasks possible for a distribution workflow element, distribution algorithm, and distribution partitions once a Oracle Unified Directory proxy with distribution is setup. For information on setting up a deployment with distribution using the `vdp-setup` GUI, see “To Configure Simple Distribution” in *Oracle Fusion Middleware Installation Guide for Oracle Unified Directory*.

The following examples describe how to configure distribution using the `dsconfig` command.

All the commands in the following procedures specify the proxy hostname (`-h`), the proxy admin port (`-p`), the bind DN (`-D`), and the bind password (`-w`). The following examples use the `-X` option to trust all certificates.

▼ To Configure Distribution

1. **Create one distribution workflow element.**

   See “Creating a Distribution Workflow Element” on page 97.

2. **Create a distribution algorithm.**

   See “Creating a Distribution Algorithm” on page 97

3. **Create one partition for each chunk of partitioned data. A partition can be associated to one remote LDAP server, or a set of replicated remote LDAP servers.**

   - For a capacity-based distribution see “Creating a `capacity` Distribution Partition” on page 98.
   - For a lexico or numeric distribution see “Creating a `lexico` or `numeric` Distribution Partition” on page 99.

- If you are using DN pattern algorithm, see "Creating a dnpattern Distribution Partition" on page 100.

Creating a Distribution Workflow Element

To configure distribution, you must create a distribution workflow element using the `dsconfig create-workflow-element` command. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  create-workflow-element \
  --element-name distrib-we \
  --type distribution \
  --set enabled:true \
  --set base-dn:ou=people,dc=example,dc=com
```

To create a distribution workflow element, the type must be `distribution`. The name of the workflow element is defined by `element-name`, in this example `distrib-we`.

Note – When declaring the `base-dn` using the `create-workflow-element` subcommand as shown above, ensure that you specify the full tree structure.

To complete the distribution element of your configuration, create the distribution algorithm and the appropriate partitions.

Creating a Distribution Algorithm

To determine how the requests will be forwarded in a distribution deployment, you must configure the distribution algorithm. The algorithm set determines how the data is partitioned and to which partition a request is sent. The possible distribution types are: `numeric`, `lexico`, or `dnpattern`.

To create the distribution algorithm, you must have a distribution workflow element. See "Creating a Distribution Workflow Element" on page 97.

Create a distribution algorithm using the `dsconfig create-distribution-algorithm` command. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  create-distribution-algorithm \
  --element-name distrib-we \
  --type numeric \
  --set distribution-attribute:uid
```

The name of the workflow element is defined by `element-name`, in this example `distrib-we`. The distribution algorithm type must be set as `capacity`, `numeric`, `lexico`, or `dnpattern`. The properties set depend on the algorithm type. In this example, `distribution-attribute` must be set, as the algorithm type is `numeric`.

Creating Distribution Partitions

You can create the following types of distribution partitions:

- capacity. See "Creating a capacity Distribution Partition" on page 98
- lexico or numeric. See "Creating a lexico or numeric Distribution Partition" on page 99
- dnpattern. See "Creating a dnpattern Distribution Partition" on page 100

Creating a capacity Distribution Partition

To create a capacity distribution partition, the distribution workflow element and distribution algorithm must already be created. You must create one distribution partition per data set.

To create a distribution partition, use the dsconfig create-distribution-partition command. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  create-distribution-partition \
  --element-name distrib-we \
  --partition-name distrib-partition1 \
  --type capacity \
  --set partition-id:1 \
  --set workflow-element: proxy-we1 \
  --set max-entries:1000
```

Note – You must create a global index catalog and have the DNs indexed to use the capacity-based algorithm. To create global index catalogs, see "To Create a Global Index Catalog Containing Global Indexes" on page 103.

A distribution partition is identified by both a partition name, in this example, distrib-partition1 and a partition id. The partition id must be an simple integer, as it will be used for the global index catalog reference. The type must be the same as the one defined by the distribution algorithm associated, in this case capacity.

To create a distribution partition, you must also indicate the name of the existing distribution workflow element (element-name) that manages the partition (here distrib-we), and the name of the next element in the work flow (workflow-element), such as an LDAP workflow element (in this example proxy-we1). The proxy workflow element indicates the path used to reach the data on the remote LDAP server. For more information on the proxy, see "Configuring an LDAP Proxy" on page 77.

When creating a capacity distribution partition, you must indicate the maximum number of entries the partition can hold, for example 1000.

Creating a lexico or numeric Distribution Partition

Lexico and numeric distribution are very similar, and as such, to create a distribution partition for lexico or numeric distribution, you must set the same properties. You must create one distribution partition per data set.

To create `lexico` or `numeric` distribution partitions, the distribution workflow element and distribution algorithm must already be created.

To create a distribution partition, use the `dsconfig create-distribution-partition` command. For example for a numeric distribution, you might create a partition as follows:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  create-distribution-partition \
  --element-name distrib-we \
  --partition-name distrib-partition1 \
  --type numeric \
  --set partition-id:1 \
  --set workflow-element: proxy-we1 \
  --set lower-bound:1000 \
  --set upper-bound:2000
```

A distribution partition is identified by both a partition name, in this example, `distrib-partition1` and a partition id. The partition id must be an simple integer, as it will be used for the global index catalog reference. The type must be the same as the one defined by the distribution algorithm associated, in this case `numeric`.

In order to create a distribution partition, you must also indicate the name of the existing distribution workflow (here `distrib-we`), and the name of the associated workflow element, such as an LDAP workflow element (in this example `proxy-we1`). The proxy workflow element indicates the path used to reach the data on the remote LDAP server. For more information on the proxy, see "Configuring an LDAP Proxy" on page 77.

When creating a `lexico` or `numeric` distribution partition, you must indicate the lower and upper boundaries of the partition. Oracle Unified Directory proxy checks to ensure that there is no overlap in the boundaries of any two partitions. This means that you cannot set partition 1 with boundaries 1000–3000 and partition 2 with boundaries 2000–4000.

Note – The upper boundary is exclusive, which means that in the example above, the partitioned data only includes values between 1000 up to 1999. If you want the upper boundary or lower boundary to be unlimited, use the keyword `unlimited`.

The properties set (in this example boundaries) are related to the type of distribution created. For more information about the properties of the partitions, linked to the algorithm type see "Configuring Distribution With `dsconfig`" on page 96.

Creating a dnpattern Distribution Partition

To create the `dnpattern` distribution partitions, the distribution workflow element and distribution algorithm must already be created.

To create a `dnpattern` distribution partition, use the `dsconfig create-distribution-partition` command. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  create-distribution-partition \
  --element-name distrib-we \
  --partition-name distrib-partition5 \
  --type dnpattern \
  --set partition-id:5 \
  --set workflow-element: proxy-we1 \
  --set dn-pattern:uid=[0-9]*[01].*
```

A distribution partition is identified by both a partition name, in this example, `distrib-partition5` and a partition id. The partition id must be an simple integer, as it will be used for the global index catalog reference. To create a distribution partition, you must also indicate the name of the existing distribution workflow (here `distrib-we`), and the name of the associated workflow element, such as an LDAP proxy (in this example `proxy-we1`). The type must be the same as the one defined by the distribution algorithm associated, in this case `dnpattern`.

In a distribution scenario that uses a `dnpattern` algorithm, requests are sent to a partition when the request RDNs below the distribution base DN match the DN string pattern. For example, if the distribution base DN is `ou=people,dc=example,dc=com` and the request base DN is `uid=1,ou=people,dc=example,dc=com`, the check against the string pattern is done on the RDN `uid=1`.

Similarly, if the distribution base DN is `ou=people,dc=example,dc=com` and the request base DN is `uid=1,ou=region1,ou=people,dc=example,dc=com`, the check against the string pattern is done on the RDNs `uid=1,ou=region1`.

DN Pattern String Syntax

The DN string pattern must comply with the DN syntax and with a subset of the Java Pattern class.

.	any character
\\	backslash
\t	TAB character
[abc]	a, b, or c
[^abc]	any character except a, b, or c

[a-zA-Z]	a through z, or A through Z, inclusive (range)
[a-d[m-p]]	a through d, or m through p (union)
[a-z&&[def]]	d, e, or f (intersection)
[a-z&&[^bc]]	a through z, except for b and c (subtraction)
[A-Z&&[^M-P]]	a through z, and not m through p (subtraction)

The following quantifiers can be used:

X?	X, once or not at all
X*	X, zero or more times
X+	X, one or more times
X{n}	X, exactly n times
X{n,}	X, at least n times
X{n,m}	X, at least n times but no more than m times

Using DN Pattern negative-match

The distribution property called negative-match allows you to specify the opposite of the DN pattern that should be matched. That is, you specify a DN pattern to be ignored; any value that *does not* match the specified DN pattern will be distributed. By default, the negative-match property is set to false.

Create a dnpattern distribution partition using negative-match as follows:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  create-distribution-partition \
  --element-name distrib-we \
  --partition-name distrib-partition5 \
  --type dnpattern \
  --set partition-id:5 \
  --set workflow-element: proxy-we1 \
  --set dn-pattern:uid=[123]*[0-9].* \
  --set negative-match:true
```

In the example above, since negative-match has been set to true, any requests with uid not starting with 1, 2, or 3, with n characters following will be forwarded to the partition.

Managing Modify DN Requests

Modifying a DN where the new entry remains in the same partition as the original entry is supported. However, by default, Oracle Unified Directory proxy does not allow users to modify the DN to a value that is outside the range of the current partition.

If you want to allow modifyDN requests to change the DN to a value that is outside the boundaries of the partition in which the entry is originally, then you must set the force-modify-dn flag to true.

For example, assuming you have set the force-modify-dn flag to true and you have two partitions: Partition 1 with uid boundaries from 0–999 and Partition 2 with uid boundaries from 1000–1999. If you want to modify an entry with the uid 1 to 1001, the change will be allowed, but the entry with the uid 1001 will remain in Partition 1. It is not moved to Partition 2.

If you then search for uid=1001, you will get an error indicating that no such entry is found. To be able to find the entry, you should use a global index catalog. This will ensure that the entries that are modified are always found. To configure a global index catalog, see "Configuring Global Indexes By Using the Command Line" on page 102.

To set force-modify-dn flag to true, use the command as follows:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  --advanced set-workflow-element-prop \
  --element-name distrib-we \
  --set force-modify-dn:true \
```

Deleting Distribution

If you want to delete a complete distribution workflow (workflow element, algorithm, and partitions), then you only need to delete the workflow element. When you delete a distribution workflow element, the associated distribution algorithm and partitions are silently deleted.

Configuring Global Indexes By Using the Command Line

Global indexes map entries to a specific distribution partition to speed up search and modify operations in distributed topologies. A global index maps entries based on a unique attribute, such as a phone number. Lists of global indexes are contained in a global index catalog. An Oracle Unified Directory proxy instance can contain one or more global index catalogs.

Note – To configure and manage global indexes and global index catalogs, you must enable specific controls on the remote servers, particularly the LDAP Pre-Read Control and the CSN Control. For more information, see "Supported LDAP Controls" in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

Configuring Global Index Catalogs by Using gicadm

Global index catalogs are stored in a Berkely database under *instance-dir*/OUD/catalogs. To ensure high availability of a distributed topology, replication of global index catalogs is recommended. For more information, see "Replication of Global Index Catalogs" on page 109.

The gicadm command is located in the server instance directory:

- for Unix: *instance-dir*/OUD/bin/gicadm
- for Windows: *instance-dir*\OUD\bat\gicadm.bat

For more information, see "gicadm" in *Oracle Fusion Middleware Command-Line Usage Guide for Oracle Unified Directory*.

The procedures in this section assume that the Oracle Unified Directory proxy is deployed in a distribution architecture and presume that you are using the default Oracle Unified Directory proxy administration port (4444).

▼ To Create a Global Index Catalog Containing Global Indexes

To create global indexes, you must first create global index catalogs, as described in the following procedure. This procedure describes how to create global index catalogs, create and add global indexes, and add data to the global indexes. You can add the data to your global indexes later, if you prefer.

Before You Begin Oracle Unified Directory proxy must be deployed for distribution.

1 Use the gicadm command to create a global index catalog:

```
$ gicadm -h localhost -D "cn=Directory Manager" -p 4444 -w password -X \
create-catalog --catalogName sampleCatalog
```

The catalog name must be unique.

2 Create and add at least one global index to the global index catalog.

The following command creates a global index of telephoneNumber attribute values and adds that global index to the global index catalog that was created in the previous step.

```
$ gicadm -h localhost -D "cn=Directory Manager" -p 4444 -w password -X \
add-index --catalogName sampleCatalog \
--attributeName telephoneNumber
```

You can use the add-index subcommand later to add additional global indexes to the global index catalog.

3 Associate the global index catalog to a distribution.

```
$ gicadm -h localhost -D "cn=Directory Manager" -p 4444 -w password -X \
associate --catalogName sampleCatalog \
--distributionWorkflowElement myDistributionName
```

For information about workflow elements, see "Configuring Workflow Elements With dsconfig" on page 48. For information about distribution, see "Configuring Distribution With dsconfig" on page 96.

4 **(Optional) Use the `split-ldif` command to generate multiple files from one LDIF file.**

The `split-ldif` command separates the content of one LDIF file into several LDIF files based on the distribution algorithm configured with your proxy. It can also generate files that contain data to load in a global index. You should use `split-ldif` during global index initialization if the remote LDAP servers will contain data that needs to be indexed when you start your Directory service. If you plan to start without data in your directory, you can skip this step.

For information on the `split-ldif` command, including examples on how to use the command to populate a global index with one or several indexed attributes, see "split-ldif" in *Oracle Fusion Middleware Command-Line Usage Guide for Oracle Unified Directory*.

5 **(Optional) Use the `gicadm import` command to import data into the global index.**

For more information see "To Import Content into a Global Index Catalog" on page 107.

▼ To View Global Index Catalog Properties

Global index catalog properties are related to global index catalog **replication**. For a list of the global index catalog properties and an explanation of their use, see "Modifying the Properties of a Global Index Catalog" on page 104.

● **To view all the properties of a global index catalog, use the `gicadm` command with the `get-catalog-prop` subcommand.**

```
$ gicadm -h localhost -D "cn=Directory Manager" -p 4444 -w password -X \
get-catalog-prop --catalogName sampleCatalog \
--property all
```

The output will be similar to the following.

```
Property   : Value(s)
-------------------:-------------------------------
replication-server : localhost:3390, localhost:4390
server-id          : 4247
window-size        : 100
heartbeat-interval : 1000
group-id           : 1
```

- **To view the value for a specific global index catalog property, specify the property.**

```
$ gicadm -h localhost -D "cn=Directory Manager" -p 4444 -w password -X \
get-catalog-prop --catalogName sampleCatalog \
--property heartbeat-interval
```

Modifying the Properties of a Global Index Catalog

Global index properties are related to the replication of global index catalogs. The following global index catalog properties are available:

- `replication-server`: This lists the servers in the replication topology, in the format `host:port`.

Note – This property should not be modified with `set-catalog-prop`. This property is modified using `enable-replication`.

- `server-id`: Specifies a unique identifier for the global index within the global index catalog replication domain. Each instance within the same global index catalog replication domain must have a different server ID. An instance which is a member of multiple global index catalog replication domains may use the same server ID for each of its global index catalog replication domain configurations.

  Syntax: 1 <= INTEGER <= 65535 or text.

  Note – This property should not be modified.

- `window-size`: Specifies the window size that the instance will use when communicating with replication servers. Default value is 100.

  Syntax: 0 <= INTEGER or text.

- `heartbeat-interval`: Specifies the heartbeat interval that the instance will use when communicating with replication servers. The instance expects a regular heartbeat from the replication server within the specified interval. If a heartbeat is not received within this interval, the instance closes its connection and connects to another replication server.

  Syntax: 100 ms <= DURATION (ms)

- `group-id`: The id associated with a specific replicated domain. This value defines the group id of the replicated domain. The replication system will preferably connect and send updates to replicate to a replication server with the same group id as itself.

  Syntax: 1 <= INTEGER <= 127

  Note – This property should not be modified.

▼ To Modify the Properties of a Global Index Catalog

For a list of the global index catalog properties, see "Modifying the Properties of a Global Index Catalog" on page 104.

● **Use the `gicadm` command with the `set-catalog-prop` subcommand.**

```
$ gicadm -h localhost -D "cn=Directory Manager" -p 4444 -w password -X \
set-catalog-prop --catalogName sampleCatalog \
--set property:value
```

For example, one of the properties that can be modified is the heartbeat interval. In this case, use:

```
--set heartbeat-interval:500
```

▼ To Modify Multi-Valued Global Index Catalog Properties

For multi-valued global index or global index catalog properties, you can add or remove a value using the `--add` or `--remove` options.

For global index catalog, only the property `replication-server` can be multi-valued.

Note – For multi-valued global index properties, use the `set-index-prop` subcommand instead.

---

1 **To add a value, use the `gicadm` command with the `set-catalog-prop` subcommand.**

```
$ gicadm -h localhost -D "cn=Directory Manager" -p replicationPort -w password -X \
set-catalog-prop --catalogName sampleCatalog \
--add replication-server:hostname
```

2 **To remove a value from a multi-valued property, use the `gicadm` command with the `set-catalog-prop` subcommand.**

```
$ gicadm -h localhost -D "cn=Directory Manager" -p 4444 -w password -X \
set-catalog-prop --catalogName sampleCatalog \
--remove replication-server:value \
```

▼ To Reset Global Index Catalog Properties To the Default Values

If you have modified any of the global index catalog properties and want to reset them to the default values, use the following procedure.

● **Use the `gicadm` command with the `set-catalog-prop` subcommand.**

For example, to reset the heartbeat interval:

```
$ gicadm -h localhost -D "cn=Directory Manager" -p 4444 -w password -X \
set-catalog-prop --catalogName nyCatalog \
--reset heartbeat-interval
```

▼ To View Global Index Properties

● **To view the properties of a global index, use the `gicadm` command with the `get-index-prop` subcommand.**

```
$ gicadm -h localhost -D "cn=Directory Manager" -p 4444 -w password -X \
get-index-prop --catalogName sampleCatalog \
--attributeName telephoneNumber --property all
```

The properties should be similar to the following:

```
Property Names                         : Property Values
----------------------------------------:----------------------------------
global-index-deleted-entry-retention-timeout : 500
db-cleaner-min-utilization                   : 50
db-log-file-max                              : 10000000
db-checkpointer-bytes-interval               : 20000000
db-checkpointer-wakeup-interval              : 30
db-num-lock-tables                           : -
db-num-cleaner-threads                       : -
db-txn-no-sync                               : false
db-txn-write-no-sync                         : true
je-property                                  : -
db-directory                                 : catalogs
db-directory-permissions                     : 700
global-index-catalogs-shared-cache           : global-index-catalogs-shared-cache
global-index-attribute                       : telephoneNumber
```

Note – Typically these values should not be modified.

▼ To Import Content into a Global Index Catalog

You can import the contents of a specific file into one or multiple global indexes in a global index catalog. You must specify the name of the catalog into which the content of the file is to be imported. You can filter the content of the file to data related to a particular index by optionally providing the `attributeName` parameter.

The data file to be imported can be created by executing the `split-ldif` command or from executing the `gicadm export` command, for example.

- **To import the contents of a file into a global index catalog, use the `gicadm` command with the `import` subcommand.**

```
$ gicadm -h localhost -D "cn=Directory Manager" -p 4444 -w password -X \
import --file file --catalogName sampleCatalog
```

The path to the file from which the contents of the catalog are imported is declared by *file*. The global index catalog is declared by its *name*.

Note – If the Oracle Unified Directory proxy stops while a `gicadm import` task is being executed, the global index catalog back end is set to `enabled=false`. In this case, re-enable the global index back end using the following command, where *sampleCatalog* is the name of the global index catalog:

```
$ dsconfig -h localhost -D "cn=Directory Manager" -p 4444 -w password -X \
set-backend-prop --backend-name sampleCatalog \
set enabled:true
```

▼ To Export Contents of a Global Index Catalog to a Directory

- **To export the contents of a global index catalog to a directory, use the `gicadm` command with the `export` subcommand.**

```
$ gicadm -h localhost -D "cn=Directory Manager" -p 4444 -w password -X \
export --exportDirectory directory-path --catalogName sampleCatalog
```

▼ To Associate a Global Index Catalog to a Distribution

- **To associate a global index catalog from a distribution, use the `gicadm` command with the `associate` subcommand.**

```
$ gicadm -h localhost -D "cn=Directory Manager" -p 4444 -w password -X \
associate --catalogName sampleCatalog \
--distributionWorkflowElement myDistributionName
```

Once the global index catalog is associated to a distribution workflow element, the global index catalog will be listed in the properties of the distribution. To confirm which global index catalog is associated to a distribution, use the `dsconfig` `get-workflow-element-prop` command. For information on workflow elements, see “Configuring Workflow Elements With `dsconfig`” on page 48.

▼ To Disassociate a Global Index Catalog From a Distribution

Before You Begin To disassociate a global index catalog from a distribution topology, you must know the distribution workflow element with which the global index catalog is associated. To confirm the name of the distribution workflow element that is using the global index catalog, view the properties of the distribution topology by using the `dsconfig` `--get-workflow-element-prop` command.

- **To disassociate a global index catalog from a distribution workflow element, use the `gicadm` command with the `disassociate` subcommand.**

```
$ gicadm -h localhost -D "cn=Directory Manager" -p 4444 -w password -X \
 disassociate --distributionWorkflowElement myDistributionName
```

▼ To Add a Global Index to a Global Index Catalog

To add a new global index to an existing global index catalog, for example to map a new attribute, use the following procedure. This procedure creates and adds the global index to the global index catalog. It is not possible to create a global index without adding it to a global index catalog.

Before You Begin You must already have a global index catalog.

- **Use the `gicadm` command with the `add-index` subcommand.**

```
$ gicadm -h localhost -D "cn=Directory Manager" -p 4444 -w password -X \
add-index --catalogName sampleCatalog --attributeName telephoncNumber
```

▼ To Remove a Global Index From a Global Index Catalog

● **Use the `gicadm` command with the `remove-index` subcommand.**

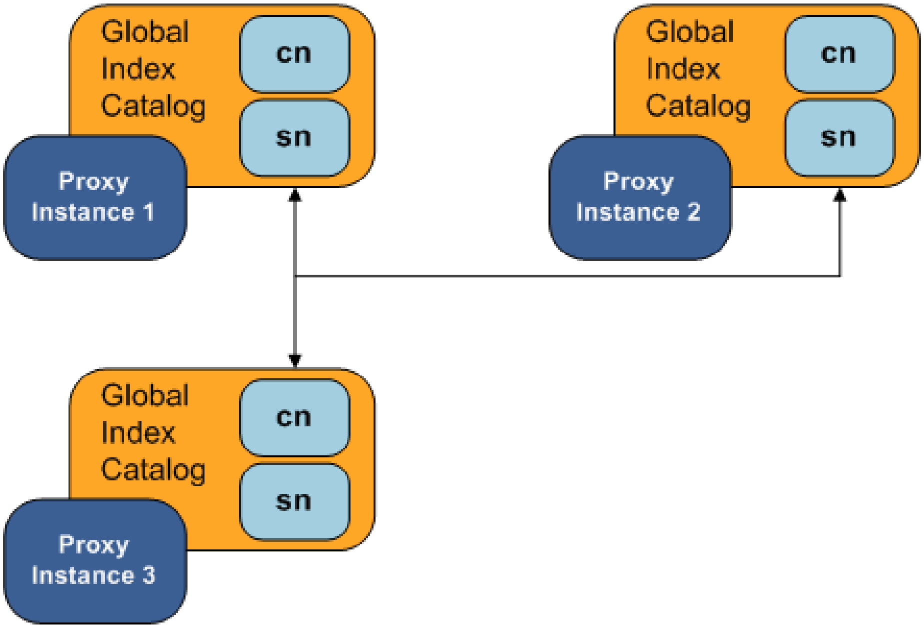
```
$ gicadm -h localhost -D "cn=Directory Manager" -p 4444 -w password -X \
remove-index --catalogName sampleCatalog --attributeName telephoneNumber
```

Replication of Global Index Catalogs

To ensure high availability, global index catalogs should be replicated. A standard hardware load balancer can be used and replication of global index catalogs can be configured in a deployment as shown by the graphic in “Multiple Replicated Proxies” in *Oracle Fusion Middleware Deployment Planning Guide for Oracle Unified Directory*.

▼ To Create a Replicated Topology and Enable Global Index Catalog Replication

Follow the steps below in order to create a replicated topology with three proxy instances, and enable global index catalog replication, as illustrated below.



1 **Install at least two instances of Oracle Unified Directory proxy in your server topology.**

For redundancy, it is recommended that these instances be on separate physical machines.

2 **Configure a global index catalog for each instance of the proxy in your topology and add one or more global indexes.**

For more information on configuring a global index catalog using the `gicadm` command, see "To Create a Global Index Catalog Containing Global Indexes" on page 103.

3 **Enable global index catalog replication.**

The Oracle Unified Directory proxy instance whose global index catalog is to be replicated across the topology is referred to, for the purposes of CLI syntax, as the *local* instance, while the other instance of the Oracle Unified Directory proxy declared in the command is referred to as the *remote* instance. For more information on running the `gicadm enable-replication` command, see "To Enable Global Index Catalog Replication" on page 110.

Repeat this step for each proxy that is part of your replicated topology.

4 **Choose an instance of Oracle Unified Directory proxy for the purposes of replication of the global index catalog, on which to initialize replication. Consider which instance of proxy has the most up to date global index catalog content.**

Otherwise, you can import the LDIF file to each proxy that is part of the topology. See "To Import Content into a Global Index Catalog" on page 107.

5 **On the instance of Oracle Unified Directory proxy chosen in the previous step, run the `gicadm initialize-replication --all` command. For more information, see "To Initialize Global Index Catalog Replication" on page 111.**

Note – When using a global index catalog with replicated remote LDAP servers, only one remote LDAP server must handle write operations if such operations can concurrently modify the same value *and* if that value is indexed. For this, you could set the weights in your load balancing workflow element to direct all write traffic to the same server. For more information, see "Modifying Load Balancing Properties" on page 90.

▼ To Enable Global Index Catalog Replication

This command configures replication without actually initializing replication. This command is executed on the local host, declared by the `-h` option, using the administration port of the local host. The remote host is declared by **`--remoteHost`** option, and must be a fully qualified host name or IP address. The command creates a global index catalog replication administrator with a bind ID of *adminUID* and a bind password of *bindPassword*.

If you created global index catalogs using `vdp-setup` during installation, the global index administrator is already created, with the same password as the directory manager. For more information on installing a distribution deployment with global index , see "To Configure Simple Distribution" in *Oracle Fusion Middleware Installation Guide for Oracle Unified Directory*.

- **To enable replication of global index catalogs, use the `gicadm enable-replication` command.**

```
$ gicadm -h localhost -D "cn=Directory Manager" -p 4444 -w password -X \
 enable-replication \
 --catalogName sampleCatalog --adminUID adminUID
 --localReplicationPort 8989 \
 --remoteReplicationPort 8989 --remoteAdminPort 4444 --remoteHost host
```

This command updates the configuration of Oracle Unified Directory proxy to replicate the content of the global index catalog called *sampleCatalog* on the local host. If one of the instances of Oracle Unified Directory proxy in the topology already replicates the global index catalog, this command updates the configuration of all other instances of Oracle Unified Directory proxy in the topology. It is therefore sufficient to execute the `gicadm enable-replication` once for the first two instances of Oracle Unified Directory proxy in the topology, and once for each new instance of Oracle Unified Directory proxy added to extend the topology.

The Oracle Unified Directory proxy instance on which you execute the command must be the instance whose replication port is declared by the `--localReplicationPort` option. It is this local instance whose global index catalog is replicated across the topology later by the `gicadm initialize-replication` command. The `--remoteReplicationPort` option will replicate the content of the global index catalog called *sampleCatalog* from the local instance on to the remote instance. The `--remoteAdminPort` is the administration port of the remote instance of Oracle Unified Directory proxy.

You can optionally declare the password for the local instance of Oracle Unified Directory proxy in a file, using the `--adminPasswordFile` suboption.

You can optionally declare the password for the remote instance of Oracle Unified Directory proxy in a file, using the `--remoteBindPasswordFile` suboption.

You can optionally declare a DN and associated password for binding to the remote server, using the `--remoteBindDN` and `--remoteBindPassword` suboptions. If you do not declare these, the global administrator declared by `--adminUID` will be used to bind.

You can also optionally require the communication through the replication port of the local server to be secure, using the `--localSecureReplication` suboption, and the communication through the replication port of the remote server to be secure, using the `--remoteSecureReplication` suboption.

▼ To Initialize Global Index Catalog Replication

This command initializes the content of the global index catalog called *sampleCatalog* from the instance of Oracle Unified Directory proxy on the server declared by the `-h` option to all instances that are part of the topology. The port specified is the administration port, and not the replication port.

1 **To initialize the replication of a global index catalog to all instances of Oracle Unified Directory proxy that are part of the replication topology, use the `gicadm initialize-replication --all` as follows:**

```
$ gicadm -h localhost -D "cn=Directory Manager" -p 4444 -w password -X \
initialize-replication --catalogName sampleCatalog \
--adminUID adminUID --all
```

2 **Check that replication is complete by using the `gicadm status-replication` command.**

If replication is complete, the status for all instances of Oracle Unified Directory proxy in the topology is given as `running replicated`.

Replication must be complete before restarting any proxy instances in the topology, for example after applying a patch.

For information about using the `gicadm status-replication` command, see "To View the Status of a Replicated Global Index Catalog Configuration" on page 112.

▼ To Disable Global Index Catalog Replication

● **To disable replication of global index catalogs, use the `gicadm disable-replication` command.**

```
$ gicadm -h localhost -D "cn=Directory Manager" -p 4444 -w password -X \
disable-replication --catalogName name --adminUID adminUID
```

The `gicadm disable-replication` command must be executed for each instance of Oracle Unified Directory proxy in the topology on which you want to disable replication.

▼ To View the Status of a Replicated Global Index Catalog Configuration

● **To display basic configuration information about a replicated global index catalog, use the `gicadm status-replication` command.**

```
$ gicadm -h hostname -p 4444 -w password -X \
status-replication --catalogName name --adminUID adminUID
```

If you do not declare a catalog name, status information for all replicated global index catalogs is displayed.

Logging of Replication Activities

Replication logs are stored in the replication repair logs. Changes are recorded in the change logs. For information on accessing these logs, see "Accessing Logs" on page 496

When replicating global index catalogs, provision disk space for change logs. By default, these logs store changes for a 24 hour period. Approximately 100Mb is required for 300,000 write operations. With the default value of 24 hours, the log must be configured based on the expected size of the service during that period. A hint is to provision approximately 150Gb for 5

000 modifications per second over 24 hours. For information how to configure logs, see "Configuring Logs With the Log Publisher" on page 461.

Lifecycle Examples for Replicated Global Index Catalogs

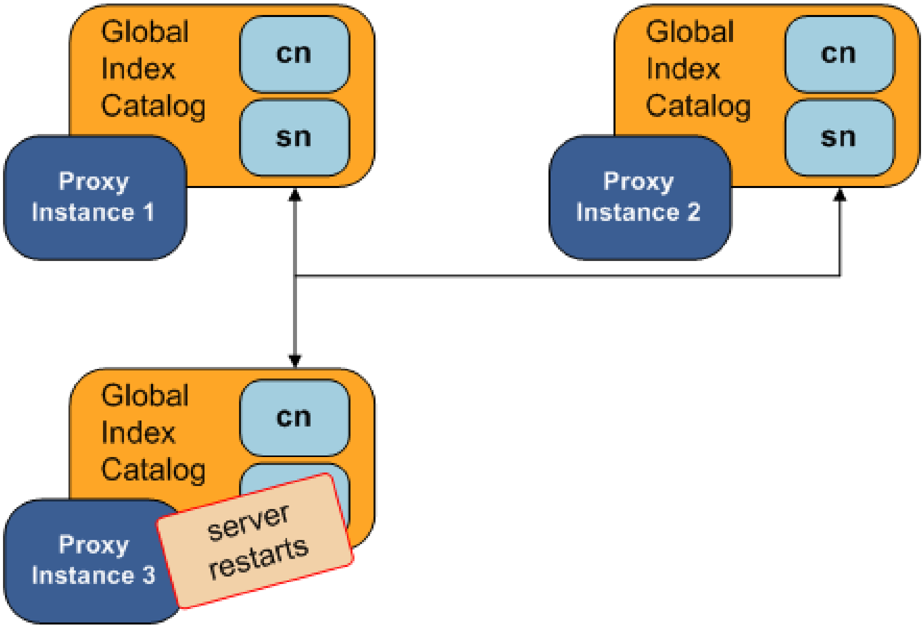
This section describes several typical lifecycle examples in which events take place in a replication topology. The basic replication topology used in all of these examples is the one created in "To Create a Replicated Topology and Enable Global Index Catalog Replication" on page 109.

EXAMPLE 3–2 To Restart a Global Index Catalog in a Replicated Topology

In the example illustrated by Figure 3–1, three instances of Oracle Unified Directory proxy are running with a replicated global index catalog. If proxy instance 3 goes down or is stopped, for whatever reason, follow these steps to ensure that the three instances of the proxy are replicated.

1. Issue the `start-ds` command on proxy instance 3.
2. You can check to see if replication is complete by executing the `gicadm status-replication` command, as described in "To View the Status of a Replicated Global Index Catalog Configuration" on page 112.

FIGURE 3–1 Restarting a Global Index Catalog

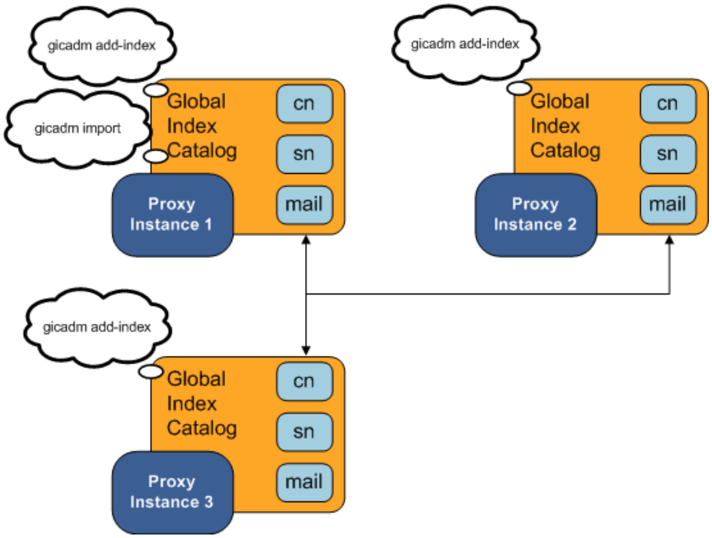


EXAMPLE 3–3 Adding a Global Index to a Replicated Global Index Catalog Topology

In the example illustrated by Figure 3–2, three instances of Oracle Unified Directory proxy are running with a replicated global index catalog. If you want to add an additional attribute, for example, `mail`, to the replicated global index catalog, follow these steps.

1. First, run the command `gicadm add-index mail` on each of the three proxy instances.
2. Export the directory data under the distribution route from one of the remote LDAP servers to an LDIF file named *file1* by using `export-ldif`.
3. Run `split-ldif` to generate GIC content in the specified directory.
4. On proxy instance 1, execute the command `gicadm import --importDirectory` *directory-name*.
5. On proxy instance 1, execute the `gicadm initialize-replication --all` command. This command pushes the changes from proxy 1 to all the other proxies in the topology, and adds the new global index.

FIGURE 3–2 Adding a Global Index to a Replicated Global Index Catalog Topology



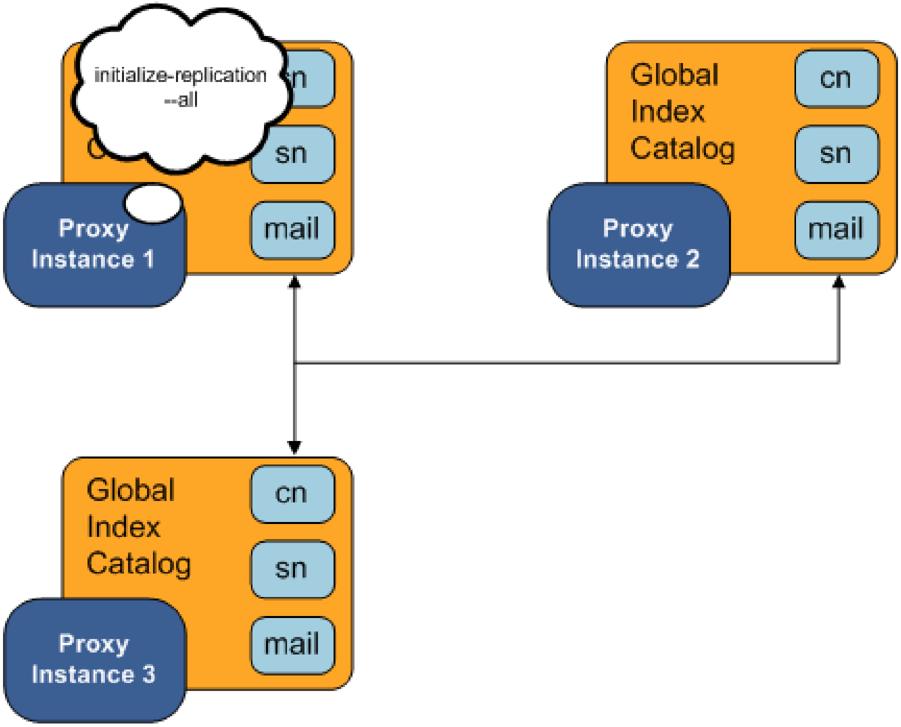
EXAMPLE 3–4 Overwriting the Contents of Replicated Global Index Catalogs

In the example illustrated by Figure 3–3, three instances of Oracle Unified Directory proxy are running with a replicated global index catalog. To overwrite the content of the global index catalogs on proxy instances 2 and 3 with the content of the global index catalog on instance 1, follow these steps.

EXAMPLE 3–4 Overwriting the Contents of Replicated Global Index Catalogs *(Continued)*

1. On proxy instance 1, execute the `gicadm initialize-replication --all` command. This replaces the content of the global index catalog on proxy instance 2 and 3 with the content of the global index catalog on proxy instance 1.

FIGURE 3–3 Overwriting the Contents of Replicated Global Index Catalogs



EXAMPLE 3–5 Adding a Proxy to a Replicated Topology

In the example illustrated by Figure 3–4, three instances of Oracle Unified Directory proxy are running with a replicated global index catalog. To add a fourth instance of Oracle Unified Directory proxy with a replicated global index catalog, follow these steps on the new proxy instance.

1. On the new proxy instance 4, execute the `gicadm create-catalog` command.
2. Run the commands`gicadm add-index cn`, `gicadm add-index sn`, and `gicadm add-index mail`.
3. Execute the `gicadm associate` command.

EXAMPLE 3–5 Adding a Proxy to a Replicated Topology *(Continued)*

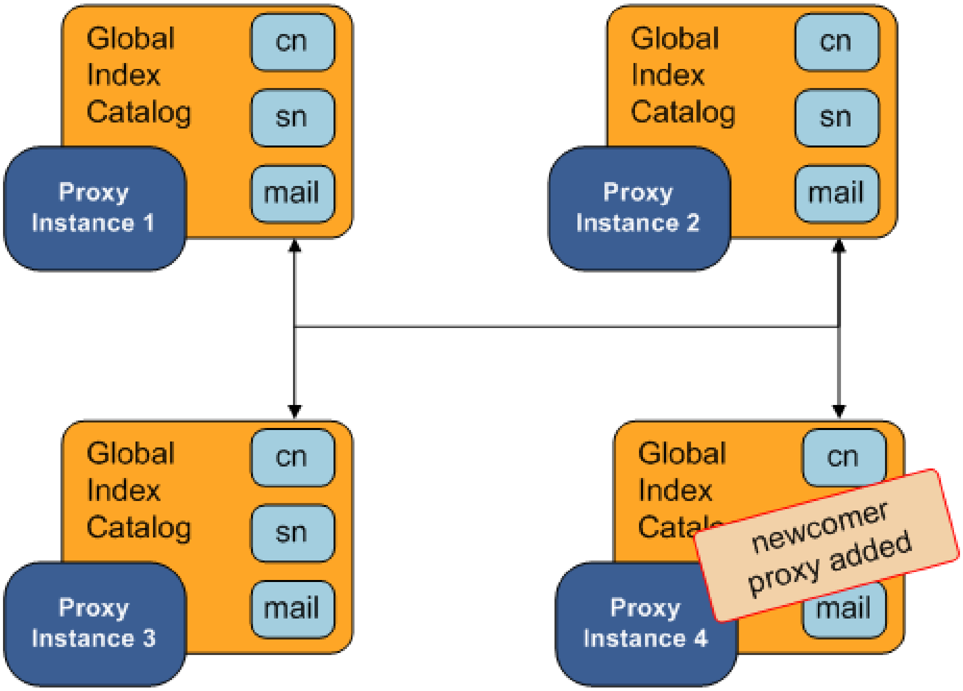
4. Run the following command:

```
gicadm enable-replication --localReplicationPort replication port of instance 4 --remoteHost name or IP address of host running ins
```

   This command configures replication between instance 1 and instance 4.

5. Run the `initialize replication --from proxy 1` command.

FIGURE 3–4 Adding a Proxy to a Replicated Topology



Configuring Controls Required by the Global Index Catalog with Oracle Unified Directory

If you are using Oracle Unified Directory proxy with Oracle Unified Directory as an LDAP data source, the connections between the proxy and directory servers must be bound using the directory server's administrator ID. Otherwise, some configuration is required on the directory server to allow the global index catalog to function correctly.

Provided that global ACIs for controls have not been modified, use the `ldapmodify` command to apply the following changes to the directory server:

```
dn: cn=Access Control Handler,cn=config
changetype: modify
add: ds-cfg-global-aci
ds-cfg-global-aci:
(targetcontrol="2.16.840.1.113730.3.4.2 || 2.16.840.1.113730.3.4.17 |
| 2.16.840.1.113730.3.4.19 || 1.3.6.1.4.1.4203.1.10.2 || 1.3.6.1.4.1.42.2.27.8.5.1 |
| 2.16.840.1.113730.3.4.16 || 1.3.6.1.1.13.1 || 1.3.6.1.4.1.42.2.27.9.5.9")
(version 3.0; acl "Anonymous control access"; allow(read) userdn="ldap:///anyone";)
 ds-cfg-global-aci: (targetattr="createTimestamp||creatorsName||modifiersName|
|modifyTimestamp||entryDN||entryUUID||subschemaSubentry||aclRights||aclRightsInfo")
(version 3.0; acl "User-Visible Operational Attributes"; allow (read,search,compare)
 userdn="ldap:///anyone";)
-
delete: ds-cfg-global-aci
ds-cfg-global-aci:
(targetcontrol="2.16.840.1.113730.3.4.2 || 2.16.840.1.113730.3.4.17 |
| 2.16.840.1.113730.3.4.19 || 1.3.6.1.4.1.4203.1.10.2 || 1.3.6.1.4.1.42.2.27.8.5.1 |
| 2.16.840.1.113730.3.4.16") (version 3.0; acl "Anonymous control access"; allow(read)
 userdn="ldap:///anyone";)
ds-cfg-global-aci:
(targetattr="createTimestamp||creatorsName||modifiersName|
|modifyTimestamp||entryDN||entryUUID||subschemaSubentry")(version 3.0;
acl "User-Visible Operational Attributes";
 allow (read,search,compare) userdn="ldap:///anyone";)
```

Note that the OIDs provided above are correct for an unmodified configuration of Oracle Unified Directory. If the default OIDs have been changed, modify the command include the correct OIDs.

The following controls are required for global index catalogs:

- The Pre-Read Control, with OID = `1.3.6.1.1.13.1`
- The CSN Control, with OID = `1.3.6.1.4.1.42.2.27.9.5.9`

Managing the Proxy Configuration With ODSM

This section describes the elements of the proxy server configuration that can be managed with Oracle Directory Services Manager.

Configure Load Balancing

If you have set up a proxy server instance without configuring either load balancing or distribution, you can configure load balancing by using ODSM. Before you begin, it is useful to understand the components that make up a load balancing deployment. For more information, see “Configuration 1: Simple Load Balancing” in *Oracle Fusion Middleware Deployment Planning Guide for Oracle Unified Directory*.

To configure load balancing by using ODSM, peform the following steps:

1. Connect to the proxy server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Home** tab.
3. Under the **Configuration** item, select **Set up Load Balancer**.
4. On the **Load Balancing: Backend Servers** screen, complete the following information:
   - In the **Load Balancing Name** field, provide a name for this load balancing workflow element.
   - Click **Add** to provide the connection details of at least two replicated backend LDAP servers across which client requests will be balanced.

     ODSM attempts to connect to these backend LDAP servers, to verify that they are accessible. If the connection attempt is unsuccessful, you are prompted to use the server details anyway, or to verify the connection details.
5. When you have added all the backend LDAP servers, click **Next** to continue.
6. On the **Load Balancing: Options** screen, complete the following information:
   - Select the **Load Balancing Algorithm**.
   - Depending on the load balancing algorithm you have selected, specify the relative weight or priority for each backend LDAP server.

   For information about the load balancing algorithms, see "Load Balancing Using the Proxy" in *Oracle Fusion Middleware Deployment Planning Guide for Oracle Unified Directory*.
7. When you have specified the load balancing options, click **Next** to continue.
8. On the **Load Balancing: Naming Contexts** screen, click **Add** to specify at least one naming context, or suffix, that will be handled by this proxy instance.
9. When you have added all of the required naming contexts, click **Next** to continue.
10. On the **Load Balancing Setup: Summary** screen, review the load balancing configuration and click **Finish** to complete the configuration.

When you have configured load balancing, you can modify any aspect of the configuration on the ODSM Configuration tab.

Configure Distribution

If you have set up a proxy server instance without configuring either load balancing or distribution, you can configure distribution by using ODSM. Before you begin, it is useful to understand the components that make up a distribution deployment. For more information, see "Configuration 2: Simple Distribution" in *Oracle Fusion Middleware Deployment Planning Guide for Oracle Unified Directory*.

To configure distribution by using ODSM, peform the following steps:

1. Connect to the proxy server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Home** tab.
3. Under the **Configuration** item, select **Set Up Distributor**.
4. On the **Distribution: Data Partitioning** screen, complete the following information:
   - Select the **Number of Partitions**.
   - Select the **Distribution Algorithm**. For more information about the available distribution algorithms, see "Data Distribution Using the Proxy" in *Oracle Fusion Middleware Deployment Planning Guide for Oracle Unified Directory*.
   - Enter the **Naming Context**, or suffix, that will be handled in this distribution deployment.
   - Select the **Network Group** in which the distributor will be configured.
   - Enter the capacity, DN Pattern, or boundaries for each partition, depending on the distribution algorithm that you have selected.
5. When you have entered all of the partition details, click **Next** to continue.
6. On the **Distribution: Server Partitions**, for each partition, click **Add** to enter the connection details of each backend LDAP server that will hold the partitioned data.

   ODSM attempts to connect to these backend LDAP servers, to verify that they are accessible. If the connection attempt is unsuccessful, you are prompted to use the server details anyway, or to verify the connection details.
7. When you have added all of the required servers, click **Next** to continue.
8. On the **Distribution: Global Index** screen, specify the global index details. For more information about global indexes, see "Global Index Catalog" in *Oracle Fusion Middleware Deployment Planning Guide for Oracle Unified Directory*.
9. When you have configured the global index, click **Next** to continue.
10. On the **Distribution: Summary** screen, review the distribution configuration and click **Finish** to complete the configuration.

When you have configured distribution, you can modify any aspect of the configuration on the ODSM Configuration tab.

CHAPTER 4

Configuring Security Between Clients and Servers

Oracle Unified Directory provides several mechanisms to secure traffic between the client and the server. The topics in this section describe these mechanisms, and how to configure them.

For information about securing access to directory data, see Chapter 9, "Controlling Access To Data."

For information about configuring security between the Oracle Unified Directory proxy and the directory server or data source, see Chapter 5, "Configuring Security Between the Proxy and the Data Source."

This chapter covers the following topics:

Getting SSL Up and Running Quickly

Oracle Unified Directory provides a number of options for configuring and using SSL and StartTLS. The numerous possibilities for configuration might be daunting for those who are unfamiliar with the technology or who just want to get up and running as quickly as possible for testing purposes.

This chapter provides a rough list of the steps that must be performed to allow Oracle Unified Directory to accept SSL-based connections using a self-signed certificate. The chapter also demonstrates how to configure SSL and StartTLS if you install the server using the QuickStart utility. Each configuration step is described in more detail in the chapters that follow.

The procedures in this section presume a knowledge of truststores and keystores. For detailed information about keystores, see "Configuring Key Manager Providers" on page 125. For detailed information about truststores, see "Configuring Trust Manager Providers" on page 131.

▼ To Accept SSL-Based Connections Using a Self-Signed Certificate

This procedure assumes the following:

- Oracle Unified Directory is installed on the system on which you are working.
- The Java `keytool` utility is in your path. If it is not, either add it to your path or provide the complete path to it when invoking the commands. The `keytool` utility is provided with the Java Runtime Environment (JRE).
- The administration connector is listening on the default port (4444) and the `dsconfig` command is accessing the server running on the local host. If this is not the case, the `--port` and `--hostname` options must be specified.

1 Generate a private key for the certificate, using the `keytool` command with the `-genkeypair` option.

For example:

```
$ keytool -genkeypair -alias server-cert -keyalg rsa \
  -dname "CN=myhost.example.com,O=Example Company,C=US" \
  -keystore config/keystore -storetype JKS
```

- `-alias` *alias*. Specifies the name that should be used to refer to the certificate in the keystore. The default name used by the server is `server-cert`.
- `-keyalg` *algorithm*. Specifies the algorithm that should be used to generate the private key. This should almost always be `rsa`.
- `-dname` *subject*. Specifies the subject to use for the certificate.

  Change the value of the `-dname` argument so that it is suitable for your environment:

  - The value of the `CN` attribute should be the fully-qualified name of the system on which the certificate is being installed.
  - The value of the `O` attribute should be the name of your company or organization.
  - The value of the `C` attribute should be the two-character abbreviation for your country.
- `-keystore` *path*. Specifies the path to the keystore file. The file will be created if it does not already exist. The default keystore path used by the server is `config/keystore`.

- `-keypass` *password*. Specifies the password that should be used to protect the private key in the keystore. If the password is not provided, you will be prompted for it.
- `-storepass` *password*. Specifies the password that should be used to protect the contents of the keystore. If the password is not provided, you will be prompted for it. The server expects the password used for the `-keypass` and `\-storepass` options to be the same.
- `-storetype` *type*. Specifies the keystore type that should be used. For the JKS keystore, for example, the value should always be `JKS`.

You are prompted for a password to protect the contents of the keystore and for a password to protect the private key.

2 **Generate a self-signed certificate for the key.**

For example:

```
$ keytool -selfcert -alias server-cert -validity 1825 \
   -keystore config/keystore -storetype JKS
```

- `-alias` *alias*. Specifies the name that should be used to refer to the certificate in the keystore. This name should be the same as the value used when creating the private key with the `-genkeypair` option.
- `-validity` *days*. Specifies the length of time in days that the certificate should be valid. The default validity is 90 days.
- `-keystore` *path*. Specifies the path to the keystore file. The file will be created if it does not already exist.
- `-keypass` *password*. Specifies the password that should be used to protect the private key in the keystore. If this is not provided, then you will be interactively prompted for it.
- `-storepass` *password*. Specifies the password that should be used to protect the contents of the keystore. If this is not provided, then you will be interactively prompted for it.
- `-storetype` *type*. Specifies the keystore type that should be used. For the JKS keystore, the value should always be `JKS`.

When you are prompted for the keystore password, enter the same password that you provided in the previous step.

3 **Create a text file named `config/keystore.pin`.**

The file must contain the password that you chose to protect the contents of the keystore. If you change this file, remember that it must match the keystore manager configuration. If you decide to create a file with a different name, for example, the corresponding keystore manager's `key-store-file` property for JKS must match the path and file name.

4 **Export the public key for the certificate that you created.**

For example:

```
$ keytool -exportcert -alias server-cert -file config/server-cert.txt -rfc \
   -keystore config/keystore -storetype JKS
```

5 Create a new trust store and import the server certificate into that trust store.

For example:

```
$ keytool -importcert -alias server-cert -file config/server-cert.txt \
  -keystore config/truststore -storetype JKS
```

6 (Optional) Type `yes` when you are prompted to trust the certificate.

This step is required *only* if the SSL and StartTLS settings were not specified during installation, or if you want to change those settings.

7 Use the `dsconfig` command to enable the key manager provider, trust manager provider, and connection handler.

For example:

```
$ dsconfig -D "cn=directory manager" -w password -n set-key-manager-provider-prop \
  --provider-name JKS --set enabled:true
$ dsconfig -D "cn=directory manager" -w password -n set-trust-manager-provider-prop \
  --provider-name "Blind Trust" --set enabled:true
$ dsconfig -D "cn=directory manager" -w password -n set-connection-handler-prop \
  --handler-name "LDAPS Connection Handler" \
  --set "trust-manager-provider:Blind Trust" --set key-manager-provider:JKS \
  --set listen-port:1636 --set enabled:true
```

Port `1636` is the standard LDAPS port, but you might not be able to use this port if it is already taken or if you are a regular user. If you need to accept SSL-based connections on a port other than `1636`, change the `listen-port` property in the last command to the port number being used.

If, in step 3, you created a text file with a location and name other than that `config/keystore.pin`, for example a text file called `config/mykeystore.pin`, specify that information as follows:

```
$ dsconfig -D "cn=directory manager" -w password -n set-key-manager-provider-prop \
  --provider-name JKS --set enabled:true \
  --set keystore-pin-file:/config/mykeystore.pin
```

For detailed information about keystores, see "Configuring Key Manager Providers" on page 125. For detailed information about truststores, see "Configuring Trust Manager Providers" on page 131.

8 The server should now have a second listener that accepts SSL-based client connections. Test the configuration with the `ldapsearch` command, for example:

```
$ ldapsearch --port 1636 --useSSL --baseDN "" --searchScope base "(objectClass=*)"
```

You are prompted to trust the server's certificate. On typing `yes`, the root DSE entry should be returned.

Configuring Key Manager Providers

Key manager providers are ultimately responsible for providing access to the certificate that should be used by the directory server when performing SSL or StartTLS negotiation.

This section covers the following topics:

- "Key Manager Provider Overview" on page 125
- "Using the JKS Key Manager Provider" on page 125
- "Using the PKCS #12 Key Manager Provider" on page 128
- "Using the PKCS #11 Key Manager Provider" on page 129

  PKCS #11 is not supported for use with the proxy.

For additional information, see the Key Manager Provider Configuration.

Key Manager Provider Overview

Oracle Unified Directory supports keystore formats for the following key manager providers:

- JKS keystore, which is the default keystore format used by Java Secure Socket Extension (JSSE)
- PKCS #12 file
- PKCS #11 device, such as a hardware security module or cryptographic accelerator

Note – PKCS #11 is not supported for use with Oracle Unified Directory proxy.

The process for configuring Oracle Unified Directory to use these key manager providers is described in detail in the following sections.

Using the JKS Key Manager Provider

The JKS keystore is the default keystore used by most JSSE implementations, and is the preferred keystore type in many environments. To configure the server to use this keystore type, you must first obtain a JKS keystore that contains a valid certificate. To do this, you can either generate a self-signed certificate or issue a certificate signing request to an existing Certificate Authority (CA) and import the signed certificate.

All of the steps described here require the use of the `keytool` utility, which is provided with the Java runtime environment. This utility is typically found in the `bin` directory below the root of the Java installation. For more information about using the `keytool` utility, see the official Java documentation (`http://download.oracle.com/javase/6/docs/technotes/tools/windows/keytool.html`).

Using the JKS key manager provider involves the following:

1. Generating the private key
2. Self-signing the certificate, or using an external certificate authority to sign the certificate
3. Configuring the JKS key manager provider

▼ To Self-Sign the Certificate

If the certificate is to be self-signed, use the `-selfcert` option. The most important arguments for use with this option include:

- `-alias` *alias*. Specifies the name that should be used to refer to the certificate in the keystore. This name should be the same as the value used when creating the private key with the `-genkeypair` option.
- `-validity` *days*. Specifies the length of time in days that the certificate should be valid. The default validity is 90 days.
- `-keystore` *path*. Specifies the path to the keystore file. The file will be created if it does not already exist.
- `-keypass` *password*. Specifies the password that should be used to protect the private key in the keystore. If this is not provided, then you will be interactively prompted for it.
- `-storepass` *password*. Specifies the password that should be used to protect the contents of the keystore. If this is not provided, then you will be interactively prompted for it.
- `-storetype` *type*. Specifies the keystore type that should be used. For the JKS keystore, the value should always be `JKS`.

● **Use the `keytool -selfcert` command to generate a self-signed certificate.**

```
$ keytool -selfcert -alias server-cert -validity 1825 \
  -keystore config/keystore -keypass password -storetype JKS \
  -storepass password
```

▼ To Sign the Certificate by Using an External Certificate Authority

If the certificate is to be signed by an external certificate authority, you must first generate a certificate signing request (CSR) using the `-certreq` option. The CSR can be submitted to a certificate authority to be signed. The method for doing this, and the method for obtaining the signed certificate, might vary from one certificate authority to another.

When you receive the signed certificate from the Certificate Authority, import it into the keystore with the `-importcert` option.

1 **Use the `-certreq` option to obtain a certificate signing request.**

```
$ keytool -certreq -alias server-cert -file /tmp/server-cert.csr \
  -keystore config/keystore -keypass password -storetype JKS \
  -storepass password
```

The arguments used with this command are as follows:

- `-alias` *alias*. Specifies the name that should be used to refer to the certificate in the keystore. This name should be the same as the value used when creating the private key with the `-genkeypair` option.
- `-file` *path*. Specifies the path to the file to which the CSR should be written. If this is not provided, the request will be written to standard output.
- `-keystore` *path*. Specifies the path to the keystore file. The file will be created if it does not already exist.
- `-keypass` *password*. Specifies the password that should be used to protect the private key in the keystore. If this is not provided, you will be interactively prompted for it.
- `-storepass` *password*. Specifies the password that should be used to protect the contents of the keystore. If this is not provided, you will be interactively prompted for it.
- `-storetype` *type*. Specifies the keystore type that should be used. For the JKS keystore, the value should always be `JKS`.

2 **Send the certificate request to an external certificate authority. The certificate authority will send you a signed certificate file. Save the file in `/tmp/server-cert.txt`**

3 **Use the `-importcert` to import the signed certificate.**

```
$ keytool -importcert -alias server-cert -file /tmp/server-cert.cert \
  -keystore config/keystore -storetype JKS -storepass password
```

The arguments used with this command are as follows:

- `-alias` *alias*. Specifies the name that should be used to refer to the certificate in the keystore. This name should be the same as the value used when creating the private key with the `-genkeypair` option.
- `-file` *path*. Specifies the path to the file containing the signed certificate. The file should be in either the DER-encoded binary format or the base64-encoded ASCII format as described in RFC 1421 (`http://www.ietf.org/rfc/rfc1421.txt`).
- `-keystore` *path*. Specifies the path to the keystore file. The file will be created if it doesn't already exist.
- `-storepass` *password*. Specifies the password that should be used to protect the contents of the keystore. If this is not provided, then you will be interactively prompted for it.
- `-storetype` *type*. Specifies the keystore type that should be used. For the JKS keystore, the value should always be `JKS`.

▼ To Configure the JKS Key Manager Provider

When you have created a JKS keystore containing a signed certificate (whether self-signed or signed by an external CA), you can configure the server to use that keystore by creating a key manager provider entry for that keystore.

This example defines an instance of a file-based key manager provider, using `dsconfig` to set the properties of the key manager provider. For details about the properties of the key manager provider, see the File Based Key Manager Provider Configuration.

- **Use the `dsconfig` command to create the key manager provider entry.**

```
$ dsconfig -D "cn=Directory Manager" -w password -X -n \
  set-key-manager-provider-prop --provider-name "JKS" \
  --set java-class:org.opends.server.extensions.FileBasedKeyManagerProvider \
  --set enabled:true --set "key-store-type:JKS" \
  --set "key-store-file:/config/keystore" \
  --set "key-store-pin:secret"
```

Using the PKCS #12 Key Manager Provider

PKCS #12 is a standard format for storing certificate information, including private keys. Oracle Unified Directory can use a PKCS #12 file as a certificate keystore if it includes the private key for the certificate.

Because PKCS #12 is a common format for storing certificate information, you might already have a certificate in this format, or the certificate authority (CA) that you use might create certificates in this form. In some cases, it might also be possible to convert an existing certificate into PKCS #12 format. For example, if you already have a certificate in a Network Security Services (NSS) certificate database, then the NSS `pk12util` tool can import it. The following example uses the `pk12util` tool to export a certificate named `server-cert` contained in the database `../../alias/slapd-config-key3.db` to a PKCS #12 file, `/tmp/server-cert.p12`:

```
$ ./pk12util -n server-cert -o /tmp/server-cert.p12 \
  -d ../../alias -P "slapd-config-"
```

To create a new certificate in PKCS #12 format, use the procedure described in "Using the JKS Key Manager Provider" on page 125 for obtaining a certificate in a JKS keystore. The only difference in the process is that you should use `-storetype PKCS12` instead of `-storetype JKS` when you invoke the `keytool` commands. For example, to create a self-signed certificate in a PKCS #12 file, use the following commands:

```
$ keytool -genkeypair -alias server-cert -keyalg rsa \
  -dname "CN=server.example.com,O=example.com,C=US" \
  -keystore config/keystore.p12 -keypass password \
  -storetype PKCS12 -storepass password

$ keytool -selfcert -alias server-cert -validity 1825 \
  -keystore config/keystore.p12 -keypass password \
  -storetype PKCS12 -storepass password
```

As with JKS, the server provides a template key manager provider for use with PKCS #12 certificate files that uses the same set of configuration attributes as the configuration entry for the JKS key manager provider. The only differences are that the value of the `key-store-type` attribute must be PKCS12, and the key-store-file attribute should refer to the location of the PKCS #12 file rather than a JKS keystore. The following example uses dsconfig to configure the PKCS #12 keystore manager provider:

```
$ dsconfig -D "cn=directory manager" -w password -X -n\
  set-key-manager-provider-prop --provider-name "PKCS12"
```

For a complete list of configurable properties, see the File Based Key Manager Provider Configuration.

Using the PKCS #11 Key Manager Provider

PKCS #11 is a standard interface used for interacting with devices capable of holding cryptographic information and performing cryptographic functions. The PKCS #11 interface has two common uses of interest for the directory server:

Note – The PKCS #11 format is not supported for use with the Oracle Unified Directory proxy.

- Cryptographic accelerators use this interface to allow products to offload their cryptographic processing to an external board (or in some cases, a special module inside the system's CPU or a framework inside the OS kernel), which might provide better performance for those operations.
- Hardware security modules (HSMs) use this interface to provide a secure repository for storing key information. This significantly reduces the likelihood that sensitive key information will be exposed and helps protect the overall integrity of the secure communication mechanisms.

At present, the PKCS #11 support that Oracle Unified Directory provides has been tested and verified only on systems running at least Solaris 10 (on SPARC and x86/x64 systems) through the use of the Solaris OS cryptographic framework. Any device that plugs into this Solaris cryptographic framework should be supported in this manner. This includes the *softtoken* device, which is simulated in software and is therefore available on all systems supporting the Solaris cryptographic framework regardless of whether they have a hardware device providing PKCS #11 support.

If you do have a third-party PKCS #11 device installed in a Solaris system, it is likely that the Solaris OS cryptographic framework is already configured to access that device. However, if you will simply be using the software token or if you are running on a Sun Fire T1000 or T2000 system and want to take advantage of the cryptographic processor included in the UltraSPARC—T1 CPU, you will likely need to initialize the PKCS #11 interface. This should first be accomplished by choosing a PIN to use for the certificate store, which can be done with this command:

```
$ pktool setpin
```

This command prompts you for the current passphrase. If you have not yet used the Solaris OS cryptographic framework, the default passphrase is `changeme`. You are then prompted twice for the new password.

Note – This step should be done while you are logged in as the user or as the role that will be used to run the directory server, because each user might have a different set of certificates.

At this point, it should be possible to use the Java `keytool` utility to interact with the Solaris cryptographic framework through PKCS #11. This will work much in the same way as it does when working with JKS or PKCS#12 keystores, with the following exceptions:

- The value of the `-keystore` argument must be `NONE`.
- The value of the `-storetype` argument must be `PKCS11`.
- You should not use the `-keypass` argument, and the tool will not prompt you for that password interactively if you do not provide it.
- The value of the `-storepass` argument must be the passphrase that you chose when using the `pktool setpin` command. Alternately, if you do not provide this argument on the command line, this is the password that you should enter when prompted.

For example, the following commands use the PKCS #11 interface to generate a self-signed certificate through the Solaris cryptographic framework:

```
$ keytool -genkeypair -alias server-cert -keyalg rsa \
  -dname "CN=server.example.com,O=example.com,C=US" \
  -keystore NONE -storetype PKCS11 -storepass password

$ keytool -selfcert -alias server-cert -validity 1825 \
  -keystore NONE -storetype PKCS11 -storepass password
```

When the certificate is installed in the PKCS #11 keystore, the directory server must be configured to use that keystore. Configure the PKCS #11 keystore provider in the same way as the entry for the JKS and PKCS#12 keystore manager providers, with the exception that the `key-store-file` attribute is not included. However, a PIN is still required and is provided either directly, in a PIN file, through a Java property, or through an environment variable.

The following example uses `dsconfig` to configure the PKCS #11 key manager provider:

```
$ dsconfig -D "cn=directory manager" -w password -X -n \
  set-key-manager-provider-prop --provider-name "PKCS11"
```

For a complete list of configurable properties, see the PKCS11 Key Manager Provider Configuration.

Developing Custom Key Manager Providers

If none of the key manager providers available with Oracle Unified Directory suits your needs, you can create your own key manager provider to obtain the key material from virtually anywhere you like.

To create a custom key manager provider, create a class that extends the `org.opends.server.api.KeyManagerProvider` super class and implement the methods that it contains. The source for the existing key manager providers is located in the `org.opends.server.extensions` package and can be useful for reference purposes.

Configuring Trust Manager Providers

Oracle Unified Directory uses trust manager providers to determine whether to trust a certificate that is presented to it. Trust managers serve an important role in the overall security of the system by ensuring that the peer (the system at the other end of the connection, whether it is an inbound connection from a client or an outbound connection to another server) is who it claims to be.

This section covers the following topics:

- "Overview of Certificate Trust Mechanisms" on page 131
- "Using the Blind Trust Manager Provider" on page 133
- "Using the JKS Trust Manager Provider" on page 133
- "Using the PKCS #12 Trust Manager Provider" on page 135

Overview of Certificate Trust Mechanisms

A trust manager provider can improve security whenever SSL or StartTLS is used by thwarting attempts to use forged certificates and foiling man-in-the-middle attacks.

The two primary use cases for trust manager providers are as follows:

- Inbound connections: a client presents its own certificate to the server during the SSL or StartTLS negotiation process, potentially for use in SASL EXTERNAL authentication.
- Outbound connections: the server attempts to establish an SSL-based connection to an external system, for example for the purpose of synchronization or for proxied or chained operations.

The trust manager has no impact on the strength of the encryption, so only the server and its peer will be able to understand the communication. Any third-party observer will be unable to decipher the exchange. The trust manager is responsible for ensuring that the peer is who it claims to be so that confidential information is not inadvertently exposed to one peer masquerading as another.

The trust manager considers a number of factors to determine whether a peer certificate should be trusted. This topic describes some of the most common criteria that are taken into account during this process.

One of the simplest trust mechanisms is the validity period for the certificate. All certificates have a specific window during which they should be considered valid, bounded by "notBefore" and "notAfter" time stamps. If the current time is beyond the "notAfter" time stamp, the certificate is expired and trust managers reject it. Similarly, certificates are also typically rejected if the current time is before the "notBefore" time stamp. Most often, the "notBefore" time stamp is set to the time that the certificate was signed, but there are cases in which a certificate might be issued that is not immediately valid. In those cases, it is important to ensure that the peer is not granted access too early.

Another very important factor in deciding whether to trust a peer certificate is the peer certificate chain. When one system presents its certificate to another, it does not present its certificate only, but a chain of certificates that describes all entities involved in the process. When a trust manager is attempting to determine whether to trust a peer, the trust manager first looks in its trust store to determine whether it contains the peer certificate. If that certificate is found, the peer will be trusted (barring rejection for another reason, such as being outside the validity period). If the peer's certificate is not found, the trust manager looks at the next certificate in the chain, which will be the certificate that was used to sign the peer's certificate (also called the issuer certificate). If the trust store contains the issuer's certificate, the server will trust that issuer certificate and will also implicitly trust any certificate that it has signed. This process continues up the certificate chain (looking at the certificate that signed the issuer certificate, and so on) until one of the certificates is found in the trust store or until the root of the chain is reached (in which case, the root certificate will be self-signed and therefore will be its own issuer). If none of the certificates in the peer chain is contained in the trust store, the peer's certificate is rejected.

This process makes it much easier to manage an environment with a large number of certificates (for example, one in which there is a large number of servers or in which many clients use SASL EXTERNAL authentication). It is not necessary for the trust store to have each individual peer certificate. The trust store can contain only one of the certificates in the peer chain. For example, if all of the certificates that might legitimately be presented to the server were signed by the same issuer, it is necessary to have only that issuer's certificate in the trust store in order to implicitly trust any of the peers.

In some environments, there might be other elements taken into account when deciding to trust a peer certificate chain. For example, there might be a certificate revocation list (CRL) that contains a list of all of the certificates that have been revoked and should no longer be considered valid even if they are still within their validity period and were signed by a trusted issuer. This can be useful, for example, if the certificate belonged to an employee that has left the company or if the private key for the certificate has been compromised. The Online Certificate Status Protocol (OCSP, as described in RFC 2560 (`http://www.ietf.org/rfc/rfc2560.txt`) also provides a similar mechanism, in which the trust manager might ask an OCSP server whether a given certificate is still valid. Oracle Unified Directory currently does not support using CRLs or OCSP when attempting to determine whether a peer certificate chain should be trusted.

Using the Blind Trust Manager Provider

The blind trust manager provider is a simple provider that trusts any certificate that is presented to it. It does not look at the expiration date, who signed the certificate, the subject or alternate names, or any other form of criteria.

The directory server provides a blind trust manager provider that is disabled by default. You can enable the provider by changing the value of the `enabled` attribute to `true`. The blind trust manager provider does not require any other configuration attributes.

Note – The blind trust manager provider is not supported for Oracle Unified Directory proxy.

The following example uses `dsconfig` to configure the blind trust manager provider:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X\
  set-trust-manager-provider-prop --provider-name "Blind Trust"
```

For a list of the configurable properties, see the Blind Trust Manager Provider Configuration.

Caution – The blind trust manager provider is provided as a convenience for testing purposes only and should never be used in a production server, especially one that is configured to allow SASL EXTERNAL authentication. If a client attempts to use SASL EXTERNAL to authenticate to the directory server using a certificate and the server blindly accepts any certificate that the client presents, the user can create a self-signed certificate that allows it to impersonate any user in the directory.

Using the JKS Trust Manager Provider

Just as the JKS keystore can be used to provide the key material for a key manager provider, it can also be used to provide information that can used by trust manager providers. In general, using a JKS file as a trust store is similar to using it as a keystore. However, because private key information is not accessed when the file is used as a trust store, there is generally no need for a PIN when accessing its contents.

When the JKS trust manager provider determines whether to trust a given peer certificate chain, it considers two factors:

- Is the peer certificate within the validity period?
- Is any certificate in the chain contained in the trust store?

If the peer certificate is not within the validity period or none of the certificates in the peer certificate chain are contained in the trust store, the JKS trust manager rejects that peer certificate.

Use the `keytool -importcert` utility to import certificates into a JKS trust store. The `-importcert` option uses these arguments:

- `-alias` *alias*. Specifies the name to give to the certificate in the trust store. Give each certificate a unique name, although the nickname is primarily for managing the certificates in the trust store and has no impact on whether a certificate is trusted.
- `-file` *path*. Specifies the path to the file containing the certificate to import. The file can be in either DER format or in base64-encoded ASCII format, as described in RFC 1421 (`http://www.ietf.org/rfc/rfc1421.txt`).
- `-keystore` *path*. Specifies the path to the file used as the JKS trust store. This path is typically `config/truststore`.
- `-storetype` *type*. Specifies the format of the trust store file. For the JKS trust manager, this must be `JKS`.
- `-storepass` *password*. Specifies the password used to protect the contents of the trust store. If the trust store file does not exist, this value is the password to assign to the trust store, and must be used for future interaction with the trust store. If this option is not provided, the password is interactively requested from the user.

The following command provides an example of importing a certificate into a JKS trust store. If the trust store does not exist, this command creates the trust store before importing the certificate.

```
$ keytool -importcert -alias server-cert -file /tmp/cert.txt \
  -keystore config/truststore -storetype JKS -storepass password
```

Oracle Unified Directory provides a template JKS trust manager provider. Use `dsconfig` to configure the following properties of the JKS trust manager provider:

- `enabled`. Indicates whether the JKS trust manager provider is enabled. The JKS trust manager provider is not available for use by other server components unless the value of this property is `true`.
- `trust-store-file`. The path to the trust store file, which is typically `config/truststore`, although an alternate file can be used if needed. The value of this property can be either an absolute path or a path that is relative to the *install-dir*.
- `trust-store-type`. The format of the trust store. For the JKS trust store provider, the value of this property is `JKS`.

The following example uses dsconfig interactive mode to configure the JKS trust manager provider:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X \
  set-trust-manager-provider-prop --provider-name "JKS"
```

For a list of the configurable properties, see the File Based Trust Manager Provider Configuration.

Using the PKCS #12 Trust Manager Provider

The PKCS #12 trust manager provider is primarily useful if you already have the peer or issuer certificates to be used in a PKCS #12 file. If you do not have the certificates in this format, use the JKS trust manager provider instead. The Java keytool utility does not currently support importing trusted certificates (that is, those with just a public key and no private key information) into a PKCS #12 file.

Oracle Unified Directory provides a template PKCS #12 trust manager provider. Use dsconfig to configure the following properties of the PKCS #12 trust manager provider:

- enabled. Indicates whether the PKCS #12 trust manager provider is enabled. The trust manager provider is not available for use by other server components unless this property has a value of true.
- trust-store-type. Specifies the format of the trust store. For the PKCS #12 trust manager provider, the value is PKCS12.
- trust-store-file. Specifies the path to the trust store file, which is typically config/truststore.p12, although an alternate file can be used if needed. The value of this property can be either an absolute path or a path that is relative to the *install-dir*.

A PIN might be required to access the contents of the PKCS #12 file. In this case, one of the following configuration attributes must be used to provide the password. (At the present time, the password must be provided in clear text.)

- trust-store-pin. Specifies the PIN needed to access the trust store directly.
- trust-store-pin-file. Specifies the path to a file containing the PIN needed to access the trust store. The value of this property can be either an absolute path or a path that is relative to the server root.
- trust-store-pin-property. Specifies the name of a Java property that holds the PIN needed to access the trust store.
- trust-store-pin-environment-variable. Specifies the name of an environment variable that holds the PIN needed to access the trust store.

  The following example uses dsconfig to configure the PKCS #12 trust manager provider:

```
$ dsconfig -D "cn=directory manager" -w password \
  set-trust-manager-provider-prop \
  --provider-name "PKCS12"
```

Configuring Certificate Mappers

A *certificate mapper* examines a certificate presented by a client and maps it to the user in the directory that should be associated with that certificate. It is primarily used in the context of processing SASL EXTERNAL authentication, in which case the client wants to authenticate to the server using its SSL certificate rather than a password or some other form of credentials.

Note – This is not applicable to Oracle Unified Directory proxy.

The examples in this section use the `dsconfig` command to modify certificate mappers. The `dsconfig` command accesses the server configuration over SSL, using the administration connector. For more information, see "Managing the Server Configuration With `dsconfig`" on page 25.

Using the Subject Equals DN Certificate Mapper

The Subject Equals DN certificate mapper is a simple certificate mapper that expects the subject of the client certificate to be exactly the same as the distinguished name (DN) of the corresponding user entry. Using this certificate mapper is easy because there are no configuration attributes associated with it. However, this mapper is not suitable for many environments because certificate subjects and user DNs are often not the same.

To enable or disable the Subject Equals DN certificate mapper, use `dsconfig` to set its `enabled` property to `true` or `false`. The following example uses `dsconfig` to configure the Subject Equals DN certificate mapper.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-certificate-mapper-prop \
  --mapper-name "Subject Equals DN" --advanced
```

Using the Subject Attribute to User Attribute Certificate Mapper

The Subject Attribute to User Attribute certificate mapper attempts to map a client certificate to a user entry based on a set of attributes that they have in common. In particular, it takes the values of a specified set of attributes from the certificate subject and attempts to locate user entries that contain those same values in a corresponding set of attributes.

Use dsconfig to set the properties of this certificate mapper:

- subject-attribute-mapping. Specifies a multi-valued property that is used to map attributes from the certificate subject to attributes in user entries. Values for this attribute consist of the name of the attribute in the certificate subject followed by a colon and the name of the corresponding attribute in the user's entry. For example, the value e:mail maps the e attribute from the certificate subject to the mail attribute in user entries. At least one attribute mapping must be defined.
- user-base-dn. Specifies a multi-valued property that is used to specify the set of base DNs below which the server is to look for matching entries. If this is not present, then the server searches below all public naming contexts.

The following example uses dsconfig to configure the Subject Attribute to User Attribute certificate mapper:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-certificate-mapper-prop \
  --mapper-name "Subject Attribute to User Attribute" --advanced
```

If multiple attribute mappings are defined, then the server combines them with an AND search. For example, if two mappings are defined cn:cn and e:mail, and the server is presented with a certificate having a subject of E=john.doe@example.com,CN=John Doe,O=Example Corp,C=US, then it generates a search filter of (&(cn=John Doe)(mail=john.doe@example.com)). Any attribute for which a mapping is defined but is not contained in the certificate subject is not included in the generated search filter. All attributes that can be used in generated search filters should have corresponding indexes in all remote LDAP databases that can be searched by this certificate mapper.

For the mapping to be successful, the generated search filter must match exactly one user in the directory (within the scope of the base DNs for the mapper). If no users match the generated criteria or if multiple users match, then the mapping fails.

Using the Subject DN to User Attribute Certificate Mapper

The Subject DN to User Attribute certificate mapper attempts to establish a mapping by searching for the subject of the provided certificate in a specified attribute in user entries. In this case, you must ensure that user entries are populated with the subjects of the certificates associated with those users. However, it is possible that this process could be automated in the future with a plug-in that automatically identifies any certificates contained in a user entry and adds the subjects of those certificates to a separate attribute.

Use dsconfig to set the properties of this certificate mapper:

- subject-attribute. This is a single-valued attribute whose value is the name of the attribute type that should contain the certificate subject in user entries. This attribute must be defined in the server schema, and it should be indexed for equality in all back ends that might be searched.

  The subject DN of the certificate received by the server will not contain any spaces between its RDN components, even though the certificate might have been created with them. The value of the subject-attribute in the user entries must also not contain any spaces between the RDN components, so that they will correctly match the subject DN of the received certificate. For example, if the original certificate looks like:

  ```
  keytool -printcert -file cert.002
  Owner: CN=test,  O=Test Certificate
  Issuer: CN=test,  O=Test Certificate
  Serial number: 49b55976
  Valid from: Mon Mar 09 19:01:26 MET 2009 until: Sat Mar 08 19:01:26 MET 2014
  Certificate fingerprints:
           MD5:  5E:08:78:36:DF:25:F4:6C:43:9E:7B:CF:1F:1E:B9:6B
           SHA1: B7:B9:1C:A0:B0:52:C3:87:3C:C2:70:27:11:6F:5E:58:C5:33:9D:6B
           Signature algorithm name: SHA1withRSA
           Version: 3
  ```

  The subject DN defined in the subject-attribute of the user entry should be:

  ```
  CN=test,O=Test Certificate
  ```

  Note the removal of the space between the RDN components of the subject-attribute.

- user-base-dn. This is a multivalued attribute that is used to specify the set of base DNs below which the server should look for matching entries. If this is not present, then the server will search below all public naming contexts.

The following example uses dsconfig to configure the Subject DN to User Attribute certificate mapper:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-certificate-mapper-prop \
  --mapper-name "Subject DN to User Attribute" --advanced
```

Although there is no standard attribute for holding the subjects of the certificates that a user might hold, the directory server does define a custom attribute type, ds-certificate-subject-dn, that can be used for this purpose. This attribute can be added to user entries along with the ds-certificate-user auxiliary object class. This attribute is multivalued attribute, and if a user has multiple certificates, then it should contain the subjects for each of them as separate values. However, this attribute is not indexed by default, so if it is to be used, update the corresponding back ends so that they contain an equality index for this attribute.

For the mapping to be successful, the certificate mapper must match exactly one user (within the scope of the base DNs for the mapper). If no entries match or if multiple entries match, then the mapping fails.

Using the Fingerprint Certificate Mapper

The Fingerprint certificate mapper attempts to establish a mapping by searching for the MD5 or SHA1 fingerprint of the provided certificate in a specified attribute in user entries. In this case, you must ensure that user entries are populated with the certificate fingerprints (in standard hexadecimal notation with colons separating the individual bytes, for example, `07:5A:AB:4B:E1:DD:E3:05:83:C0:FE:5F:A3:E8:1E:EB`). In the future, this process could be automated by a plug-in that automatically identifies any certificates contained in user entries and adds the fingerprints of those certificates to the appropriate attribute.

Use `dsconfig` to set the properties of this certificate mapper:

- `fingerprint-attribute`. Specifies a single-valued attribute whose value is the name of the attribute type that should contain the certificate fingerprint in user entries. This attribute must be defined in the server schema, and it should be indexed for equality in all back ends that can be searched.
- `fingerprint-algorithm`. Specifies which digest algorithm to use to calculate certificate fingerprints. The value is either `MD5` or `SHA1`.
- `user-base-dn`. Specifies a multi-valued attribute that is used to specify the set of base DNs below which the server is to look for matching entries. If this property is not present, then the server searches below all public naming contexts.

The following example uses `dsconfig` to configure the Fingerprint certificate mapper:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-certificate-mapper-prop \
  --mapper-name "Fingerprint Mapper" --advanced
```

Although there is no standard attribute for holding certificate fingerprints, the directory server does define a custom attribute type, `ds-certificate-fingerprint`, that can be used for this purpose. This attribute can be added to user entries along with the `ds-certificate-user` auxiliary object class. This attribute is multi-valued, and if a user has multiple certificates, then it should contain the fingerprints for each of them as separate values. However, this attribute type is not indexed by default in any of the server back ends, so if it is to be used, add the corresponding equality index to all appropriate back ends.

For the mapping to be successful, the certificate mapper must match exactly one user (within the scope of the base DNs for the mapper). If no entries match or if multiple entries match, then the mapping fails.

Configuring SSL and StartTLS for LDAP and JMX

When you have configured Oracle Unified Directory with at least one enabled key manager provider and at least one enabled trust manager provider, you can enable SSL and StartTLS for the connection handlers.

The examples in this section use the `dsconfig` command to modify the server configuration. The `dsconfig` command accesses the server configuration over SSL via the administration connector. As such, the relevant connection options must be specified, including how the SSL certificate is trusted. These examples use the `-X` option to trust all certificates.

Configuring the LDAP and LDAPS Connection Handlers

The LDAP connection handler is responsible for managing all communication with clients using LDAP. By default, the LDAP protocol does not specify any form of security for protecting that communication, but it can be configured to use SSL or also to allow the use of the StartTLS extended operation.

The server configures two connection handlers that can be used for this purpose. While the LDAP connection handler entry is enabled by default and is used to perform unencrypted LDAP communication, it can also be configured to support StartTLS. For information, see “To Enable StartTLS Support” on page 142. The LDAPS connection handler entry is disabled, but the default configuration is set up for “To Enable SSL-Based Communication” on page 142.

The following sections describe how to configure LDAP and LDAPS connection handler parameters with `dsconfig`.

▼ To Enable a Connection Handler

- **Set the `enabled` property of the connection handler to `true`.**

  This example enables the LDAP connection handler.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X \
  set-connection-handler-prop --handler-name "LDAP Connection Handler" \
  --set enabled:true
```

▼ To Specify a Connection Handler's Listening Port

- **Set the `listen-port` property of the connection handler.**

  The `listen-port` property specifies the port number to use when communicating with the server through this connection handler. The standard port to use for unencrypted LDAP communication (or LDAP using StartTLS) is `389`, and the standard port for SSL-encrypted

LDAP is 636. However, it might be desirable or necessary to change this in some environments (for example, if the standard port is already in use, or if you are running on a UNIX system as a user without sufficient privileges to bind to a port below 1024).

This example sets the LDAPS connection handler's listen port to 1636.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X \
  set-connection-handler-prop --handler-name "LDAPS Connection Handler" \
  --set listen-port:1636
```

▼ To Specify a Connection Handler's Authorization Policy

- **Set the `ssl-client-auth-policy` property of the connection handler.**

The `ssl-client-auth-policy` property specifies how the connection handler should behave when requesting a client certificate during the SSL or StartTLS negotiation process. If the value is `optional`, the server requests that the client present its own certificate but still accepts the connection even if the client does not provide a certificate. If the value is `required`, the server requests that the client present its own certificate and rejects any connection in which the client does not do so. If the value is `disabled`, the server does not ask the client to present its own certificate.

This example sets the LDAPS connection handler's authorization policy to `required`.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X \
  set-connection-handler-prop --handler-name "LDAPS Connection Handler" \
  --set ssl-client-auth-policy:required
```

▼ To Specify a Nickname for a Connection Handler's Certificate

- **Set the `ssl-cert-nickname` property of the connection handler.**

The `ssl-cert-nickname` property specifies the nickname of the certificate that the server presents to clients during SSL or StartTLS negotiation. This property is primarily useful when multiple certificates are in the keystore and you want to specify which certificate is to be used for that listener instance.

This example sets the nickname of the LDAP connection handler's certificate to `server-cert`.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X \
  set-connection-handler-prop --handler-name "LDAP Connection Handler" \
  --set ssl-cert-nickname:server-cert
```

▼ To Specify a Connection Handler's Key Manager Provider

- **Set the `key-manager-provider` property of the connection handler.**

The `key-manager-provider` property specifies which key manager provider among the available "Configuring Key Manager Providers" on page 125 that should be used by the connection handler to obtain the key material for the SSL or StartTLS negotiation.

This example sets the LDAP connection handler's key manager provider to JKS. The specified manager must already be configured for the command to succeed.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X \
  set-connection-handler-prop --handler-name "LDAP Connection Handler" \
  --set key-manager-provider:JKS
```

▼ To Specify a Connection Handler's Trust Manager Provider

● **Set the `trust-manager-provider` property of the connection handler.**

The `trust-manager-provider` property specifies which trust manager provider among the available "Configuring Trust Manager Providers" on page 131 to be used by the connection handler to decide whether to trust client certificates presented to it.

This example sets the LDAP connection handler's trust manager to JKS. The specified manager must already be configured for the command to succeed.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X \
  set-connection-handler-prop --handler-name "LDAP Connection Handler" \
  --set trust-manager-provider:JKS
```

▼ To Enable StartTLS Support

1. **Specify the appropriate values for the `key-manager-provider` and `trust-manager-provider` properties.**

2. **Set the `allow-start-tls` property to `true`, as follows:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X \
  set-connection-handler-prop --handler-name "LDAP Connection Handler" \
  --set allow-start-tls:true
```

Note – If SSL is enabled, the `allow-start-tls` property cannot be set.

StartTLS is not supported for connections between the Oracle Unified Directory proxy and the remote LDAP servers. Depending on the setting of the remote LDAP server SSL policy, StartTLS client connections can be passed from the proxy to the remote LDAP servers as SSL connections or as insecure connections. For more information, see "To Create a Global Index Catalog Containing Global Indexes" on page 103.

▼ To Enable SSL-Based Communication

1. **Display the connection handler properties to ensure that the configured key manager provider and trust manager provider values are correct.**

The following example displays the properties of the LDAPS connection handler:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X \
  get-connection-handler-prop --handler-name "LDAPS Connection Handler"
```

2 **Set the `enabled` property to `true`, as follows:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X \
  set-connection-handler-prop --handler-name "LDAPS Connection Handler" \
  --set enabled:true
```

Note – If SSL is enabled, non-SSL communication will not be available for that connection handler instance.

Enabling SSL in the JMX Connection Handler

The JMX connection handler can be used to communicate with clients using the JMX (Java Management Extensions) protocol. This protocol does not support the use of StartTLS to allow both encrypted and unencrypted communication over the same port, but it can be configured to accept only unencrypted JMX or only SSL-encrypted JMX communication.

The JMX connection handler provides the server's default configuration for communicating over JMX. To enable SSL for this connection handler, use `dsconfig` to set the following configuration attributes:

- `key-manager-provider`. Specifies the DN of the configuration entry for the key manager provider that is used to obtain the key material for the SSL negotiation.
- `ssl-cert-nickname`. Specifies the nickname (or alias) of the certificate that is presented to clients.
- `use-ssl`. Indicates whether the connection handler is to use SSL to communicate with clients.

The following example uses `dsconfig` to configure the JMX connection handler:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X \
  set-connection-handler-prop --handler-name "JMX Connection Handler"
```

Using SASL Authentication

The LDAP protocol definition provides two ways in which clients can authenticate to the server: LDAP simple authentication and SASL authentication.

Note – SASL is not supported for use with Oracle Unified Directory proxy.

In LDAP simple authentication, the client specifies the DN and password for the user. This is by far the most common authentication mechanism, and in most cases it is also the easiest to use. However, it has a number of limitations, including the following:

- The user is always required to provide a full DN, rather than something that could be more user-friendly like a username.
- Only password-based authentication is allowed.
- The client must provide the complete clear-text password to the server.

To address these issues, it is also possible to authenticate clients through the Simple Authentication and Security Layer (SASL), as defined in RFC 4422 (`http://www.ietf.org/rfc/rfc4422.txt`). This is a very extensible framework, and makes it possible for servers to support many different kinds of authentication.

Supported SASL Mechanisms

The directory server currently supports the following SASL mechanisms:

Note – With Oracle Unified Directory proxy, currently the only supported SASL mechanism is ANONYMOUS.

ANONYMOUS

This mechanism does not actually authenticate clients, but does provide a mechanism for including trace information in server logs for debugging purposes.

CRAM-MD5

This mechanism is provided for backward compatibility only. Do not configure CRAM-MD5 in a production environment. Use the DIGEST-MD5 mechanism instead, because it provides much better security.

DIGEST-MD5

This mechanism provides the ability for clients to use password-based authentication without sending the password to the server. Instead, the client only needs to provide information that proves it knows the password. This mechanism offers more options and better security than the CRAM-MD5 mechanism.

EXTERNAL

This mechanism provides the ability for clients to identify themselves based on information provided outside of the direct flow of LDAP communication. In Oracle Unified Directory, this may be achieved through the use of SSL client certificates.

GSSAPI

This mechanism provides the ability for clients to authenticate to the server through their participation in a Kerberos V5 environment.

PLAIN

This mechanism uses a password based authentication, but does offer the ability to use a username rather than requiring a DN.

Support for additional SASL mechanisms can be added by implementing custom SASL mechanism handlers in the server..

Because SASL mechanisms are so extensible, the set of information that the client needs to provide to the server in order to perform the authentication varies from one mechanism to another. As such, Oracle Unified Directory clients use a generic interface for users to provide this information. This is exposed through the `-o` or `--saslOption` argument, and the value for this argument should be a name-value pair. Select which SASL mechanism to use using the `mech` option, for example:

```
--saslOption mech=DIGEST-MD5
```

The other options that are available for use depend on the SASL mechanism that has been chosen, as described in the following sections.

Authorization IDs

Many of the SASL mechanisms below provide the ability to identify a user based on an authorization ID rather than a user DN. An authorization ID may be given in one of two forms:

`dn:`*dn* This is used to provide the full DN of the user to authenticate (for example, `dn:uid=john.doe,ou=People,dc=example,dc=com`). A value of `dn:` with no DN is to be treated as the anonymous user, although this form is not accepted by many of the SASL mechanisms listed below.

`u:`*username* This is used to provide the username of the user rather than the full DN (for example, `u:john.doe`).

If the `u:`*username* form is used, the mechanism that the server uses to resolve that username to the corresponding user entry is based on the identity mapping configuration within the server.

SASL Options for the ANONYMOUS Mechanism

Because the ANONYMOUS mechanism is not really used to perform authentication, no additional options are required. However, the following option can be supplied:

`trace` This option can be used to provide a trace string that is written to the server's access log. This can be useful for debugging or to identify the client, although without authentication it is not possible to rely on the validity of this value.

The following command demonstrates the use of SASL anonymous authentication:

```
$ ldapsearch --hostname server.example.com --port 1389 --saslOption mech=ANONYMOUS \
  --saslOption "trace=Example Trace String" --baseDN "" \
  --searchScope base "(objectClass=*)"
```

SASL Options for the CRAM-MD5 Mechanism

The CRAM-MD5 mechanism is used to perform password-based authentication to the server without exposing the clear-text password. It does this by providing an MD5 digest of the clear-text password combined with some randomly-generated data provided by the server, which helps prevent replay attacks.

The SASL CRAM-MD5 mechanism has one SASL option that must be provided:

`authid` This specifies the identity of the user that is authenticating to the server. It should be an authorization ID value as described above.

The password is specified using either the `--bindPassword` or `--bindPasswordFile` option, just as when using simple authentication. The following command demonstrates the use of SASL CRAM-MD5 authentication:

```
ldapsearch --hostname server.example.com --port 1389 --saslOption mech=CRAM-MD5 \
--saslOption authid=u:john.doe --baseDN "" --searchScope base "(objectClass=*)"
```

SASL Options for the DIGEST-MD5 Mechanism

The DIGEST-MD5 mechanism is similar to the CRAM-MD5 mechanism, but it is more secure because it combines random data from both the client and the server in order to help foil both replay and man-in-the-middle attacks. DIGEST-MD5 authentication also offers a number of SASL options, including the following:

`authid` Specifies the identity of the user that is authenticating to the server. This option must be provided.

`realm` This option should not be specified as a DN.

Note – Do not use the `realm` option, because the server does not use it when mapping identities.

`digest-uri` Specifies the digest URI that the client uses to communicate with the server. This is an optional parameter, but if it is provided, specify it in the form `ldap/`*serveraddress*, where *serveraddress* is the fully-qualified address of the server.

Note – Do not use the `digest-uri` option in a production environment.

`authzid` Specifies the authorization ID that should be used during the authentication process. This option can be used to indicate that the operations requested on the connection after authentication should be performed under the authority of another user.

The password is specified using either the `--bindPassword` or `--bindPasswordFile` option, just as when using simple authentication. The following command demonstrates the use of SASL DIGEST-MD5 authentication:

```
$ ldapsearch --hostname server.example.com --port 1389 --saslOption mech=DIGEST-MD5 \
  --saslOption authid=u:john.doe --saslOption realm=dc=example,dc=com --baseDN "" \
  --searchScope base "(objectClass=*)"
```

SASL Options for the EXTERNAL Mechanism

The EXTERNAL mechanism is used to perform authentication based on information that is available to the server outside of the LDAP session. At present, this is available only through SSL client authentication, in which case the information that the client's SSL certificate will be used to authenticate that client. As such, it is necessary to use SSL or StartTLS when communicating with the server, and a client certificate keystore must be available.

The EXTERNAL mechanism does not support any additional SASL options. In most cases, it can be requested using either `--saslOption mech=EXTERNAL` or `--useSASLExternal`. The following command demonstrates the use of SASL EXTERNAL authentication:

```
$ ldapsearch --hostname server.example.com --port 1636 --useSSL \
  --keyStorePath /path/to/key.store --keyStorePasswordFile /path/to/key.store.pin \
  --trustStorePath /path/to/trust.store --saslOption mech=EXTERNAL --baseDN "" \
  --searchScope base "(objectClass=*)"
```

For more information, see "Configuring SASL External Authentication" on page 149.

SASL Options for the GSSAPI Mechanism

The GSSAPI mechanism is used to perform authentication in a Kerberos V5 environment, and generally requires that the client system be configured to participate in such an environment. The options available for use with the GSSAPI mechanism include:

`authid` Specifies the authentication ID that should be used to identify the user. This ID should be in the form of a Kerberos principal and not in the authorization ID form described previously. This option must be provided if the user has not authenticated to Kerberos before attempting to bind.

`authzid` Specifies the authorization ID that should be used to identify the user under whose authority operations should be performed. The directory server does not yet support this capability.

`quality-of-protection` Specifies the quality of protection to use for the communication. Currently, only the `auth` quality-of-protection value is supported by the directory server clients. The `auth-int` and `auth-conf` values are supported by the server.

If the user already has a valid Kerberos ticket on the system when attempting to use GSSAPI, the client attempts to use it so that no password is required. However, if the user does not have a valid Kerberos ticket or if it cannot be accessed for some reason, a password must be provided using either the `--bindPassword` or `--bindPasswordFile` options.

The following command demonstrates the use of SASL GSSAPI authentication for a user that already has a valid Kerberos session:

```
$ ldapsearch --hostname server.example.com --port 1389 --saslOption mech=GSSAPI \
--saslOption authid=jdoe@EXAMPLE.COM --baseDN "" --searchScope base "(objectClass=*)"
```

SASL Options for the PLAIN Mechanism

The PLAIN mechanism provides many of the same capabilities as LDAP simple authentication, although the user may be identified in the form of an authorization ID rather than requiring a full DN. The following options are available for use when using SASL PLAIN authentication:

`authid` Specifies the identity of the user that is authenticating to the server. It should be an authorization ID value as described above. This option must be provided.

`authzid` Specifies the identity of the user under whose authority operations should be performed. It should also be in the form of an authorization ID. The directory server does not yet support this capability.

The password is specified using either the `--bindPassword` or `--bindPasswordFile` option, just as when using simple authentication. The following command demonstrates the use of SASL PLAIN authentication:

```
$ ldapsearch --hostname server.example.com --port 1389 --saslOption mech=PLAIN \
--saslOption authid=u:john.doe --baseDN "" --searchScope base "(objectClass=*)"
```

Configuring SASL Authentication

This section describes the requirements for configuring directory server to use the various SASL authentication mechanisms.

Note – SASL is not supported for use with Oracle Unified Directory proxy.

Configuring SASL External Authentication

The SASL EXTERNAL mechanism is used to allow a client to authenticate itself to the directory server using information provided outside of what is strictly considered LDAP communication. The directory server currently supports authentication using a client certificate presented to the server during SSL or StartTLS negotiation, for LDAP communication only.

Configuring the LDAP Connection Handler to Allow SASL EXTERNAL Authentication

For the directory server to be able to map the client certificate to a user entry, ensure that the connection handler is configured to handle client certificates. Use the `dsconfig` to set the following LDAP connection handler properties:

- **ssl-client-auth-policy.** Specifies whether the directory server prompts the client to present its own certificate during the SSL or StartTLS negotiation process. To support SASL EXTERNAL authentication, the value must be either `optional` or `required`. If the value is `disabled`, clients are not prompted to provide a certificate and no certificate is available for authentication.
- **trust-manager-provider.** Specifies the DN of the trust manager provider used to determine whether the directory server trusts the validity of the client certificate. If the directory server does not trust the client certificate, the SSL or StartTLS negotiation fails and it is not possible for the client to request SASL EXTERNAL authentication. If the directory server trusts illegitimate client certificates, it is possible for malicious users to forge certificates and impersonate any user in the directory. In most cases, the JKS or PKCS12 trust manager provider should be used and the corresponding trust store loaded only with the issuer certificates that are used to sign client certificates.

Note – The `dsconfig` command accesses the server configuration over SSL via the administration connector. As such, the relevant connection options must be specified, including how the SSL certificate is trusted. These examples use the `-X` option to trust all certificates.

The following example uses `dsconfig` to set LDAP connection handler properties:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager"-w password -X -n \
  set-connection-handler-prop --handler-name "LDAP Connection Handler"
```

Configuring the EXTERNAL SASL Mechanism Handler

SASL EXTERNAL bind requests are processed by the SASL mechanism handler. Use the `dsconfig` command to set the following SASL mechanism handler properties:

- **java-class.** Specifies the fully-qualified name of the Java class that provides the logic for the SASL mechanism handler. For the EXTERNAL mechanism, this value is always `org.opends.server.extensions.ExternalSASLMechanismHandler`. An advanced property.
- **enabled.** Indicates whether the EXTERNAL SASL mechanism is enabled for use in the directory server. If you do not want to allow clients to use SASL EXTERNAL authentication, change its value to `false`.
- **certificate-mapper.** Specifies the DN of the configuration entry for the certificate mapper to be used to map client certificates to user entries.
- **certificate-validation-policy.** Specifies whether the directory server attempts to locate the client certificate in the user's entry after establishing a mapping. If the value is `always`, the authentication succeeds only if the mapped user's entry contains the certificate presented by the client. If the value is `ifpresent` (the default value) and the user's entry contains one or more certificates, the authentication succeeds only if one of those certificates matches the one presented by the client. If the value is `ifpresent` and the user's entry does not contain any certificates, the authentication still succeeds based on the fact that it would have been accepted by the trust manager and mapped by the certificate mapper. If the value is `never`, the server does not attempt to match the certificate to a value in the user's entry even if that entry contains one or more certificates.
- **certificate-attribute.** Specifies the name of the attribute that holds user certificates to be examined if the `certificate-validation-policy` property has a value of either `always` or `ifpresent`.

The following example uses `dsconfig` to set EXTERNAL SASL mechanism handler properties:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager"-w password -X -n \
  set-sasl-mechanism-handler-prop --handler-name "EXTERNAL" --advanced
```

Configuring SASL DIGEST-MD5 Authentication

This section explains the access control and privilege restrictions on a user using the authorization ID keyword (`authzid`). If the user is not using the `authzid` keyword, these restrictions do not apply. Any user that binds using DIGEST-MD5 and the `authzid` keyword must fulfill the following requirements:

- The authentication ID (`authid`) must be granted access by an ACI that grants it the proxy right to the authorization ID.
- The authentication ID (`authid`) entry must contain the `proxied-auth` privilege. The following example creates a test environment and demonstrates the requirements for user authentication using the DIGEST-MD5 SASL mechanism.

The following example creates a test environment and then demonstrates the requirements for a user authentication using the DIGEST-MD5 SASL mechanism.

1. Import the following entries into the directory. These entries define an ACI and three users:
   - The entry `uid=user.0,ou=People,dc=example,dc=com` does not have the `proxied-auth` privilege but is granted proxy access by the ACI.
   - The entry `uid=user.1,ou=People,dc=example,dc=com` has the `proxied-auth` privilege but is not granted proxy access by the ACI.
   - The entry `uid=user.2,ou=People,dc=example,dc=com` has the `proxied-auth` privilege and is granted proxy access by the ACI.

```
dn: ou=People,dc=example,dc=com
objectClass: top
objectClass: organizationalunit
objectClass: posixGroup
ou: People
aci: (target="ldap:///uid=proxy user,ou=People,dc=example,dc=com") \
 (targetattr="*") (version 3.0; acl "allow SASL Example"; \
 allow (proxy) userdn="ldap:///uid=user.0,ou=People,dc=example,dc=com ||
 ldap:///uid=user.2,ou=People,dc=example,dc=com";)

dn: uid=user.0,ou=People,dc=example,dc=com
objectClass: top
objectClass: person
objectClass: organizationalperson
objectClass: inetorgperson
...
description: This is the description for user.0

dn: uid=user.1,ou=People,dc=example,dc=com
objectClass: top
objectClass: person
objectClass: organizationalperson
objectClass: inetorgperson
...
description: This is the description for user.1
ds-privilege-name: proxied-auth
```

```
dn: uid=proxy user,ou=People,dc=example,dc=com
objectClass: top
objectClass: person
objectClass: organizationalperson
objectClass: inetorgperson
...
description: This is the description for proxy user

dn: uid=user.2,ou=People,dc=example,dc=com
objectClass: top
objectClass: person
objectClass: organizationalperson
objectClass: inetorgperson
...
description: This is the description for user.2
ds-privilege-name: proxied-auth
```

2. Bind using DIGEST-MD5 as `uid=user.1,ou=People,dc=example,dc=com`:

   ```
   $ ldapsearch --port 1389 -w password --saslOption mech=DIGEST-MD5 \
     --saslOption authid=dn:uid=user.1,ou=People,dc=example,dc=com --saslOption \
     authzid=dn:uid=proxy user,ou=People,dc=example,dc=com --baseDN "" \
     --searchScope base "(objectClass=*)"
    The SASL DIGEST-MD5 bind attempt failed Result Code: 49 (Invalid Credentials)
   ```

   The search fails because `uid=user.1,ou=People,dc=example,dc=com` is not granted the proxy right by the ACI.

3. Bind using DIGEST-MD5 as `uid=user.0,ou=People,dc=example,dc=com`:

   ```
   $ ldapsearch --port 1389 -w password --saslOption mech=DIGEST-MD5 \
     --saslOption authid=dn:uid=user.0,ou=People,dc=example,dc=com --saslOption \
     authzid=dn:uid=proxy user,ou=People,dc=example,dc=com --baseDN "" \
     --searchScope base "(objectClass=*)"
   The SASL DIGEST-MD5 bind attempt failed Result Code: 49 (Invalid Credentials)
   ```

   The search fails because `uid=user.0,ou=People,dc=example,dc=com` does not have the `proxied-auth`property.

4. Bind using DIGEST-MD5 as `uid=user.2,ou=People,dc=example,dc=com` authid with both access control access and the `proxied-auth` privilege:

   ```
   $ ldapsearch --port 1389 -w password --saslOption mech=DIGEST-MD5 \
     --saslOption authid=dn:uid=user.2,ou=People,dc=example,dc=com --saslOption \
     authzid=dn:uid=proxy user,ou=People,dc=example,dc=com --baseDN "" \
     --searchScope base "(objectClass=*)"
   dn:
   objectClass: ds-root-dse
   objectClass: top
   ```

   The search succeeds because `uid=user.2,ou=People,dc=example,dc=com` has access allowed by the ACI and the `proxied-auth` privilege.

Configuring SASL GSSAPI Authentication

This section explains the access control and privilege restrictions on a user using the authorization ID keyword (authzid). If the user is not using the authzid keyword, the restrictions do not apply.

Any user that binds using GSSAPI must fulfill the following requirements:

- The authentication ID (authid) must be granted access by an ACI that grants it the proxy right to the authorization ID.
- The authentication ID (authid) entry must contain the proxied-auth privilege.

The following example creates a test environment with three example entries and demonstrates the requirements for user authentication using the GSSAPI SASL mechanism. These examples require a fully configured Kerberos environment, including a valid keytab file.

1. Create three Kerberos principals in the realm TESTLOCAL.NET:
   - user.0@TESTLOCAL.NET
   - user.1@TESTLOCAL.NET
   - user.2@TESTLOCAL.NET
2. Configure the GSSAPI SASL handler to be enabled, to use the regular expression identity mapper, and to use a valid TESTLOCAL.NET keytab file.

   ```
   $ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X \
     set-sasl-mechanism-handler-prop --handler-name "GSSAPI" \
     --set enabled:true --set identity-mapper:"Regular Expression" \
     --set keytab:keytabPath
   ```

   The default value of the GSSAPI enabled property is false, so it must be set to true. The default value of identity-mapper is Regular Expression. The default value of the keytab property is /etc/krb5/krb5.keytab.
3. Import the following entries into the directory. These entries define an ACI and three users:
   - The entry uid=user.0,ou=People,dc=example,dc=com does not have the proxied-auth privilege but is granted proxy access by the ACI.
   - The entry uid=user.1,ou=People,dc=example,dc=com has the proxied-auth privilege but is not granted proxy access by the ACI.
   - The entry uid=user.2,ou=People,dc=example,dc=com has the proxied-auth privilege and is granted proxy access by the ACI.

   ```
   dn: ou=People,dc=example,dc=com
   objectClass: top
   objectClass: organizationalunit
   objectClass: posixGroup
   ou: People
   aci: (target="ldap:///uid=proxy user,ou=People,dc=example,dc=com") \
    (targetattr="*") (version 3.0; acl "allow SASL Example"; \
    allow (proxy) userdn="ldap:///uid=user.0,ou=People,dc=example,dc=com"
   ```

```
 || "ldap:///uid=user.2,ou=People,dc=example,dc=com";)


dn: uid=user.0,ou=People,dc=example,dc=com
objectClass: top
objectClass: person
objectClass: organizationalperson
objectClass: inetorgperson
uid=user.0
...
description: This is the description for user.0

dn: uid=user.1,ou=People,dc=example,dc=com
objectClass: top
objectClass: person
objectClass: organizationalperson
objectClass: inetorgperson
uid=user.1
...
description: This is the description for user.1
ds-privilege-name: proxied-auth

dn: uid=user.2,ou=People,dc=example,dc=com
objectClass: top
objectClass: person
objectClass: organizationalperson
objectClass: inetorgperson
uid=user.2
...
description: This is the description for user.2
ds-privilege-name: proxied-auth

dn: uid=proxy user,ou=People,dc=example,dc=com
objectClass: top
objectClass: person
objectClass: organizationalperson
objectClass: inetorgperson
uid=proxy user
...
description: This is the description for proxy user
```

4. Run this command to demonstrate a failing GSSAPI SASL bind using the Kerberos principal, `user.0@TESTLOCAL.NET`:

   ```
   $ ldapsearch --port 1389 \
     --saslOption mech=GSSAPI \
     --saslOption authid=user.1@TESTLOCAL.NET \
     --saslOption authzid=dn:uid=proxy user,ou=People,dc=example,dc=com \
     --baseDN "" --searchScope base "(objectClass=*)"
   The SASL DIGEST-MD5 bind attempt failed
   Result Code:  49 (Invalid Credentials)
   ```

   This search fails because `user.0@TESTLOCAL.NET` maps to `uid=user.0,ou=People,dc=example,dc=com`, which has the `proxied-auth` privilege but does not have access control permissions to `uid=proxy user,ou=People,dc=example,dc=com`.

5. Run this command to demonstrate a failing GSSAPI SASL bind using the Kerberos principal, `user.1@TESTLOCAL.NET`.

   ```
   $ ldapsearch --port 1389 \
     --saslOption mech=GSSAPI \
     --saslOption authid=user.2@TESTLOCAL.NET \
     --saslOption authzid=dn:uid=proxy user,ou=People,dc=example,dc=com \
     --baseDN "" --searchScope base "(objectClass=*)"
   The SASL DIGEST-MD5 bind attempt failed
   Result Code:  49 (Invalid Credentials)
   ```

   This search fails because `user.1@TESTLOCAL.NET` maps to `uid=user.1,ou=People,dc=example,dc=com`, which has access control permissions to `uid=proxy user,ou=People,dc=example,dc=com` but does not have the `proxied-auth` privilege.

6. Run this command to demonstrate a successful GSSAPI SASL bind using the Kerberos principal `user.2@TESTLOCAL.NET`:

   ```
   $ ldapsearch --port 1389 \
     --saslOption mech=GSSAPI \
     --saslOption authid=user.0@TESTLOCAL.NET \
     --saslOption authzid=dn:uid=proxy user,ou=People,dc=example,dc=com \
     --baseDN "" --searchScope base "(objectClass=*)"
   dn:
   objectClass: ds-root-dse
   objectClass: top }}} \\ \\
   ```

   This search succeeds because `user.2@TESTLOCAL.NET` maps to `uid=user.2,ou=People,dc=example,dc=com`, which has both the `proxied-auth` privilege and access control permission to `id=proxy user,ou=People,dc=example,dc=com`.

Configuring Kerberos and the Oracle Unified Directory Directory Server for GSSAPI SASL Authentication

The following sections describe how to configure the directory server and Kerberos Version 5 for GSSAPI SASL authentication.

- "To Configure Kerberos V5 on a Host" on page 156
- "To Specify SASL Options for Kerberos Authentication" on page 156
- "Example Configuration of Kerberos Authentication Using GSSAPI With SASL" on page 157
- "Troubleshooting Kerberos Configuration" on page 167

▼ To Configure Kerberos V5 on a Host

You must configure Kerberos V5 on the host machine where your LDAP clients will run.

1 **Install Kerberos V5 according to its installation instructions.**

Sun recommends installing the Sun Enterprise Authentication Mechanism 1.0.1 client software.

2 **Configure the Kerberos software.**

Using the Sun Enterprise Authentication Mechanism software, configure the files under `/etc/krb5`. This configuration sets up the `kdc` server, and defines the default realm and any other configuration required by your Kerberos system.

3 **If necessary, modify the file `/etc/gss/mech` so that the first value that is listed is `kerberos_v5`.**

▼ To Specify SASL Options for Kerberos Authentication

You must specify appropriate SASL options for the Kerberos installation.

1 **Before using a client application that is enabled with the GSSAPI mechanism, initialize the Kerberos security system with your user Principal.**

`$ kinit` *user-principal*

where the *user-principal* is your SASL identity, for example, `bjensen@example.com`.

2 **Specify SASL options for using Kerberos.**

Note that in the UNIX environment, you must set the `SASL_PATH` environment variable to the correct path for the SASL libraries. For example in the Korn shell:

`$ export SASL_PATH=`*SASL-library*

This path assumes that the Oracle Unified Directory software is installed on the same host where the LDAP tools are invoked.

The following example of the `ldapsearch` tool shows the use of the `-o` (lowercase letter o) option to specify SASL options for using Kerberos:

```
$ ldapsearch -h www.host1.com -p 1389 -o mech=GSSAPI -o authid="bjensen@EXAMPLE.COM" \
 -o authzid="bjensen@EXAMPLE.COM" -b "dc=example,dc=com" "(givenname=Richard)"
```

The `authid` can be omitted because it is present in the Kerberos cache that was initialized by the `kinit` command. If `authid` is present, `authid` and `authzid` must be identical, although the `authzid` intended for proxy operations is not used. The value of `authid` is the Principal that is used in identity mapping. The Principal must be the full Principal, including the realm.

Example Configuration of Kerberos Authentication Using GSSAPI With SASL

Configuring Kerberos for the Oracle Unified Directory directory server can be complicated. Your first point of reference should be the Kerberos documentation.

For more help, use the following example procedure to get an idea of which steps to follow. Be aware, however, that this procedure is an example. You must modify the procedure to suit your own configuration and your own environment.

Additional information about configuring and using Kerberos in the Solaris OS can be found in *System Administration Guide: Security Services*. This guide is a part of the Solaris documentation set. You can also consult the man pages.

Information about this example and the steps used are as follows:

1. "Assumptions for This Example" on page 157
2. "All Machines: Edit the Kerberos Client Configuration File" on page 158
3. "All Machines: Edit the Administration Server ACL Configuration File" on page 159
4. "KDC Machine: Edit the KDC Server Configuration File" on page 160
5. "KDC Machine: Create the KDC Database" on page 160
6. "KDC Machine: Create an Administration Principal and Keytab" on page 160
7. "KDC Machine: Start the Kerberos Daemons" on page 161
8. "KDC Machine: Add Host Principals for the KDC and Oracle Unified Directory Machines" on page 161
9. "KDC Machine: Add an LDAP Principal for the Directory Server" on page 162
10. "KDC Machine: Add a Test User to the KDC" on page 162
11. "Directory Server Machine: Install the Directory Server" on page 162
12. "Directory Server Machine: Configure the Directory Server to Enable GSSAPI" on page 164
13. "Directory Server Machine: Create and Configure the Directory Server LDAP" on page 163
14. "Directory Server Machine: Add a Test User to the Directory Server" on page 165
15. "Directory Server Machine: Obtain a Kerberos Ticket as the Test User" on page 166
16. "Client Machine: Authenticate to the Directory Server Through GSSAPI" on page 166

Assumptions for This Example

This example procedure describes the process of configuring one machine to operate as a Key Distribution Center (KDC), and a second machine to run the directory server. The result of this procedure is that users can perform Kerberos authentication through GSSAPI.

It is possible to run both the KDC and the directory server on the same machine. If you choose to run both on the same machine, use the same procedure, but omit the steps for the directory server machine that have already been done for the KDC machine.

This procedure makes a number of assumptions about the environment that is used. When using the example procedure, modify the values accordingly to suit your environment. These assumptions are:

- This system has a fresh installation of the Solaris 10 software with the latest recommended patch cluster installed. Kerberos authentication to the directory server can fail if the appropriate Solaris patches are not installed.
- The machine that is running the Kerberos daemons has the fully qualified domain name of `kdc.example.com`. The machine must be configured to use DNS as a naming service. This configuration is a requirement of Kerberos. Certain operations might fail if other naming services such as `file` are used instead.
- The machine that is running the directory server has the fully qualified domain name of `directory.example.com`. This machine must also be configured to use DNS as a naming service.
- The directory server machine serves as the client system for authenticating to the directory server through Kerberos. This authentication can be performed from any system that can communicate with both the directory server and Kerberos daemons. However, all of the necessary components for this example are provided with the Oracle Unified Directory directory server, and the authentication is performed from that system.
- Users in the directory server have DNs of the form `uid=`*username*`,ou=People,dc=example,dc=com`. The corresponding Kerberos principal is *username*`@EXAMPLE.COM`. If a different naming scheme is used, a different GSSAPI identity mapping must be used.

All Machines: Edit the Kerberos Client Configuration File

The `/etc/krb5/krb5.conf` configuration file provides information that Kerberos clients require in order to communicate with the KDC.

Edit the `/etc/krb5/krb5.conf` configuration file on the KDC machine, the directory server machine, and any client machines that will authenticate to the directory server using Kerberos.

- Replace every occurrence of "`___default_realm___`" with "`EXAMPLE.COM`".
- Replace every occurrence of "`___master_kdc___`" with "`kdc.example.com`".
- Remove the lines that contain "`___slave_kdcs___`" as there will be only a single Kerberos server.
- Replace "`___domain_mapping___`" with "`.example.com = EXAMPLE.COM`" (note the initial period in `.example.com`).

The updated `/etc/krb5/krb5.conf` configuration file should look like the contents of the following example.

EXAMPLE 4–1 Edited Kerberos Client Configuration File `/etc/krb5/krb5.conf`

```
#pragma ident   "@(#)krb5.conf  1.2     99/07/20 SMI"
# Copyright (c) 1999, by Sun Microsystems, Inc.
# All rights reserved.
#
# krb5.conf template
# In order to complete this configuration file
# you will need to replace the __<name\>__ placeholders
# with appropriate values for your network.
#

[libdefaults]
        default_realm = EXAMPLE.COM
[realms]
        EXAMPLE.COM = {
                kdc = kdc.example.com
                admin_server = kdc.example.com
        }
[domain_realm]
        .example.com = EXAMPLE.COM
[logging]
        default = FILE:/var/krb5/kdc.log
        kdc = FILE:/var/krb5/kdc.log
        kdc_rotate = {

# How often to rotate kdc.log. Logs will get rotated no more
# often than the period, and less often if the KDC is not used
# frequently.
                period = 1d

# how many versions of kdc.log to keep around (kdc.log.0, kdc.log.1, ...)
                versions = 10
        }

[appdefaults]
        kinit = {
                renewable = true
                forwardable= true
        }
        gkadmin = {
                help_url =
 http://docs.sun.com:80/ab2/coll.384.1/SEAM/@AB2PageView/1195
        }
```

All Machines: Edit the Administration Server ACL Configuration File

Replace "`___default_realm___`" with "`EXAMPLE.COM`" in the `/etc/krb5/kadm5.acl` configuration file. The updated file should look like the following example.

EXAMPLE 4–2 Edited Administration Server ACL Configuration File

```
#
# Copyright (c) 1998-2000 by Sun Microsystems, Inc.
# All rights reserved.
#
```

EXAMPLE 4–2 Edited Administration Server ACL Configuration File *(Continued)*

```
# pragma ident   "@(#)kadm5.acl  1.1     01/03/19 SMI"
*/admin@EXAMPLE.COM *
```

KDC Machine: Edit the KDC Server Configuration File

Edit the `/etc/krb5/kdc.conf` file to replace "`___default_realm___`" with "`EXAMPLE.COM`". The updated file should look like the following example.

EXAMPLE 4–3 Edited KDC Server Configuration File `/etc/krb5/kdc.conf`

```
# Copyright 1998-2002 Sun Microsystems, Inc.  All rights reserved.
# Use is subject to license terms.
#
#ident  "@(#)kdc.conf   1.2     02/02/14 SMI"

[kdcdefaults]
        kdc_ports = 88,750

[realms]
        EXAMPLE.COM = {
                profile = /etc/krb5/krb5.conf
                database_name = /var/krb5/principal
                admin_keytab = /etc/krb5/kadm5.keytab
                acl_file = /etc/krb5/kadm5.acl
                kadmind_port = 749
                max_life = 8h 0m 0s
                max_renewable_life = 7d 0h 0m 0s
                default_principal_flags = +preauth
        }
```

KDC Machine: Create the KDC Database

```
$ /usr/sbin/kdb5_util create -r EXAMPLE.COM -s
Initializing database '/var/krb5/principal' for realm 'EXAMPLE.COM',
master key name 'K/M@EXAMPLE.COM'
You will be prompted for the database Master Password.
It is important that you NOT FORGET this password.
Enter KDC database master key: password
Re-enter KDC database master key to verify: password
$
```

KDC Machine: Create an Administration Principal and Keytab

Use the following command to create an administration user with a Principal of `kws/admin@EXAMPLE.COM` and service keys that will be used by the administration daemon.

```
$ /usr/sbin/kadmin.local
kadmin.local:  add_principal kws/admin
Enter password for principal "kws/admin@EXAMPLE.COM": secret
Re-enter password for principal "kws/admin@EXAMPLE.COM": secret
Principal "kws/admin@EXAMPLE.COM" created.
```

```
kadmin.local:  ktadd -k /etc/krb5/kadm5.keytab kadmin/kdc.example.com
Entry for principal kadmin/kdc.example.com with kvno 3, encryption type
 DES-CBC-CRC added to keytab WRFILE:/etc/krb5/kadm5.keytab.
kadmin.local:  ktadd -k /etc/krb5/kadm5.keytab changepw/kdc.example.com

Entry for principal changepw/kdc.example.com with kvno 3, encryption type
 DES-CBC-CRC added to keytab WRFILE:/etc/krb5/kadm5.keytab.
kadmin.local:  ktadd -k /etc/krb5/kadm5.keytab kadmin/changepw
Entry for principal kadmin/changepw with kvno 3, encryption type
 DES-CBC-CRC added to keytab WRFILE:/etc/krb5/kadm5.keytab.
kadmin.local:  quit$
```

KDC Machine: Start the Kerberos Daemons

The Kerberos daemons are managed by the Service Management Facility (SMF) framework. Run the following commands to start the KDC and administration daemons:

```
$ /etc/init.d/kdc start
$ /etc/init.d/kdc.master start
$


$ svcadm disable network/security/krb5kdc
$ svcadm enable network/security/krb5kdc
$ svcadm disable network/security/kadmin
$ svcadm enable network/security/kadmin
$
```

The KDC process appears in the process list as `/usr/lib/krb5/krb5kdc`. The administration daemon appears as `/usr/lib/krb5/kadmind`.

KDC Machine: Add Host Principals for the KDC and Oracle Unified Directory Machines

Use the following sequence of commands to add host Principals to the Kerberos database for the KDC and the directory server machines. The host Principal is used by certain Kerberos utilities such as `klist`.

```
$ /usr/sbin/kadmin -p kws/admin
Enter Password: secret
kadmin:  add_principal -randkey host/kdc.example.com
Principal "host/kdc.example.com@EXAMPLE.COM" created.
kadmin:  ktadd host/kdc.example.com
Entry for principal host/kdc.example.com with kvno 3, encryption type
 DES-CBC-CRC added to keytab WRFILE:/etc/krb5/krb5.keytab.
kadmin:  add_principal -randkey host/directory.example.com
Principal "host/directory.example.com@EXAMPLE.COM" created.
kadmin:  ktadd host/directory.example.com
Entry for principal host/directory.example.com with kvno 3, encryption type
 DES-CBC-CRC added to keytab WRFILE:/etc/krb5/krb5.keytab.
kadmin:  quit
$
```

KDC Machine: Add an LDAP Principal for the Directory Server

For the directory server to be able to validate the Kerberos tickets that are held by authenticating users, the directory server must have its own Principal. Currently, the Oracle Unified Directory directory server is hard coded to require a Principal of `ldap/`*fqdn*`@`*realm* where *fqdn* is the fully-qualified domain name of the directory server and *realm* is the Kerberos realm. The *fqdn* must match the fully qualified name that is provided when you install the directory server. In this case, the Principal for the directory server would be `ldap/directory.example.com@EXAMPLE.COM`.

Use the following sequence of commands to create an LDAP Principal for the directory server:

```
$ /usr/sbin/kadmin -p kws/admin
Enter Password: secret
kadmin: add_principal -randkey ldap/directory.example.com
Principal "ldap/directory.example.com@EXAMPLE.COM" created.
kadmin: quit
$
```

KDC Machine: Add a Test User to the KDC

To perform Kerberos authentication, the user authenticating must exist in the Kerberos database. In this example, the user has the user name `kerberos-test`, which means that the Kerberos Principal is `kerberos-test@EXAMPLE.COM`.

Create the user by using the command sequence in this example:

```
$ /usr/sbin/kadmin -p kws/admin
Enter Password: secret
kadmin:  add_principal kerberos-test
Enter password for principal "kerberos-test@EXAMPLE.COM": secret

Re-enter password for principal "kerberos-test@EXAMPLE.COM": secret

Principal "kerberos-test@EXAMPLE.COM" created.
kadmin:  quit
$
```

Directory Server Machine: Install the Directory Server

Install the directory server using at least version 1.3. Versions of the directory server earlier than 1.3 do not offer full support of GSSAPI SASL. The following table lists the installation settings that this section uses in examples.

Variable Type	Example Value
Fully qualified directory server DNS name	`directory.example.com`
Server port	`389`

Variable Type	Example Value
Suffix	`dc=example,dc=com`
Installation directory	`/asinst_1/oud`
Oracle Unified Directory server user	`oud`
Oracle Unified Directory server group	`oud`
Kerberos test principal	`kerberos-test`
Oracle Unified Directory keytab path	`/asinst_1/oud/config/oud.keytab`

Note – The fully qualified directory server DNS name must resolve to the same IP address on all of the servers (the Oracle Unified Directory servers and the Kerberos Key Distribution Center (KDC) and client machines that expect to bind to the server using GSSAPI SASL).

Directory Server Machine: Create and Configure the Directory Server LDAP

As mentioned previously, to authenticate Kerberos users through GSSAPI, Oracle Unified Directory must have its own Principal in the KDC. For authentication to work properly, the Principal information must reside in a Kerberos keytab on the directory server machine. This information must be in a file that is readable by the user account under which the directory server operates.

Note – This step must be performed before the `GSSAPI SASL mechanism handler` is configured. The handler checks to make sure the keytab file exists before it will initialize.

Create a keytab file with the correct properties by using the following command sequence:

```
$ kadmin -p kws/admin@EXAMPLE.COM
kadmin:  addprinc -randkey ldap/directory.example.com
WARNING: no policy specified for ldap/directory.example.com@EXAMPLE.COM;
  defaulting to no policy
Principal "ldap/directory.example.com@EXAMPLE.COM" created.
kadmin:  ktadd -k asinst_1/oud/config/oud.keytab ldap/directory.example.com
Entry for principal ldap/directory.example.com with kvno 3,
  encryption type AES-128 CTS mode
  with 96-bit SHA-1 HMAC added to keytab WRFILE:asinst_1/oud/config/oud.keytab.
Entry for principal ldap/directory.example.com with kvno 3,
  encryption type Triple DES cbc mode
  with HMAC/sha1 added to keytab WRFILE:asinst_1/oud/config/oud.keytab.
Entry for principal ldap/directory.example.com with kvno 3,
  encryption type ArcFour with HMAC/md5
  added to keytab WRFILE:asinst_1/oud/config/oud.keytab.
Entry for principal ldap/directory.example.com with kvno 3,
  encryption type DES cbc mode with RSA-MD5
  added to keytab WRFILE:asinst_1/oud/config/oud.keytab.
kadmin:  quit
```

Change the permissions and ownership on this custom keytab. Make the keytab owned by the user account used to run the directory server and readable only by that user:

```
$ chown oud:oud asinst_1/oud/config/oud.keytab
$ chmod 600 asinst_1/oud/config/oud.keytab
```

Finally, to allow these changes to take effect, stop and restart the directory server.

Directory Server Machine: Configure the Directory Server to Enable GSSAPI

This step shows examples of managing the `GSSAPI SASL mechanism handler` on the directory server host `directory.example.com`.

Use the `dsconfig` command as shown in the following example to enable the GSSAPI SASL mechanism handler on the directory server host `directory.example.com` and configure it to use the `asinst_1/oud/config/oud.keytab`.

```
$ dsconfig -X -n -p 4444 -h directory.example.com \
  -D "cn=directory manager" -w password
  set-sasl-mechanism-handler-prop \
  --handler-name GSSAPI \
  --set enabled:true \
  --set keytab:asinst_1/oud/config/oud.keytab \
  --set server-fqdn:directory.example.com
```

The last line in this command sets the GSSAPI SASL mechanism property `server-fqdn` to `directory.example.com`. This is an optional parameter, which can be left out only if it is assured that a hostname lookup on the directory server host returns the exact hostname that was used in creating the LDAP principal. Setting this property explicitly assures that the two names are the same (in this example, `directory.example.com`).

Confirm that the configuration is correct by examining the properties of the GSSAPI SASL mechanism handler on the directory server host `directory.example.com`.

```
$ dsconfig -X -n -p 4444 -h directory.example.com \
  -D "cn=directory manager" -w password \
  get-sasl-mechanism-handler-prop \
  --handler-name GSSAPI
Property              : Value(s)
----------------------:---------------------
enabled               : true
identity-mapper       : Regular Expression
kdc-address           : -
keytab                : asinst_1/oud/config/oud.keytab
principal-name        : -
quality-of-protection : none
```

```
realm                  : -
server-fqdn            : directory.example.com
```

If necessary for troubleshooting, you can use `dsconfig` to list the status of all the SASL mechanism handlers on the directory server host `directory.example.com`.

```
$ dsconfig -X -n -p 4444 -h directory.example.com \
  -D "cn=directory manager" -w password \
  list-sasl-mechanism-handlers
SASL Mechanism Handler : Type       : enabled
-----------------------:------------:--------
ANONYMOUS              : anonymous  : false
CRAM-MD5               : cram-md5   : true
DIGEST-MD5             : digest-md5 : true
EXTERNAL               : external   : true
GSSAPI                 : gssapi     : true
PLAIN                  : plain      : true
```

If necessary, you can use `dsconfig` to disable the GSSAPI SASL mechanism handler on the directory server host `directory.example.com`.

```
$ dsconfig -X -n -p 4444 -h directory.example.com \
  -D "cn=directory manager" -w password \
  set-sasl-mechanism-handler-prop \
  --handler-name GSSAPI \
  --set enabled:false
```

Directory Server Machine: Add a Test User to the Directory Server

To authenticate a Kerberos user to the directory server, there must be a directory entry for the user that corresponds to the Kerberos Principal for that user.

In a previous step, a test user was added to the Kerberos database with a Principal of `kerberos-test@EXAMPLE.COM`. Because of the identity mapping configuration added to the directory, the corresponding directory entry for that user must have a DN of `uid=kerberos-test,ou=People,dc=example,dc=com`.

Before you can add the user to the directory, you must create the file `testuser.ldif` with the following contents.

EXAMPLE 4–4 New `testuser.ldif` File

```
dn: uid=kerberos-test,ou=People,dc=example,dc=com
changetype: add
objectClass: top
objectClass: person
objectClass: organizationalPerson
objectClass: inetOrgPerson
uid: kerberos-test
givenName: Kerberos
sn: Test
cn: Kerberos Test
description: An account for testing Kerberos authentication through GSSAPI
```

Next, use `ldapmodify` to add this entry to the server:

```
$ ldapmodify -D "cn=Directory Manager" -w - -f testuser.ldif
adding new entry uid=kerberos-test,ou=People,dc=example,dc=com
$
```

Directory Server Machine: Obtain a Kerberos Ticket as the Test User

The test user exists in the Kerberos database, the directory server, and the KDC. Therefore, it is now possible to authenticate as the test user to the directory server over Kerberos through GSSAPI.

First, use the `kinit` command to get a Kerberos ticket for the user, as shown in the following example:

```
$ kinit kerberos-test
Password for kerberos-test@EXAMPLE.COM: secret
$
```

Then, use the `klist` command to view information about this ticket:

```
$ klist
Kerberos 5 ticket cache: ’API:6’
Default principal: kerberos-test@EXAMPLE.COM
Valid Starting     Expires            Service Principal
03/23/09 12:35:05  03/23/09 20:35:05  krbtgt/EXAMPLE.COM@EXAMPLE.COM
renew until 03/30/09 12:34:15
$
```

Client Machine: Authenticate to the Directory Server Through GSSAPI

The final step is to authenticate to the directory server by using GSSAPI. The `ldapsearch` utility provided with The directory server provides support for SASL authentication, including GSSAPI, DIGEST-MD5, and EXTERNAL mechanisms. However, to bind by using GSSAPI you must provide the client with the path to the SASL library. Provide the path by setting the `SASL_PATH` environment variable to the `lib/sasl` directory:

```
$ SASL_PATH=SASL-library
$ export SASL_PATH
$
```

To actually perform a Kerberos-based authentication to the directory server using `ldapsearch`, you must include the `-o mech=GSSAPI` and `-o authzid=`*principal* arguments.

You must also specify the fully qualified host name, shown here as `-h directory.example.com`, which must match the value of the `nsslapd-localhost` attribute on `cn=config` for the server. This use of the `-h` option is needed because the GSSAPI authentication process requires the host name provided by the client to match the host name provided by the server.

The following example retrieves the `dc=example,dc=com` entry while authenticated as the Kerberos test user account created previously:

```
$ ldapsearch -h directory.example.com -p 389 -o mech=GSSAPI \
 -o authzid="kerberos-test@EXAMPLE.COM" -b "dc=example,dc=com" -s base "(objectClass=*)"
version: 1
dn: dc=example,dc=com
dc: example
objectClass: top
objectClass: domain
$
```

Check the directory server access log to confirm that the authentication was processed as expected:

```
$ tail -12 /local/ds/logs/access

[24/Jul/2004:00:30:47 -0500] conn=0 op=-1 msgId=-1 - fd=23 slot=23 LDAP
        connection from 1.1.1.8 to 1.1.1.8
[24/Jul/2004:00:30:47 -0500] conn=0 op=0 msgId=1 - BIND dn="" method=sasl
     version=3 mech=GSSAPI
[24/Jul/2004:00:30:47 -0500] conn=0 op=0 msgId=1 - RESULT err=14 tag=97
     nentries=0 etime=0, SASL bind in progress
[24/Jul/2004:00:30:47 -0500] conn=0 op=1 msgId=2 - BIND dn="" method=sasl
     version=3 mech=GSSAPI
[24/Jul/2004:00:30:47 -0500] conn=0 op=1 msgId=2 - RESULT err=14 tag=97
     nentries=0 etime=0, SASL bind in progress
[24/Jul/2004:00:30:47 -0500] conn=0 op=2 msgId=3 - BIND dn="" method=sasl
     version=3 mech=GSSAPI
[24/Jul/2004:00:30:47 -0500] conn=0 op=2 msgId=3 - RESULT err=0 tag=97
     nentries=0 etime=0 dn="uid=kerberos-test,ou=people,dc=example,dc=com"
[24/Jul/2004:00:30:47 -0500] conn=0 op=3 msgId=4 - SRCH base="dc=example,dc=com"
     scope=0 filter="(objectClass=*)" attrs=ALL
[24/Jul/2004:00:30:47 -0500] conn=0 op=3 msgId=4 - RESULT err=0 tag=101 nentries=1
     etime=0
[24/Jul/2004:00:30:47 -0500] conn=0 op=4 msgId=5 - UNBIND
[24/Jul/2004:00:30:47 -0500] conn=0 op=4 msgId=-1 - closing - U1
[24/Jul/2004:00:30:48 -0500] conn=0 op=-1 msgId=-1 - closed.
$
```

This example shows that the bind is a three-step process. The first two steps return LDAP result `14` (SASL bind in progress), and the third step shows that the bind was successful. The `method=sasl` and `mech=GSSAPI` tags show that the bind used the GSSAPI SASL mechanism. The `dn="uid=kerberos-test,ou=people,dc=example,dc=com"` at the end of the successful bind response shows that the bind was performed as the appropriate user.

Troubleshooting Kerberos Configuration

If the Kerberos installation does not perform as expected, check the following conditions:

- Perform a successful `kinit` using the test principal from the directory server machine to make sure that the directory server can authenticate to the Kerberos KDC.
- Perform a successful `kinit` using the test principal from the client machines to make sure that the client machines can authenticate to the Kerberos KDC.

- Make sure that the directory server's keytab file exists and is readable by the directory server. That is, make sure that the keytab file's ownership and permission settings are correct.
- Make sure that the LDAP principal name in the keytab file matches the hostname that the directory server used when it was configured. The following example shows a configuration that fails:
  1. Configure GSSAPI as shown below. The value specified for the `server-fqdn` attribute, `bad.example.com`, does not match the value used in creating the keytab, `directory.example.com`.

     ```
     $ dsconfig -X -n -p 4444 -h directory.example.com \
       -D "cn=directory manager" -w password \
       set-sasl-mechanism-handler-prop \
       --handler-name GSSAPI \
       --set enabled:true \
       --set keytab:asinst_1/oud/config/oud.keytab \
       --set server-fqdn:bad.example.com
     ```
  2. From a client, attempt an ldapsearch authenticating using GSSAPI.

     ```
     $ ldapsearch -h directory.example.com \
       -o mech=GSSAPI -o authid=kerberos-test@EXAMPLE.COM \
       --searchScope base \
       -b "uid=kerberos-test,ou=people,dc=example,dc=com" "(objectclass=*)"
     An error occurred while attempting to perform GSSAPI authentication to
       the Directory Server: \
     PrivilegedActionException(AccessController.java:-2)
     Result Code:  82 (Local Error)
     ```

     The search fails as expected.
  3. To determine the cause of the search failure, inspect the directory server's access log:

     ```
     $ tail asinst_1/oud/logs/access
     [23/Mar/2009:13:12:59 -0500] CONNECT conn=14 from=129.150.33.77:65076
       to=192.168.0.199:1389 protocol=LDAP
     [23/Mar/2009:13:13:00 -0500] BIND REQ conn=14 op=0 msgID=1
       type=SASL mechanism=GSSAPI dn=""
     [23/Mar/2009:13:13:00 -0500] BIND RES conn=14 op=0 msgID=1
       result=49 authFailureID=1310915   authFailureReason="An unexpected error
       occurred while trying to create an GSSAPI context:
       major code (13) No valid credentials provided,
       minor code (-1)   Failed to find any Kerberos Key" etime=253
     [23/Mar/2009:13:13:00 -0500] DISCONNECT conn=14 reason="Client Disconnect"
     ```

     The message in the minor code of the last record in the access log shows that the directory server could not find a match in the keytab file.
  4. To fix the situation, disable the handler and then re-enable it with the correct information, as shown in the following example.

     ```
     $ dsconfig -X -n -p 4444 -h directory.example.com \
       -D "cn=directory manager" -w password \
       set-sasl-mechanism-handler-prop \
       --handler-name GSSAPI \
       --set enabled:false
     $ dsconfig -X -n -p 4444 -h directory.example.com
     ```

```
  -D "cn=directory manager" -w password \
  set-sasl-mechanism-handler-prop \
  --handler-name GSSAPI \
  --set enabled:true \
  --set keytab:asinst_1/oud/config/oud.keytab \
  --set server-fqdn:directory.example.com
$ ldapsearch -h directory.example.com \
  -o mech=GSSAPI \
  -o authid=kerberos-test@EXAMPLE.COM \
  --searchScope base \
  -b "uid=kerberos-test,ou=people,dc=example,dc=com" "(objectclass=*)"
dn: uid=kerberos-test,ou=People,dc=example,dc=com
changetype: add
objectClass: top
objectClass: person
objectClass: organizationalPerson
objectClass: inetOrgPerson
uid: kerberos-test
givenName: Kerberos
sn: Test
cn: Kerberos Test
description: An account for testing Kerberos authentication through GSSAPI
```

Testing SSL, StartTLS, and SASL Authentication With `ldapsearch`

The `ldapsearch` utility included with the directory server is useful for testing that the server is properly configured to support SSL and StartTLS. This utility includes a number of options that are well-suited for testing in a number of different scenarios. This section describes how to use `ldapsearch` to test SSL and StartTLS communication, and SASL EXTERNAL authentication. The same process can be used with many of the other client tools provided with the directory server, including `ldapmodify`, `ldapcompare`, and `ldapdelete`.

ldapsearch Command Line Arguments Applicable To Security

The following command-line arguments are of particular interest when using the `ldapsearch` tool to communicate via SSL or StartTLS:

- `-h` *address* or `--hostname` *address* Specifies the address of the directory server to which you want to connect. If no value is specified, the IPv4 loopback address (`127.0.0.1`) is used.
- `-p` *port* or `--port` *port* Specifies the port number on which the directory server is listening for connections. If no value is specified, the standard unencrypted LDAP port (`389`) is used.
- `-Z` or `--useSSL` Indicates that the client should use SSL to secure communication with the directory server. If this option is used, the value specified for the port argument must be one on which the server is listening for SSL-based connections. The default LDAPS port is `636`.

- `-q` or `--startTLS` Indicates that the client should use the StartTLS extended operation to secure communication with the directory server. If this option is used, the value specified for the port argument must be the one on which the server is listening for clear-text LDAP connections. Note that the port argument is not required if the server is listening on the default LDAP port (`389`).
- `-r` or `--useSASLExternal` Indicates that the client should use SASL EXTERNAL authentication to authenticate to the directory server. If this option is used, you must also provide a keystore path.
- `-X` or `--trustAll` Indicates that the client should blindly trust any certificate that the directory server presents. This option should not be used in conjunction with the argument used to specify the trust store path.
- `-K` *path* or `--keyStorePath` *path* Specifies the path to the keystore that should be used if the client is to present a certificate to the directory server (for example, when using SASL EXTERNAL authentication). This should be the path to a JKS keystore.
- `-W` *password* or `--keyStorePassword` *password* Specifies the PIN required to access the contents of the key tore. This should not be used in conjunction with the keystore password file argument.
- `--keyStorePasswordFile` *path* Specifies the path to a file containing the PIN required to access the contents of the keystore. This should not be used in conjunction with the keystore password argument.
- `-N` *nickname* or `--certNickname` *nickname* Specifies the nickname, or alias, of the certificate that the client should present to the directory server. The keystore path argument must also be provided. If no nickname is given, then the client will pick the first acceptable client certificate that it finds in the keystore.
- `-P` *path* or `--trustStorePath` *path* Specifies the path to the JKS trust store file that the client should use when determining whether to trust the certificate presented by the directory server. If this argument is not given and the `trustAll` option is not given, then any certificate presented to the client will be displayed and the user will be prompted about whether to trust it.
- `--trustStorePassword` *password* Specifies the password needed to access the trust store contents. In most cases, no trust store password is required. This should not be used in conjunction with the trust store password file option.
- `--trustStorePasswordFile` *path* Specifies the path to a file containing the password needed to access the trust store contents. In most cases, no trust store password is required. This should not be used in conjunction with the trust store password option.
- `-E` or `--reportAuthzID` Indicates that the directory server should include the authorization identity of the authenticated user in the bind response. This is useful when performing SASL authentication to determine the user to which the client certificate (or other form of SASL credentials if a mechanism other than EXTERNAL was used) was mapped.

Testing SSL

The following demonstrates the use of `ldapsearch` to communicate with a directory server using LDAP over SSL:

```
$ ldapsearch --hostname directory.example.com --port 1636 \
--useSSL --baseDN "" --searchScope base "(objectClass=*)"
```

In this case, no trust store was specified, and the `--trustAll` argument was also not given. Therefore, when the server presents its certificate to the client, the user will be prompted about whether that certificate should be trusted. The entire sequence might look something like:

```
$ ldapsearch --hostname directory.example.com --port 1636 \
--useSSL --baseDN "" --searchScope base "(objectClass=*)"

The server is using the following certificate:
Subject DN: CN=directory.example.com, O=Example Corp, C=US
Issuer DN: CN=directory.example.com, O=Example Corp, C=US
Validity: Fri Mar 02 16:48:17 CST 2007 through Thu might 31 17:48:17 CDT 2007
Do you want to trust this certificate and continue connecting to the server?
Please enter "yes" or "no":
dn:
objectClass: ds-rootDSE
objectClass: top
```

If the client simply wants to always trust any certificate that the server presents without being prompted, then the `--trustAll` argument might be provided. For example:

```
$ ldapsearch --hostname directory.example.com --port 1636 \
--useSSL --trustAll --baseDN "" --searchScope base \
"(objectClass=*)"
```

If the client has a trust store and wants to use that to determine whether to trust the server certificate, then the `--trustStorePath` argument might also be given. For example:

```
$ ldapsearch --hostname directory.example.com --port 1636 \
--useSSL --trustStorePath client.truststore --baseDN "" \
--searchScope base "(objectClass=*)"
```

Testing StartTLS

The process for using StartTLS with the `ldapsearch` utility is almost identical to the process for using SSL. The only differences are that you should use the port on which the server is listening for unencrypted LDAP requests and that you should indicate that StartTLS should be used instead of SSL (that is, use `--useStartTLS` instead of `--useSSL`). The following example is the equivalent of the first example given for using SSL with `ldapsearch` except that it uses StartTLS to secure the communication:

```
$ ldapsearch -h directory.example.com --port 1389 \
--useStartTLS --baseDN "" --searchScope base "(objectClass=*)"
```

This applies to all of the other examples given. Simply change the port number from the LDAPS port to the LDAP port, and replace the `--useSSL` option with `--useStartTLS`.

Testing SASL External Authentication

Note – SASL is not supported for use with Oracle Unified Directory proxy.

SASL EXTERNAL authentication might be used in conjunction with either SSL or StartTLS. The primary differences are that it will be necessary to provide a keystore that contains the client certificate, the PIN required to access the contents of that keystore, and a flag indicating that the client should use SASL EXTERNAL authentication. The following example demonstrates sample usage for such a command:

```
$ ldapsearch --hostname directory.example.com --port 1636 \
--useSSL --keyStorePath /path/to/client.keystore \
--keyStorePasswordFile /path/to/client.keystore.pin \
--useSASLExternal --certNickName nickname \
--baseDN "" --searchScope base \
"(objectClass=*)"
```

When using SASL EXTERNAL authentication, it is also often useful to ask the server to return the authorization identity to ensure that the authentication is being performed as the correct user. The following demonstrates an example of this process. (Note the value reported on the line beginning with the "#" character.)

```
$ ldapsearch --hostname directory.example.com --port 1636 \
--useSSL --keyStorePath /path/to/client.keystore \
--keyStorePasswordFile /path/to/client.keystore.pin \
--useSASLExternal --reportAuthzID --certNickName nickname \
--baseDN "" --searchScope base "(objectClass=*)"

# Bound with authorization ID dn:uid=test.user,dc=example,dc=com
dn:
objectClass: ds-rootDSE
objectClass: top
```

Controlling Connection Access Using Allowed and Denied Rules

You can use connection handler allowed and denied client rules to control which hosts can make TCP connections to the server. Connection handlers are responsible for accepting connections to the server.

The different types of connection handlers and their configuration properties are presented in this section and include the following:

- `allowed-client`. Specifies a set of host names or address masks that determine the clients that are allowed to establish connections to this Connection Handler. Valid values include a host name, a fully qualified domain name, a domain name, an IP address, or a subnetwork with subnetwork mask.
- `denied-client`. Specifies a set of host names or address masks that determine the clients that are not allowed to establish connections to this Connection Handler. Valid values include a host name, a fully qualified domain name, a domain name, an IP address, or a subnetwork with subnetwork mask. If both allowed and denied client masks are defined and a client connection matches one or more masks in both lists, then the connection is denied. If only a denied list is specified, then any client not matching a mask in that list is allowed.

Note – Both IPv4 and IPv6 addresses are supported.

Property Syntax of Allowed and Denied Client Rules

The `allowed-client` and `denied-client` properties share the same syntax to perform pattern matching against IP (IPv4 or IPv6) addresses and host names.

The following syntaxes are supported:

- IP address - The IP address of the clients to be allowed or denied can be specified in the rule. For example:

  ```
  ds-cfg-denied-client:   192.168.5.6
  ds-cfg-allowed-client:  2001:fecd:ba23:cd1f:dcb1:1010:9234:4088
  ```
- IP address with CIDR notation - A range of IP addresses can be allowed or denied by specifying an IP address using CIDR notation . For example:

  ```
  ds-cfg-denied-client:   192.168.5.6/28
  ds-cfg-allowed-client:  2001:0db8:1234::/48
  ```

  The first denies clients in the range `192.168.5.0` - `192.168.5.15` and the second allows clients in the range `2001:0db8:1234:0000:0000:0000:0000:0000` - `2001:0db8:1234:ffff:ffff:ffff:ffff:ffff`.
- IP address with '*' notation - A range of IP addresses (IPv4 only) can be allowed or denied by specifying an IP address with a '*' character to match parts of the IP address. For example:

  ```
  ds-cfg-denied-client:   192.168.5.*
  ds-cfg-allowed-client:   129.45.*.*
  ```

  The first example denies clients with IP addresses starting with 192.168.5 and the second allows clients with IP address starting with 129.45. Notice that the second example uses multiple match characters. To allow all IP addresses to match, the rule would look like:

```
ds-cfg-denied-client:   *.*.*.*
```

- DNS names - Clients can be restricted by DNS name. For example to restrict clients with the host name `foo.example.com`, enter:

  ```
  ds-cfg-denied-client:   foo.example.com
  ```

- DNS names with pattern matching - This is similar to IP address pattern matching. The property can specify the '*' character to match parts of the DN name:

  ```
  ds-cfg-allowed-client: foo.*.test.com
  ```

  The property allows clients with DN names such as: `foo.bar.test.com` or `foo.foobar.test.com`. To only match DNS names ending in a suffix the property would be:

  ```
  ds-cfg-allowed-client: .example.com
  ```

  This property allows clients with DNS names such as: `test.example.com` or `test.me.example.com`.

Note – Care should be taken when using DNS properties, since the host name resolution depends on the server name service configuration.

Configuring Allowed and Denied Client Rules

Each connection handler needs to have its own set of rules. For example:

```
dn: cn=LDAP Connection Handler,cn=Connection Handlers,cn=config
objectClass: top
objectClass: ds-cfg-connection-handler
objectClass: ds-cfg-ldap-connection-handler
cn: LDAP Connection Handler
ds-cfg-java-class: org.opends.server.protocols.ldap.LDAPConnectionHandler
ds-cfg-enabled: true
ds-cfg-listen-address: 0.0.0.0
ds-cfg-listen-port: 389
ds-cfg-accept-backlog: 128
ds-cfg-allow-ldap-v2: true
ds-cfg-keep-stats: true
ds-cfg-use-tcp-keep-alive: true
ds-cfg-use-tcp-no-delay: true
ds-cfg-allow-tcp-reuse-address: true
ds-cfg-send-rejection-notice: true
ds-cfg-max-request-size: 5 megabytes
ds-cfg-max-blocked-write-time-limit: 2 minutes
ds-cfg-num-request-handlers: 2
ds-cfg-allow-start-tls: false
ds-cfg-use-ssl: false
ds-cfg-ssl-client-auth-policy: optional
ds-cfg-ssl-cert-nickname: server-cert
ds-cfg-denied-client: *.example.com
ds-cfg-denied-client:  129.45.*.*
ds-cfg-denied-client:   192.168.5.6
```

```
dn: cn=LDAPS Connection Handler,cn=Connection Handlers,cn=config
objectClass: top
objectClass: ds-cfg-connection-handler
objectClass: ds-cfg-ldap-connection-handler
cn: LDAPS Connection Handler
ds-cfg-java-class: org.opends.server.protocols.ldap.LDAPConnectionHandler
ds-cfg-enabled: true
ds-cfg-listen-address: 0.0.0.0
ds-cfg-listen-port: 636
ds-cfg-accept-backlog: 128
ds-cfg-allow-ldap-v2: true
ds-cfg-keep-stats: true
ds-cfg-use-tcp-keep-alive: true
ds-cfg-use-tcp-no-delay: true
ds-cfg-allow-tcp-reuse-address: true
ds-cfg-send-rejection-notice: true
ds-cfg-max-request-size: 5 megabytes
ds-cfg-max-blocked-write-time-limit: 2 minutes
ds-cfg-num-request-handlers: 2
ds-cfg-allow-start-tls: false
ds-cfg-use-ssl: true
ds-cfg-ssl-client-auth-policy: optional
ds-cfg-ssl-cert-nickname: server-cert
ds-cfg-key-manager-provider: cn=JKS,cn=Key Manager Providers,cn=config
ds-cfg-trust-manager-provider: cn=JKS,cn=Trust Manager Providers,cn=config
ds-cfg-allowed-client: .example.com
ds-cfg-allowed-client: foo.*.test.com
ds-cfg-allowed-client: 192.168.6.7/22
```

Use the `dsconfig` command to manage the allowed and denied properties for each connection handler. For example:

```
dsconfig -n -X -p 4444 -D "cn=directory manager" -w password \
set-connection-handler-prop   --handler-name "LDAPS Connection Handler" \
--set denied-client:.example.com \
--set allowed-client:192.168.1.6/17
```

Note – Denied rules are applied before the allowed rules.

CHAPTER 5

Configuring Security Between the Proxy and the Data Source

Security configuration between the proxy and the remote LDAP servers can be configured as follows:

- During installation of Oracle Unified Directory proxy, by using the `oud-proxy-setup` GUI. For more information, see "Setting Up the Proxy Server by Using the GUI" in *Oracle Fusion Middleware Installation Guide for Oracle Unified Directory*.
- After installation of Oracle Unified Directory proxy, by using the `dsconfig` command in interactive mode. For general information about using the `dsconfig` command, see "Managing the Server Configuration With `dsconfig`" on page 25.

For security management, network groups can be enabled to classify incoming client connections. You can use network groups to restrict operations that can be performed based on how the connection has been classified. Use this functionality, for example, to restrict access to clients that connect from a specified IP address only. For more information, see "Configuring Network Groups With `dsconfig`" on page 38.

For secure client authentication between the proxy and remote LDAP servers, the certificate of the proxy must be imported into the truststore of each remote LDAP server. In this case, for Oracle Unified Directory proxy, a keystore is mandatory. The keystore must be configured manually. For details, see "Configuring Key Manager Providers" on page 125.

The security of Oracle Unified Directory proxy does not bypass the back-end ACI.

How the Proxy Manages Secure Connections

The Oracle Unified Directory proxy manages both the security with the client and with the directory server. The proxy supports both SSL and StartTLS.

When you configure Oracle Unified Directory proxy security, you must specify how the proxy connects to the remote LDAP server by indicating if the proxy should use SSL `always`, `never`, or `user`.

If you configure Oracle Unified Directory proxy security as `always`, then regardless how the client connects to the proxy, the connection with the remote LDAP server will always be secured using SSL.

Similarly, if you configure Oracle Unified Directory proxy security as `never`, then regardless if the client connects to the proxy with a secure connection, the connection between the proxy and the remote LDAP directory server will not be secured.

If you configure Oracle Unified Directory proxy security as `user`, then the security between the proxy and the remote LDAP directory servers will be the same as the security between the client and the proxy. For example, if the client connect with SSL, then the connection with the remote LDAP server will also use SSL. One notable exception is if the client connects using StartTLS, then Oracle Unified Directory proxy will connect to the remote LDAP servers using SSL.

For more information see “Modes of Secure Connection” on page 178.

Modes of Secure Connection

The Oracle Unified Directory proxy handles connections to the remote LDAP servers in three SSL security modes:

- `always`
- `never`
- `user`

You can view or edit these settings using the `dsconfig --advanced` command. Choose Extension from the main menu.

The `remote-ldap-server-ssl-policy` property manages the three SSL security modes.

When the `remote-ldap-server-ssl-policy` property is set to `always` or user, the Oracle Unified Directory proxy needs to trust the remote LDAP servers. To achieve this, you need to manually import the certificates of each remote LDAP server into the proxy's truststore.

The `always` Secure Mode

With the `remote-ldap-server-ssl-policy` property set to `always`, all connections made from the proxy to the remote LDAP servers are fully secure SSL connections, regardless how the client connects to the proxy.

In this mode, the pool size refers to one type of connection pool: secure LDAPS connections.

In the `always` secure mode, the certificate of each remote LDAP server must be imported into the truststore of the Oracle Unified Directory proxy. If there is a large number of back-end LDAP servers that are not Oracle Unified Directory servers, and if certificates were not managed during installation, importing certificates into the truststore of the Oracle Unified Directory proxy can be a constraint. For test environment purposes, you can speed up this process by using the `ssl-trust-all` parameter. This parameter requests the proxy to trust all remote LDAP servers.

The `never` Secure Mode

With the `remote-ldap-server-ssl-policy` property set to `never`, none of the connections from the Oracle Unified Directory proxy to the remote LDAP servers are secure SSL connections.

In this mode, the monitoring connection by Oracle Unified Directory proxy of the remote LDAP servers is never secure.

In this mode, the pool size refers to one type of connection pool: unsecure LDAP connections.

The `user` Secure Mode

With the `remote-ldap-server-ssl-policy` property set to `user`, incoming requests from clients to the proxy dictate whether the connection between the Oracle Unified Directory proxy and remote LDAP servers should be secure, regardless how the client connects to the Oracle Unified Directory proxy.

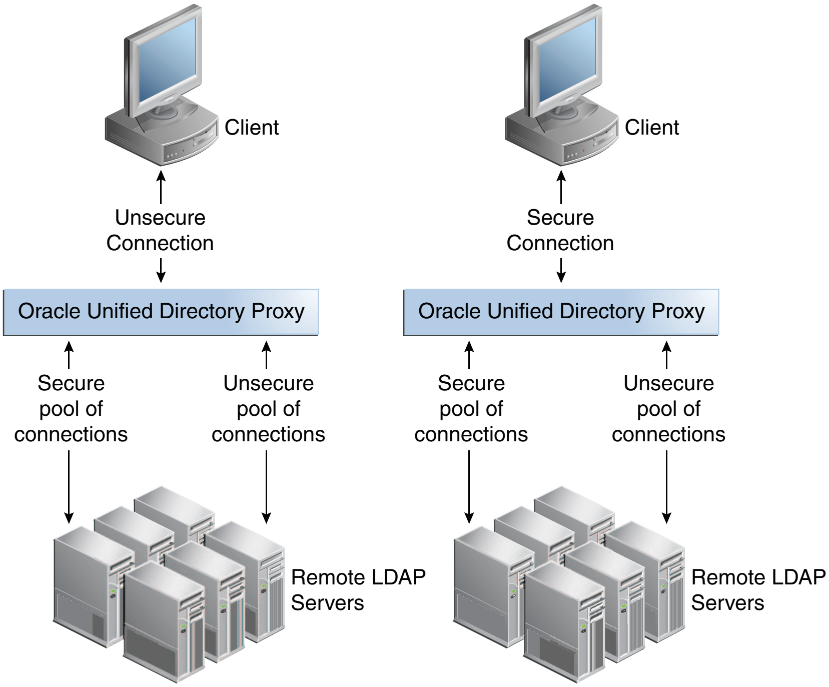
If the incoming client request is secure, whether SSL or StartTLS, the connection from the Oracle Unified Directory proxy to the remote LDAP servers is a secure SSL connection.

If the incoming client request is not secure, the connection from the Oracle Unified Directory proxy to the remote LDAP servers is not a secure SSL connection.

In this mode, the monitoring connection by Oracle Unified Directory proxy of the remote LDAP servers is never secure.

Two pools of connections are created, one secure and one unsecure. This is shown in Figure 5–1. In the scenario on the left, the client connects to Oracle Unified Directory proxy using an unsecure connection, and the unsecure pool of connections from the proxy to the remote LDAP servers is used. In the scenario on the right, the client connects to proxy using a secure connection, whether SSL or StartTLS, and the secure SSL pool of connections from Oracle Unified Directory proxy to the remote LDAP servers is used.

FIGURE 5–1 Connections in the user Secure Mode

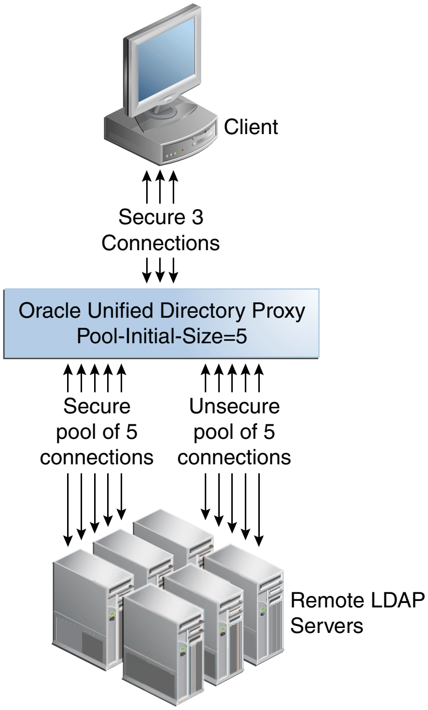

Client
Unsecure Connection
Oracle Unified Directory Proxy
Secure pool of connections
Unsecure pool of connections
Remote LDAP Servers
Client
Secure Connection
Oracle Unified Directory Proxy
Secure pool of connections
Unsecure pool of connections
Remote LDAP Servers

In the user mode, the certificate of each remote LDAP server must be imported into the truststore of the Oracle Unified Directory proxy. If there is a large number of remote LDAP servers that are not Oracle Unified Directory servers, and if certificates were not managed during installation, importing certificates into the truststore of the Oracle Unified Directory proxy can be a constraint. For test environment purposes, you can speed up this process by using the ssl-trust-all parameter. This parameter requests the Oracle Unified Directory proxy to trust all remote LDAP servers.

When the remote-ldap-server-ssl-policy property is set to user, the pool size refers to two types of connection pools: unsecure LDAP connections and secure LDAPS connections. If for example the pool-initial-size is set to 5 connections, as shown in Figure 5–2, then when the LDAP Extension is initialized, there will be one pool of 5 LDAP connections and one pool of 5 LDAPS connections, or a total of 10 connections. Each pool evolves separately after this initialization, based on parameters set for that pool.

Note – By default, pool-initial-size is set to 10 connections.

FIGURE 5–2 Multiple Pools of Connections


Client
Secure 3 Connections
Oracle Unified Directory Proxy
Pool-Initial-Size=5
Secure pool of 5 connections
Unsecure pool of 5 connections
Remote LDAP Servers

Configuring Security Between the Proxy and Data Source Using `dsconfig`

The `dsconfig` tool accesses the server over a secured connection with certificate authentication. If you run `dsconfig` in non-interactive mode, as `dsconfig` –n, specification of the trust store parameters depends on whether you run the command locally or remotely. For more information on running the command locally or remotely, see "Overview of the `dsconfig` Command" on page 25.

▼ To Configure Security Between the Proxy and Directory Servers Using `dsconfig`

This task highlights the main steps to take to configure security for connections to remote LDAP servers. Where the process is similar to that provided for configuring security between Oracle Unified Directory proxy and the client, pointers are given to the related procedure.

1 **If the remote LDAP servers do not require client authentication to be passed from the proxy, proceed directly to step 2.**

If the remote LDAP servers require client authentication to be passed from Oracle Unified Directory proxy, perform the following sub-steps:

a. **Configure a keystore for remote LDAP server connections.**

To do this, on the Oracle Unified Directory proxy, generate a certificate using the Java `keytool`. The keystore must be configured manually. For details, see "Configuring Key Manager Providers" on page 125.

Self-sign the certificate or have the certificate signed by an external certificate authority. For details, see "Configuring Key Manager Providers" on page 125.

b. **Configure a key manager provider on the proxy for the keystore for remote LDAP server connections.**

For details, see "Configuring Key Manager Providers" on page 125. This key manager provider can be separate to that used for handling secure connections to clients.

c. **If the remote LDAP servers require client authentication, the certificate of the proxy must be imported into the truststore of each remote LDAP server.**

For information about importing and exporting certificates on Oracle Unified Directory, see "Configuring Key Manager Providers" on page 125.

2 **For the proxy to establish secure connections with the remote LDAP servers, configure a truststore.**

All remote LDAP servers requiring a secure connection need to have their certificates imported into the Oracle Unified Directory proxy truststore. All of these remote LDAP server certificates can be imported into a single Oracle Unified Directory proxy truststore or distributed among multiple Oracle Unified Directory proxy truststores. You can have as many Oracle Unified Directory proxy truststores as there are remote LDAP server certificates to be imported.

An LDAP proxy extension targeting a secured connection to a remote LDAP data source must reference in its configuration the appropriate truststore manager. This enables the LDAP proxy extension to access the imported remote LDAP server certificate, to accept the secure connection.

3 **Each truststore requires a Oracle Unified Directory proxy trust manager provider.**

To list Oracle Unified Directory proxy trust manager providers, use the `dsconfig list-trust-manager-providers` command. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
list-trust-manager-providers
```

To create a Oracle Unified Directory proxy trust manager provider, use the `dsconfig create-trust-manager-provider` command. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
create-trust-manager-provider \
--provider-name Backend\ Servers \
--type file-based --set enabled:true \
--set trust-store-file:/localhost/config/backend-servers-truststore \
--set trust-store-type:JKS \
--set trust-store-pin-file:/installPath/config/backend-servers-truststore.pin
```

4 **Import the certificates of the remote LDAP servers into the proxy truststore.**

Configurable LDAP Extension Properties Relevant to Security

When managing connections to remote LDAP servers using `dsconfig`, a number of configurable LDAP Extension security connection properties are available. For information about managing LDAP extensions, see "Configuring an LDAP Proxy" on page 77. Configurable properties that either directly or indirectly relate to security considerations include the following:

`remote-ldap-server-ssl-policy`

This important value governs the overall security mode of the connections between the Oracle Unified Directory proxy and remote LDAP servers. Its use is covered in the section "Modes of Secure Connection" on page 178.

`pool-increment`

If the `remote-ldap-server-ssl-policy` property is set to `user`, two pools of connections are created and the incremental change of size of each pool is set to `pool-increment`. For more information on this property, see "Viewing LDAP Proxy Element Properties" on page 78.

`pool-initial-size`

If the `remote-ldap-server-ssl-policy` property is set to `user`, two pools of connections are created and the initial size, and minimum size, of each pool is set to `pool-initial-size`. In this case, therefore, there will initially be twice the total number of connections indicated in `pool-initial-size`. For details, see "Modes of Secure Connection" on page 178.

`pool-max-size`

If the `remote-ldap-server-ssl-policy` property is set to `user`, two pools of connections are created and the maximum size of each pool is set to `pool-max-size`.

The default value is 1000 connections. For more information on this property, see "Viewing LDAP Proxy Element Properties" on page 78.

`remote-ldap-server-ssl-port`

The port number for SSL connections from Oracle Unified Directory proxy to the remote LDAP server.

`ssl-client-alias`

When a keystore is created for client authentication, several keys can be stored in it. Use this property to specify which key to use. For more information about keystores, see "Getting SSL Up and Running Quickly" on page 121. See also "Configuring Key Manager Providers" on page 125.

`ssl-key-manager-provider`

Specifies a key manager provider to use for the LDAP Server Extension. The key manager provider is not mandatory and can be used if the remote LDAP server is configured for client authentication. The referenced key manager provider must be enabled. For more information about key manager providers, see "Configuring Key Manager Providers" on page 125.

`ssl-trust-all`

If this parameter is set to `true`, all remote LDAP servers are trusted. The default value is `false`. Setting this value to `true` avoids having to import certificates from remote LDAP servers but is insecure.

Note that although the interactive `dsconfig --advanced` command offers Blind Trust as a possible trust manager provider, Blind Trust is not supported for this release of the Oracle Unified Directory proxy. Instead, if you want to avoid the import of certificates, set the `ssl-trust-all` parameter to true. This presents an insecure deployment and is not recommended for production environments, only for testing purposes.

If the `remote-ldap-server-ssl-policy` is set to `never`, then the value of the `ssl-trust-all` parameter is irrelevant. All connections between the Oracle Unified Directory proxy will be insecure (unencrypted) in this case. For more information on the `remote-ldap-server-ssl-policy`, see "Modes of Secure Connection" on page 178.

`ssl-trust-manager-provider`

Specifies which trust manager provider to use for the LDAP Server Extension. The trust manager provider is mandatory unless the `ssl-trust-all` parameter is set to `true`. The referenced trust manager provider must be enabled.

StartTLS and the Proxy

StartTLS is supported for client connections to the Oracle Unified Directory proxy. For more information, see "Configuring SSL and StartTLS for LDAP and JMX" on page 140 and see also "Testing SSL, StartTLS, and SASL Authentication With `ldapsearch`" on page 169.

Connections between the proxy and the directory servers are never passed in StartTLS. If a StartTLS connection arrives from the client to the Oracle Unified Directory proxy, and if the `remote-ldap-server-ssl-policy` is set to `user`, then the connection between the Oracle Unified Directory proxy is passed in SSL. For information on the `remote-ldap-server-ssl-policy`, see "Modes of Secure Connection" on page 178.

Setting Access Control Using Network Group Criteria

The network group criteria allow you to set lists of allowed or denied clients, which can help reinforce the security of your deployment.

For example, if you know that requests to your Oracle Unified Directory proxy deployment should always come from a restricted number of clients, then you could create a list of allowed clients as part of the network group criteria. In this case, any requests from clients other than the allowed clients listed will be rejected.

For more information on setting network group criteria, see "Modifying Network Group Properties" on page 40.

CHAPTER 6

Managing Oracle Unified Directory With Oracle Directory Services Manager

Oracle Directory Services Manager (ODSM) is an interface for managing instances of Oracle Unified Directory. ODSM enables you to configure the structure of the directory, define objects in the directory, add and configure users, groups, and other entries. ODSM is also the interface you use to manage entries, schema, security, and other directory features.

This section covers the following topics:

- "Invoking Oracle Directory Services Manager" on page 188
- "Connecting to the Server From Oracle Directory Services Manager" on page 188
- "Displaying Server Information With Oracle Directory Services Manager" on page 188

Additional information about using ODSM to manage Oracle Unified Directory is available in the following sections:

- "Managing Data With Oracle Directory Services Manager" on page 303
- "Searching Data With Oracle Directory Services Manager" on page 245
- "Managing the Server Configuration With Oracle Directory Services Manager" on page 54
- "Managing the Proxy Configuration With ODSM" on page 117
- "Managing the Schema With Oracle Directory Services Manager" on page 446
- "Managing Access Control With Oracle Directory Services Manager" on page 362
- "Configuring Password Policies by Using Oracle Directory Services Manager" on page 421

Note – When you use ODSM with the Firefox 3 browser, there is a known issue that causes some of the icons to be displayed twice. The issue is harmless.

Invoking Oracle Directory Services Manager

For information about supported browsers for ODSM, refer to System Requirements and Supported Platforms for Oracle Fusion Middleware 11gR1, which is linked from: http://www.oracle.com/technetwork/middleware/ias/downloads/fusion-certification-100350.html

To invoke ODSM, enter the following URL into your browser's address field: `http://`*host*`:`*port*`/odsm` where *host* is the name of the managed server on which ODSM is running and *port* is the managed server port number of the admin server. The default admin port is 7001.

Connect to the server as described in the following section.

Connecting to the Server From Oracle Directory Services Manager

On the main ODSM screen, enter the following information to connect to an Oracle Unified Directory instance:

- **Server.** Enter the name of the directory server to which you want to connect.
- **Port.** Enter the administration port number of the directory server to which you want to connect.
- **User name.** Enter the bind DN to connect to the directory.
- **Password.** Enter the bind password to connect to the directory.

If SSL is enabled, you are asked to trust the server certificate.

Note – If you change the browser language setting, you must update the session in order to use the new setting. To update the session, either reenter the ODSM URL in the URL field and press Enter or quit and restart the browser.

Displaying Server Information With Oracle Directory Services Manager

The Home tab of each server instance in ODSM enables you to view specific information about the server.

View Version Information

The version information panel indicates the version number of the ODSM instance, the Oracle Unified Directory instance, and the version of the Java Runtime Edition (JRE).

View the Server Role

The server role can be one or more of the following, depending on how the Oracle Unified Directory instance was set up.

- Directory
- Proxy
- Load Balancer
- Distributor
- Replication Gateway
- Replication Server

For more information, see "Selecting a Server Role" in *Oracle Fusion Middleware Installation Guide for Oracle Unified Directory*.

View Server Statistics

The OUD Statistics panel displays installation details and basic monitoring information for this server instances. The following information is displayed:

- **Server Start Time.** The latest date and time on which the server was started successfully.
- **Installation Path.** The network path to the installation files for this server instance.
- **Instance Path.** The network path to the instance files for this server instance.
- **Administrative User.** The root user that was configured when the server was set up. For more information, see "Managing Root User, Global Administrator, and Administrator Accounts" on page 381.
- **Total LDAP Operations Completed (per sec) (since startup).** The total number of LDAP operations performed on the server, divided by the number of seconds that have passed since server startup.
- **Average Elapsed Time per Operation (since startup) (ms).** The average time taken to complete an LDAP operation.
- **Connection Rate (con/sec).** The number of connections that the server is currently handling per second.

View the Configured Connection Handlers

The Connection Handlers panel details of all the connection handlers that are configured for this server instance, including the type of connection handler, the port on which that connection handler is listening, and whether the connection handler is enabled.

For more information about connection handlers, see "Configuring the Connection Handlers With `dsconfig`" on page 35 and "Managing Administration Traffic to the Server" on page 62.

View the Configured Naming Contexts

The Naming Contexts panel displays all naming contexts, or suffixes, that are configured on this server instance, including the network group to which that naming context belongs, the number of entries in the naming context and whether or not that naming context is replicated.

View the Configured Data Sources

For proxy servers, the Data Sources panel displays all of the data sources, or back-end LDAP servers that are managed through that proxy instance.

CHAPTER 7

Managing Directory Data

The topics included in this chapter describe how to add, modify, remove, and search data in the directory server. These topics also describe how to make searches more efficient, by indexing data, how to ensure that entries are unique, and how to use advanced data features such as virtual attributes.

This chapter covers the following topics:

Importing and Exporting Data

The directory server provides several mechanisms to move data into and out of a specific back end. This chapter outlines the various options and then describes the import and export mechanisms in more detail.

This section covers the following topics:

- "Exporting Data Using `export-ldif`" on page 198
- "Creating MakeLDIF Template Files" on page 202

Populating a Stand-Alone Directory Server With Data

To populate a stand-alone directory server with data, use one of the following methods:

- Import the data from an LDAP Data Interchange Format (LDIF) file while you are setting up the server, either by using the `setup` utility in GUI mode or by using the `setup` utility in interactive command-line mode. This is the most convenient method of initializing a stand-alone server or the first server in a replicated topology.
- Start with an empty suffix and add entries by using the `ldapmodify` command, for example:

  ```
  $ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password \
    -a -f /usr/local/add_entry.ldif
  ```
- Import data from an LDIF file, using the `import-ldif` command. For example:

  ```
  $ import-ldif -b dc=example,dc=com -n userRoot -l /var/tmp/Example.ldif
  ```

  This method is much more efficient for the addition of bulk entries. The `import-ldif` command imports data from an LDIF file either by replacing any existing data in the suffix or by appending data to a base DN. Similarly, the `export-ldif` command exports entries from a database to an LDIF file, which can then be imported to another server. Both tools support file compression, SASL extension, and client/server authentication using SSL and startTLS.
- Copy the binary database from another server. This method is also called *binary copy*.

  ```
  $ cp instance-path/db/example.db destination-path/db
  ```
- Restore the database from a backup using the `restore` command, for example:

  ```
  $ restore -d /home/backup/userRoot
  ```

Note – Performing a binary database copy or restoring a database from a backup requires the source server and the destination server to have the same database remote LDAP structures and indexes.

Importing Data Using `import-ldif`

The `import-ldif` command is used to populate a directory server back end with data read from an LDIF file or with data generated based on a "Creating MakeLDIF Template Files" on page 202. In most cases, `import-ldif` is significantly faster than adding entries using `ldapmodify`.

The `import-ldif` command supports both LDIF files and compressed files (`.zip`).

Note –

- A complete import to an entire Oracle Berkeley DB Java Edition (JE) back end will have better performance than a partial import to a branch of the JE back end. All imported LDIF files must use UTF-8 character-set encoding.
- Importing *suffixes* is a resource-intensive operation. If you import LDIF files that include a large number of suffixes, your system might have insufficient heap to complete the import operation. Before importing such LDIF files, you should therefore increase the heap as much as possible. For more information, see Chapter 14, "Tuning Performance," and "Importing Large Data Sets" on page 217.

You do not need root privileges to import an LDIF file, but you must authenticate as a user with root permissions, such as `cn=Directory Manager`.

`import-ldif` Operation Modes

The `import-ldif` command has two modes of operation: online and offline.

- **Online mode**. In online mode, `import-ldif` contacts a running directory server instance and registers an import task. The command accesses the task back end over SSL via the administration connector. For more information, see "Managing Administration Traffic to the Server" on page 62. Online mode runs automatically when any connection options (such as `--hostname`, `--port`, `--bindDN`, and `--bindPassword`) are specified.

  In general, if you expect to do online imports, you should increase the heap when you start the server. For more information, see Chapter 14, "Tuning Performance."
- **Offline mode**. When no connection options are specified, the command runs in offline mode. In offline mode, `import-ldif` accesses the database directly rather than through a directory server instance. In this case, the directory server must be stopped.

▼ To Import Data in Offline Mode

This procedure imports a remote LDAP database with new entries specified in an import LDIF file. The command runs in *offline* mode, which requires the server to be shut down prior to import.

1 **Stop the server if it is running.**

```
$ stop-ds
```

2 **Import the LDIF file, as shown in the following example:**

```
$ import-ldif -b dc=example,dc=com -n userRoot -l Example.ldif
```

This command specifies the base DN for the branch of the data that should be included in the import (`-b`), the back-end ID into which the data is imported (`-n`), and the LDIF file used for the import (`-l`).

▼ To Replace Existing Data During an Offline Import

The following procedure replaces an existing back-end with new entries specified in an import file.

1 **Stop the server if it is running.**

```
$ stop-ds
```

2 **Import the LDIF file, replacing the existing data. For example:**

```
$ import-ldif --includeBranch dc=example,dc=com --backendID userRoot \
  --replaceExisting --ldifFile Example.ldif
```

▼ To Append Imported Data to Existing Data

The following procedure appends the entries in an import file to the existing entries in the back end.

1 **Stop the server if it is running.**

```
$ stop-ds
```

2 **Import the LDIF file, appending the new data to the existing data. For example:**

```
$ import-ldif --backendID userRoot --append --ldifFile new.ldif
```

▼ To Import Fractional Files

The `import-ldif` command provides options to import a portion of an import file by specifying the base DN to include or exclude during the process.

This example imports all entries below the base DN, `dc=example,dc=com`, and excludes all entries below `ou=People,dc=example,dc=com`.

1 **Stop the server if it is running.**

```
$ stop-ds
```

2 **Import a portion of the LDIF file. For example:**

```
$ import-ldif --includeBranch dc=example,dc=com \
  --excludeBranch ou=People,dc=example,dc=com --backendID userRoot --replaceExisting \
  --ldifFile Example.ldif
```

▼ To Import Fractional Files by Using Filters

The `import-ldif` command provides options to import part of an import file by using filters for data inclusion or exclusion. Make sure that you fully understand how this mechanism works before you use it.

In this example, the contents of an LDIF file are imported, except those entries that match the search filter `l=Auckland` (that is, `location=Auckland`).

Note – The `--includeFilter` option works in a similar manner to `--excludeFilter`, except that it includes all entries that match the search filter during import.

1 **Stop the server if it is running.**

```
$ stop-ds
```

2 **Import a portion of the file by using an exclude filter. For example:**

```
$ import-ldif --excludeFilter "(l=Auckland)" --backendID userRoot \
  --replaceExisting --ldifFile Example.ldif
```

▼ To Include or Exclude Attributes During Import

The `import-ldif` command provides options to include and exclude attributes during import by using the `--includeAttribute` and `--excludeAttribute` options, respectively. Make sure that you fully understand how this mechanism works before you use it.

1 **Stop the server if it is running.**

```
$ stop-ds
```

2 **(Optional) View the entries of the import file before you start the import.**

The directory server provides useful utilities to search, modify, compare, or delete import files without connecting to the server. You can use the `ldifsearch` command to display an entry in your import file. For example, to display the entry for Sam Carter, use the following command:

```
$ ldifsearch -b dc=example,dc=com --ldifFile Example.ldif "(cn=Sam Carter)"
dn: uid=scarter,ou=People,dc=example,dc=com
objectClass: person
objectClass: inetOrgPerson
objectClass: organizationalPerson
objectClass: top
givenname: Sam
uid: scarter
cn: Sam Carter
telephonenumber: +1 408 555 4798
sn: Carter
userpassword: sprain
roomnumber: 4612
mail: scarter@example.com
l: Sunnyvale
ou: Accounting
ou: People
facsimiletelephonenumber: +1 408 555 9751
```

In this entry, notice the presence of the `roomnumber` attribute below the `telephonenumber` attribute.

3 **Import the file, excluding the `roomnumber` attribute for all entries.**

```
$ import-ldif --excludeAttribute "roomnumber" --backendID userRoot \
  --replaceExisting --ldifFile Example.ldif
```

4 **Start the server.**

```
$ start-ds
```

5 **Perform an `ldapsearch` to verify the import.**

The following example shows that the `roomnumber` attribute is now absent from Sam Carter's entry.

```
$ ldapsearch --port 1389 --baseDN dc=example,dc=com --bindDN "cn=Directory Manager" \
  --bindPassword password "(cn=Sam Carter)"
dn: uid=scarter,ou=People,dc=example,dc=com \
objectClass: person
objectClass: organizationalPerson
objectClass: inetOrgPerson
objectClass: top
givenName: Sam
uid: scarter
cn: Sam Carter
sn: Carter
telephoneNumber: +1 408 555 4798
ou: Accounting
ou: People
l: Sunnyvale
mail: scarter@example.com
facsimileTelephoneNumber: +1 408 555 9751
```

▼ To Import a Compressed LDIF File

The `import-ldif` utility supports compressed LDIF files.

1 **Stop the server if it is running.**

```
$ stop-ds
```

2 **Import the compressed LDIF file.**

```
$ import-ldif --includeBranch dc=example,dc=com
  --excludeBranch "ou=People,dc=example,dc=com" --ldifFile Example.ldif \
  --backendID userRoot --replaceExisting --isCompressed
```

▼ To Record Rejected or Skipped Entries During Import

The `import-ldif` command provides a means to write to an output file for any entries that are rejected or skipped during the import process. This enables easy debugging of an LDIF file. Rejected entries occur when the directory server rejects the added entries due to schema violations. Skipped entries occur when entries cannot be placed under the specified base DN.

1 **Stop the server if it is running.**

```
$ stop-ds
```

2 **Import the file, using the `--rejectFile` and `--skipFile` options.**

You can also use the `--overWrite` option to replace any previous items in the two files. Without the option, the directory server appends new rejected and skipped entries to the existing files.

```
$ import-ldif --backendID userRoot --append --ldifFile new.ldif
  --overwrite --rejectFile rejected.ldif --skipFile skipped.ldif
```

3 **(Optional) View the contents of the `rejectFile` and `skipFile` to determine which entries were rejected or skipped during the import. For example:**

```
$ more rejected.ldif
# Entry ou=Contractors,dc=example,dc=com read from LDIF starting at line 1
is not valid because it violates the server’s schema configuration:
Entry ou=Contractors,dc=example,dc=com violates the Directory Server schema
configuration because it includes attribute changeType which is not allowed.
changetype: add objectclasses defined in that entry objectclass: top
objectclass: organizationalUnit ou: Contractors ou: Product Testing
ou: Product Dev ou: Accounting ...

$ more skipped.ldif
# Skipping entry ou=People,dc=example,dc=com because the DN is not one that should be
  included based on the include and exclude branches objectclass: top
  objectclass: organizationalunit ou: People
  aci: (target ="ldap:///ou=People,dc=example,dc=com")(targetattr ="userpassword ||
  telephonenumber || facsimiletelephonenumber")(version 3.0;acl "Allow self entry
  modification"; allow (write)(userdn = "ldap:///self");)
  aci: (target ="ldap:///ou=People,dc=example,dc=com")(targetattr h3.="cn || sn ||
  uid") (targetfilter ="(ou=Accounting)")(version 3.0;acl "Accounting Managers Group
  Permissions"; allow (write)
  (groupdn = "ldap:///cn=Accounting Managers,ou=groups,dc=example,dc=com");)
  aci: (target ="ldap:///ou=People,dc=example,dc=com")(targetattr h3.="cn || sn ||
  uid") (targetfilter ="(ou=Human Resources)")(version 3.0;acl "HR Group Permissions";
  allow write)(groupdn = "ldap:///cn=HR Managers,ou=groups,dc=example,dc=com");) aci:
  (target ="ldap:///ou=People,dc=example,dc=com")(targetattr h3.="cn ||sn || uid")
  (targetfilter ="(ou=Product Testing)")(version 3.0;acl "QA Group Permissions"; allow
  (write)(groupdn = "ldap:///cn=QA Managers,ou=groups,dc=example,dc=com");)
  aci: (target ="ldap:///ou=People,dc=example,dc=com")(targetattr h3.="cn || sn ||
  uid") (targetfilter ="(ou=Product Development)")(version 3.0;acl "Engineering Group
  Permissions"; allow (write)(groupdn =
  "ldap:///cn=PD Managers,ou=groups,dc=example,dc=com");) ...
```

To Import Data From a MakeLDIF Template

The directory server includes the Java utility, `makeLDIF`, that can be used to generate sample data for import. The `makeLDIF` utility requires a template file. You can create your own template file, or you can use the template file located in *install-dir*`/config/MakeLDIF/example.template`, editing it as required. For more information, see “Creating MakeLDIF Template Files” on page 202.

1 **Stop the server if it is running.**

```
$ stop-ds
```

2 **Import the data, using a template file.**

The sample template generates 10,003 sample entries in the specified back end.

```
$ import-ldif --backendID userRoot --templateFile example.template --randomSeed 0
```

See Also "make-ldif" in *Oracle Fusion Middleware Command-Line Usage Guide for Oracle Unified Directory*

▼ To Run an Import in Online Mode

The `import-ldif` utility can also be run with the server online. In online mode, the command accesses the task back end over SSL via the administration connector. To run the command in online mode you must specify the relevant connection options, including how the SSL certificate will be trusted. This example uses the `-X` option to trust all certificates. For more information, see "Managing Administration Traffic to the Server" on page 62.

● **Run the `import-ldif` command with the appropriate connection options.**

```
$ import-ldif -h localhost -port 4444 -D "cn=Directory Manager" -w password -X \
  -l /ldif-files/example.ldif
```

▼ To Schedule an Import

The `import-ldif` utility provides a `--start` option for scheduling the import at some future date. You can view this scheduled task by using the `manage-tasks` utility. The command accesses the task back end over SSL via the administration connector. To schedule an import task, you must specify the relevant connection options, including how the SSL certificate will be trusted. This example uses the `-X` option to trust all certificates. For more information, see

● **Run the `import-ldif` command with the `--start` option.**

```
$ import-ldif -h localhost -port 4444 -D "cn=Directory Manager" -w password -X \
  -l /ldif-files/example.ldif --start 20080124121500
```

See Also "Configuring Commands As Tasks" on page 64

Exporting Data Using `export-ldif`

The `export-ldif` command is used to export data from a directory server back end. The command is useful for the following tasks:

- Backing up directory data
- Exporting data to another application
- Repopulating a database after a change to the directory topology
- Reinitializing master servers in a replicated topology

Note – The `export-ldif` command cannot be used to export data from the following back ends: `monitor`, `ads-truststore`, `backup`, and `config-file-handler`.

`export-ldif` Operation Modes

The `export-ldif` command has two modes of operation: online and offline.

- **Online mode**. In online mode, `export-ldif` contacts a running directory server instance and registers an export task. This mode runs automatically when the LDAP connection options (`--hostname`, `--port`, `--bindDN`, and `--bindPassword`) are used. The command accesses the task back end over SSL via the administration connector. For more information, see "Managing Administration Traffic to the Server" on page 62.
- **Offline mode**. When no connection options are specified, the command runs in offline mode. In offline mode, `export-ldif` accesses the database directly rather than through a directory server instance. In this case, the directory server must be stopped.

To Export Data to LDIF

1. **Stop the server if it is running.**

```
$ stop-ds
```

2. **Export the back end to a specified LDIF file.**

```
$ export-ldif --includeBranch "dc=example,dc=com" --backendID userRoot \
  --ldifFile example.ldif
```

To Export Partial Data

The `export-ldif` command provides options to export a part of a back end by specifying the base DN and its children for inclusion or exclusion during processing.

1. **Stop the server if it is running.**

```
$ stop-ds
```

2. **Export a portion of the back end.**

In this example, only the entries under `ou=People,dc=example,dc=com` are exported.

```
$ export-ldif --includeBranch ou=People,dc=example,dc=com --backendID userRoot \
  --ldifFile example-people.ldif
```

3. **(Optional) Use the `ldifsearch` command to verify the exported file.**

The `ldifsearch` command verifies entries in an LDIF file without connecting to the directory server. You can use it in a manner similar to the `ldapsearch` command. For example:

```
$ ldifsearch -b dc=example,dc=com --ldifFile export.ldif "(objectclass=*)"
dn: ou=People,dc=example,dc=com
objectClass: organizationalunit
```

```
objectClass: top
ou: People
dn: uid=scarter,ou=People,dc=example,dc=com
objectClass: person
objectClass: organizationalPerson
objectClass: inetOrgPerson
objectClass: top
givenName: Sam
uid: scarter
cn: Sam Carter
sn: Carter
telephoneNumber: +1 408 555 4798
userPassword: {SSHA}Ocpp2P4sImz2MziL69AUG9+khdIhFpmU4B5mvA==
roomNumber: 4612
ou: Accounting
ou: People
l: Sunnyvale
mail: scarter@example.com
facsimileTelephoneNumber: +1 408 555 9751 ...
```

▼ To Export Part of a Back End by Using Filters

The `export-ldif` command provides options to export part of a back end by using a search filter. The directory server includes or excludes all entries that match the filter. Make sure that you fully understand how this mechanism works before you use it.

In this example, only those entries that match the search filter `l=Cupertino` (that is, `location=Cupertino`) are exported. The `--excludeFilter` option works in a similar manner to `--includeFilter`, except that it excludes all entries that match the filter during export.

1 **Stop the server if it is running.**

```
$ stop-ds
```

2 **Export a portion of the back end by using the `--includeFilter` option.**

```
$ export-ldif --includeFilter "(l=Cupertino)" --backendID userRoot \
  --ldifFile export.ldif
```

▼ To Include or Exclude Attributes During Export

The `export-ldif` utility provides options to include and exclude attributes during export by using the `--includeAttribute` and `--excludeAttribute` options, respectively. Make sure that you fully understand how this mechanism works before you use it.

1 **(Optional) With the server running, view a sample entry, by using the `ldapsearch` command. For example:**

```
$ ldapsearch --baseDN dc=example,dc=com "(cn=Sam Carter)"
dn: uid=scarter,ou=People,dc=example,dc=com
objectClass: person
objectClass: inetOrgPerson
objectClass: organizationalPerson
objectClass: top
```

```
givenname: Sam
uid: scarter
cn: Sam Carter
telephonenumber: +1 408 555 4798
sn: Carter
userpassword: sprain
roomnumber: 4612
mail: scarter@example.com
l: Sunnyvale
ou: Accounting
ou: People
facsimiletelephonenumber: +1 408 555 9751
```

2 **Stop the server.**

```
$ stop-ds
```

3 **Export the back end, using the `--includeAttribute` option to specify the attributes that should be included in the export.**

You can use the `--includeAttribute` option multiple times for each attribute that should be included. In this example, only the top level attributes are exported.

```
$ export-ldif --backendID userRoot --includeAttribute dn --includeAttribute dc \
  --includeAttibute cn --includeAttribute sn --includeAttribute givenname \
  --includeAttribute objectclass --includeAttribute ou --includeAttribute uid \
  --ldifFile export.ldif
```

4 **(Optional) Use the `ldifsearch` command to verify the export file.**

If an error occurs, the server continues processing the command.

```
$ ldifsearch --baseDN dc=example,dc=com --ldifFile export.ldif "(objectclass=*)"
dn: dc=example,dc=com
objectClass: domain
objectClass: top
dc: example
dn: ou=Groups,dc=example,dc=com
objectClass: organizationalunit
objectClass: top
ou: Groups
dn: cn=Directory Administrators,ou=Groups,dc=example,dc=com
objectClass: groupofuniquenames
objectClass: top
cn: Directory Administrators
ou: Groups
dn: ou=People,dc=example,dc=com
objectClass: organizationalunit
objectClass: top
ou: People ...
```

To Export to LDIF and Then Compress the File

The `export-ldif` command allows you to compress the output LDIF file.

1 **Stop the server if it is running.**

```
$ stop-ds
```

2 Export to LDIF and then compress the file.

```
$ export-ldif --backendID userRoot --ldifFile export.ldif --compress
```

▼ To Run an Export in Online Mode

The `export-ldif` command can also be run with the server online. In online mode, the command accesses the task back end over SSL via the administration connector. For more information, see "Managing Administration Traffic to the Server" on page 62. To run the command in online mode you must specify the relevant connection options, including how the SSL certificate will be trusted. This example uses the `-X` option to trust all certificates.

- **Run the `export-ldif` command with the LDAP connection options. For example:**

```
$ export-ldif -h localhost -p 4444 -D "cn=Directory Manager" -w password -X \
  --includeBranch "dc=example,dc=com" --backendID userRoot --ldifFile export.ldif
```

▼ To Schedule an Export

The `export-ldif` utility provides a `--start` option for scheduling the export at some future date. You can view this scheduled task by using the `manage-tasks` utility. The command accesses the task back end over SSL via the administration connector. For more information, see "Managing Administration Traffic to the Server" on page 62. To schedule an export task, you must specify the relevant connection options, including how the SSL certificate will be trusted. This example uses the `-X` option to trust all certificates.

The server must be running to schedule an export.

- **Run the `export-ldif` command with the `--start` option and the LDAP connection parameters.**

The `--start` option takes as its value a date and time in the format `yyyymmddhhmmss`. For example:

```
$ export-ldif -h localhost -p 4444 -D "cn=Directory Manager" -w password -X \
  --includeBranch "dc=example,dc=com" --backendID userRoot \
  --ldifFile export.ldif --start 20080124121500
```

Creating MakeLDIF Template Files

The `make-ldif` command can use template files to define the way in which LDIF files are to be generated. This approach allows for flexibility without the need to alter any code to produce the desired result. The topics in this section describe how to use the `make-ldif` command to create customized LDIF files.

The Template File Format

Template files can contain up to four sections, that must be provided in the following order:

1. "Custom Tag Includes" on page 203
2. "Global Replacement Variables" on page 203

3. “Branch Definitions” on page 204
4. “Template Definitions” on page 205

Custom Tag Includes

Custom tag includes provide a mechanism for loading custom tags and making them available for use when processing make-ldif templates. This should be done using the include directive, as follows:

```
include com.example.opends.makeldif.MyCustomTag
```

The specified class must be in the class path, and it must be a subclass of the org.opends.server.tools.makeldif.Tag class. For information about developing custom tags, see “Defining Custom Tags” on page 216.

All of the standard replacement tags that are provided with make-ldif are automatically available for use and therefore do not require an explicit include directive.

Global Replacement Variables

The first section that should be present in the template file is the section that defines the global replacement variables. Global replacement variables are used to define strings of text that can be referenced later in the template file and are automatically replaced as each line is read into memory (much like a C preprocessor replaces macros in code with their defined values). For example, the following replacement variable definition creates a global replacement variable named suffix with a value of dc=example,dc=com:

```
define suffix=dc=example,dc=com
```

When a global replacement variable is defined, any case in which that variable name appears in square brackets (for example, [suffix]), causes the token to be replaced with the value that has been defined for that replacement variable.

When all the replacement variable definitions have been read (as signified by the first blank line following one or more replacement variable definitions), all remaining lines that are read from the template file are processed on a line-by-line basis. Any occurrences of a replacement variable name in square brackets are replaced with the value of that variable. Because that replacement is done as the template file is read into memory, replacement variables can occur in any point, including branch and template definitions, and even inside tags.

If there are global replacement variables defined in the template file, they must appear at the top of the file and there should not be any spaces between them. However, replacement variables are not required. If there are no replacement variables, the template file must start with the branch definitions.

Branch Definitions

Branch definitions are used in make-ldif template files to define the basic structure to use for the generated LDIF. They specify the entry or entries that should appear at the top of the hierarchy, and the number and types of entries that should appear below them.

The most basic form of a branch definition is as follows:

```
branch: dc=example,dc=com
```

This example specifies that the following entry is to be created with a DN of `dc=example,dc=com`:

```
dn: dc=example,dc=com
objectClass: top
objectClass: domain
dc: example
```

The basic structure of the entry is defined by the RDN attribute of `dc` specified in the DN of the branch definition. The `make-ldif` command automatically associates the `dc` RDN attribute with the `domain` object class. The `make-ldif` command has similar definitions for other common RDN attributes in branch entries:

`o` Creates an entry with the `organization` object class.

`ou` Creates an entry with the `organizationalUnit` object class.

`c` Creates an entry with the `country` object class.

You can also use any other kind of RDN attribute for a branch entry. For branch entries with an RDN attribute other than the ones specified above, the entry is created with the `untypedObject` and `extensibleObject` object classes.

The branch definition provided above does not cause any additional entries to be created below that branch entry. To do this, you must specify one or more `subordinateTemplate` lines. For example:

```
branch: ou=People,dc=example,dc=com
subordinateTemplate: person:100
```

This causes the `ou=People,dc=example,dc=com` entry to be created, and then 1000 other entries created below it modeled after the `person` template. The `person` template should be defined later in the template file. For more information, see "Template Definitions" on page 205.

Note – Branch entries are not limited to just one `subordinateTemplate` definition. You can specify multiple `subordinateTemplate` definitions by including them on separate lines of the branch definition. The following example creates 1000 entries based on the `person` template and an additional 100 entries based on the `certificatePerson` template:

```
branch: ou=People,dc=example,dc=com
subordinateTemplate: person:10000
subordinateTemplate: certificatePerson:100
```

In all of the examples described previously, the branch entries themselves contain only the DN, the RDN attribute, and the object classes associated with the RDN attribute. You can include any other attributes in the branch entry by including them in the branch definition in the template file. For example, the branch definition:

```
branch: dc=example,dc=com
description: This is the description for dc=example,dc=com
```

creates the entry:

```
dn: dc=example,dc=com
objectClass: top
objectClass: domain
dc: example
description: This is the description for dc=example,dc=com
```

This additional text can be static, can contain any defined global replacement variables, or can contain a subset of the replacement tags that can be used in template definitions. For an overview of the tags available and information about which tags can be used in branch definitions, see “Standard Replacement Tags” on page 207.

Template Definitions

The heart of the `make-ldif` template file structure is the set of template definitions. Templates define the structure of the entries that are generated. They specify the set of attributes that should be included in the entries and the types of values that those attributes should contain. The specification of values is handled through tags that are parsed by `make-ldif` and replaced with the appropriate values for those tags.

A sample template definition might look as follows:

```
template: person
rdnAttr: uid
objectClass: top
objectClass: person
objectClass: organizationalPerson
objectClass: inetOrgPerson
```

```
givenName: <first>
sn: <last>
cn: {givenName} {sn}
initials: {givenName:1}<random:chars:ABCDEFGHIJKLMNOPQRSTUVWXYZ:1>{sn:1}
employeeNumber: <sequential:0>
uid: user.{employeeNumber}
mail: {uid}@[maildomain]
userPassword: password
telephoneNumber: <random:telephone>
homePhone: <random:telephone>
pager: <random:telephone>
mobile: <random:telephone>
street: <random:numeric:5> <file:streets> Street
l: <file:cities>
st: <file:states>
postalCode: <random:numeric:5>
postalAddress: {cn}${street}${l}, {st}  {postalCode}
description: This is the description for {cn}.
```

This example illustrates some of the flexibility that `make-ldif` provides when generating LDIF data. The tags that can be included in a template definition are described in the topics that follow (see "Standard Replacement Tags" on page 207 and "Attribute Value Reference Tags" on page 215).

At the top of the template definition are two lines that provide information about the template itself and are not included in the entries created from this template. The first line specifies the name of the template. This is the name that is referenced in the `subordinateTemplate` lines of the branch definition. The second line specifies the name of the attribute that should be used as the RDN attribute for the entry. The RDN attribute must be assigned a value in the body of the template definition, and the way in which the value is assigned must ensure that the value will be unique among all other entries created with the same template below the same parent.

Note – It is possible to specify multivalued RDNs by separating the attribute names with a plus sign, as shown in the following example:

```
rdnAttr: uid+employeeNumber
```

If multivalued RDNs are used, all of the RDN attributes must be defined values in the template body and the combination of the RDN values for each entry must be unique. However, it is possible for one or more of the attributes in the RDN to be non-unique as long as the combination is never duplicated.

In addition to the `template` and `rdnAttr` lines, you can include one or more `subordinateTemplate` lines. This enables you to include dynamically-generated entries below other entries that have been dynamically generated (for example, if each user entry has one or more entries below it), and to allow for complex hierarchies. Although there is no limit placed on this level of nesting, you must ensure that no recursive loops are created by having a subordinateTemplate that either directly or indirectly will create additional entries using the same template.

Template definitions also support the concept of inheritance through the use of the extends keyword. For example, entries generated from the following template definition include all of the attributes defined in the person template as well as userCertificate;binary with the specified format:

```
template: certificatePerson
rdnAttr: uid
extends: person
userCertificate;binary:: <random:base64:1000>
```

Multiple inheritance is allowed (by including multiple lines with the extends keyword), but as with the subordinateTemplate keyword it is important not to create a recursive loop in which a template file could either directly or indirectly inherit from itself.

make-ldif Template File Tags

To ensure that make-ldif can generate LDIF files that can be used to simulate a wide variety of deployments, a large number of tags have been defined for use in templates. This section describes the standard set of tags that can be used in a make-ldif template file. You can also create custom tags, as described in "Defining Custom Tags" on page 216.

Standard Replacement Tags

The make-ldif standard replacement tags are special elements that are enclosed in angle brackets (beginning with a less-than sign (<) and ending with a greater-than sign (>) that are dynamically replaced with generated values. Some standard replacement tags do not require any arguments (for example, <first>). Others do take arguments, in which case the tag name comes first followed by a colon and the argument list with a colon between each argument (for example, <random:numeric:5>). The tag name is treated in a case-insensitive manner, although the arguments are generally case sensitive.

The following types of standard replacement tags are currently included as part of make-ldif:

The DN tag

The DN standard replacement tag is replaced with the DN of the current entry. If that DN is not yet available (for example, because the RDN attribute has not yet been assigned a value in the entry being generated), it is replaced with an empty string. In general, you should ensure that all RDN attributes are assigned values earlier in the template before this tag is used.

The DN tag can be used without any arguments (for example, <DN>), in which case it is replaced with the full DN of the entry. The tag can also take a single integer argument, which specifies the maximum number of components to include in the output. For example, the tag `<DN:1>` will only include the left most DN component (often called the RDN) for the entry. So if the entry being generated will have a DN of `uid=john.doe,ou=People,dc=example,dc=com`, the tag `<DN:1>` will be replaced with `uid=john.doe`. If the argument value is negative rather than positive, then it takes the absolute value of the given argument value and takes that number of components from the end of the DN. For example, using a DN of `uid=john.doe,ou=People,dc=example,dc=com` the tag `<DN:-1>` is replaced with `dc=com`.

This tag can be used in both branch and template definitions.

The File tag

The File standard replacement tag is replaced with a line from a specified file. It requires either one or two arguments. The first argument is the path to the data file, and can be either an absolute path or the name of a file (with no path information) that is contained in the `config/MakeLDIF` directory. If there is a second argument, it must have a value of either `sequential` or `random`, which indicates whether the lines in the file should be taken in sequential order or chosen at random. If the second argument is not provided, the values are selected at random. For example, the tags `<file:cities>` and `<file:cities:random>` both cause the tag to be replaced with a randomly-selected line from the `cities` file, but the tag `<file:cities:sequential>` causes the city names to be taken in sequential order. If sequential ordering is used and all values are exhausted, it will wrap back around to the first line of the file.

The `make-ldif` command includes a number of standard data files that can be used in generated data. These files are included in the `config/MakeLDIF` directory and therefore only the filename is required. The files include:

`cities`	Contains a list of common city names
`first.names`	Contains a list of common first names
`last.names`	Contains a list of common last names
`states`	Contains a list of all two-character US state abbreviations
`streets`	Contains a list of common street names

This tag can be used in both branch and template definitions.

The First tag

The First standard replacement tag is replaced with a first name taken from the `config/MakeLDIF/first.names` file. Note that there is a special relationship between the `<first>` and `<last>` tags such that the combination of the first and last names is always unique. When every possible combination from the first and last name files has been exhausted, make-ldif appends an integer value onto the last name to ensure that the value always remains unique.

The `<first>` tag does not take any arguments. It can be used only in template definitions. It is not allowed for use in branch definitions.

The GUID tag

The GUID standard replacement tag is replaced with a randomly generated GUID (globally-unique identifier) value. All GUID values generated are guaranteed to be unique. The values generated consist of 32 hexadecimal digits in dash-delimited groups of 8, 4, 4, 4, and 12 digits, respectively (for example, `12345678-90ab-cdef-1234-567890abcdef`).

The `<guid>` tag does not take any arguments. It can be used in both branch and template definitions.

The IfAbsent tag

The IfAbsent standard replacement tag does not generate any value of its own, and is therefore always be replaced with an empty string. However, its value is that it can prevent an attribute from appearing in the entry altogether based on whether a specified attribute or attribute value exists.

For example, consider the following template:

```
template: example
rdnAttr: cn
objectClass: top
objectClass: untypedObject
objectClass: extensibleObject
cn: <guid>
displayName: <presence:50>{cn}
description: <ifabsent:displayName>{cn}
```

In this case, the `description` attribute is only included in the generated entry if the `displayName` attribute is not included (that is, the resulting entry will contain either `displayName` or `description` but not both).

The `IfAbsent` tag requires either one or two arguments. The first argument is the name of the target attribute. If there is a second argument, it specifies a particular value for the target attribute. If a value is provided, the `IfAbsent` tag takes action if that value is included in the generated entry.

This tag can be used in both branch and template definitions.

The IfPresent tag

The IfPresent standard replacement tag does not generate any value of its own, and is therefore always replaced with an empty string. However, its value is that it can prevent an attribute from appearing in the entry altogether based on whether a specified attribute or attribute value exists.

For example, consider the following template:

```
template: example
rdnAttr: cn
objectClass: top
objectClass: untypedObject
objectClass: extensibleObject
cn: <guid>
displayName: <presence:50>{cn}
description: <ifpresent:displayName>{cn}
```

In this case, the `description` attribute will only be included in the generated entry if the `displayName` attribute is also included (that is, the resulting entry will either contain neither attribute or it will contain both attributes).

The IfPresent tag requires either one or two arguments. The first argument is the name of the target attribute. If there is a second argument, it specifies a particular value for the target attribute. If a value is provided, the IfPresent tag will only take action if that value is included in the generated entry.

This tag can be used in both branch and template definitions.

The Last tag

The Last standard replacement tag is replaced with a last name taken from the `config/MakeLDIF/last.names` file. Note that there is a special relationship between the `<first>`and `<last>`tags such that the combination of the first and last names will always be unique. When every possible combination from the first and last name file has been exhausted, make-ldif will append an integer value onto the last name to ensure that the value always remains unique.

The `<last>`tag does not take any arguments. It can only be used in template definitions. It is not allowed for use in branch definitions.

The List tag

The List standard replacement tag is replaced with a string selected from a provided list of values. The values to use should be provided as arguments to the List tag (at least one argument must be provided). Optionally, each value can be followed with a semicolon and an integer value that specifies the relative weight for that value. If a value does not include a weight, the weight for that item is assumed to be one. The weight is used to control how frequently the associated value is chosen compared with all of the other values in the list.

For example, to select from a list of the colors red, green, and blue in which all listed colors have equal weights, you can use:

```
<list:red:green:blue>
```

If the color red is to appear twice as frequently as either of the other colors, you can use:

```
<list:red;2:green;1:blue;1>
```

Note that in this case, the `;1` following the green and blue elements are not technically needed since the weight of any item that does not explicitly include a weight is one, but it is provided in the example above for clarity.

This tag can be used in both branch and template definitions.

The ParentDN tag

The ParentDN standard replacement tag is replaced with the DN of the parent entry of the entry being generated. This should always be available.

This tag does not take any arguments. It can only be used in template definitions. It cannot be used in branch definitions.

The Presence tag

The Presence standard replacement tag does not generate any value of its own, and is therefore always replaced with an empty string. However, its value is that it can be used to cause the associated attribute to appear in the entry a specified percentage of the time.

For example, consider the following template:

```
template: example
rdnAttr: cn
objectClass: top
objectClass: untypedObject
objectClass: extensibleObject
cn: <guid>
displayName: <presence:50>{cn}
```

In this case, the displayName attribute will only be present in about 50% of the entries generated.

The Presence tag requires exactly one argument, which is an integer value between 0 and 100, indicating the percentage of entries that should have the associated attribute.

This tag can be used in both branch and template definitions.

The Random tag

The Random standard replacement tag is replaced with a randomly-generated value. A number of different types of values can be generated. This tag accepts a variable number of arguments, but the first argument always specifies the type of value to generate. That type may be one of the following values:

`alpha`
This causes the tag to be replaced with a specified number of lowercase ASCII alphabetic characters (that is, the character set `abcdefghijklmnopqrstuvwxyz`). This requires exactly one more argument, which is an integer specifying the number of characters to include in the generated value. For example, `<random:alpha:5>` generates a string of five randomly-selected alphabetic characters.

`numeric`
This causes the tag to be replaced with one or more numeric digits. There can be either one or two additional arguments. If there is one additional argument, it specifies the number of numeric digits to include in the value (for example, `<random:numeric:5>` will generate a string of five numeric digits). If there are two additional arguments, they will specify the upper and lower bounds for a randomly-generated number (for example, `<random:numeric:5:10>` will generate a random integer between 5 and 10, inclusive).

`alphanumeric`
This causes the tag to be replaced with a specified number of lowercase ASCII alphabetic characters (that is, the character set `abcdefghijklmnopqrstuvwxyz`) and/or numeric digits (that is, the character set `0123456789`). This requires exactly one more argument, which is an integer specifying the number of characters to include in the generated value. For example, `<random:alphanumeric:5>` will generate a string of five randomly-selected alphanumeric characters.

`chars`
This causes the tag to be replaced with characters from a user-defined character set. This can take either two or three additional arguments. The first additional argument is the characters for the user-defined character set. If there is a single argument after the character set, it specifies the number of characters to take from that set (for example, `<random:chars:abcd:3>` will cause three

characters to be chosen in which each of those characters is either a, b, c, or d). If there are two arguments after the character set, they must be integer values and the number of characters generated will be an integer between this range (for example, `<random:chars:abcd:3:5>` will cause between 3 and 5 characters to be included in the value, where each character is either a, b, c, or d).

`hex`
This causes the tag to be replaced with a specified number of hexadecimal characters (that is, the character set `0123456789abcdef`). This requires exactly one more argument, which is an integer specifying the number of characters to include in the generated value. For example, `<random:hex:5>` will generate a string of five randomly-selected hexadecimal characters.

`base64`
This causes the tag to be replaced with a specified number of characters allowed in the base64 character set (`ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwx` This requires exactly one more argument, which is an integer specifying the number of characters to include in the generated value. For example, `<random:base64:5>` will generate a string of five randomly-selected hexadecimal characters.

`month`
This causes the tag to be replaced with the name of a month of the year. If there are no additional arguments, the full name of the month is included (for example, `<random:month>` might return a value of `October`). If there is a single additional argument, it must be an integer value that specifies the maximum number of characters to include from the name of the month (for example, `<random:month:3>` might generate a value of `Oct`).

`telephone`
This causes the tag to be replaced with a randomly-generated telephone number in the format 123-456-7890. It does not take any additional arguments (that is, it should always be used like `<random:telephone>`).

This tag can be used in both branch and template definitions.

The RDN tag

The RDN standard replacement tag is replaced with the RDN (that is, the leftmost DN component) of the current entry. If the RDN is not yet available (for example, because the RDN attribute has not yet been assigned a value in the entry being generated), it will be replaced with an empty string. In general, you should ensure that all RDN attributes are assigned values earlier in the template before this tag is used. The behavior of this tag is identical to that of the DN tag when used with a single argument whose value is one (that is, `<dn:1>`).

The RDN tag does not take any arguments. It can be used in both branch and template definitions.

The Sequential tag

The Sequential standard replacement tag is replaced with an integer value. Each entry is given a sequentially-incrementing value (for example, the first entry is given a value of zero, the next entry a value of one, and so on).

This tag can take zero, one, or two arguments:

- If there are no arguments (that is, the tag is `<sequential>`), the first value will be zero, and the value will be reset to zero for each new branch.
- If there is a single argument, it must be an integer that specifies the initial value to use (for example, a tag of `<sequential:1000>` will start generating values at 1000 instead of 0). The value will be reset to the specified initial value for each new branch.
- If there are two arguments, the first must be an integer that specifies the initial value, and the second should be a Boolean value of either `true` or `false` indicating whether to reset the counter each time a new branch is started.

This tag can be used in both branch and template definitions.

The _DN tag

The _DN (note the leading underscore character) standard replacement tag is replaced with the DN of the entry being generated, but with an underscore used instead of a comma between DN components. Apart from using underscores instead of commas, this works exactly like the DN tag. As such, it can also take an optional integer argument that specifies the number of components from the left (or from the right if the value is negative) should be included.

This tag can be used in both branch and template definitions.

The _ParentDN tag

The _ParentDN (note the leading underscore character) standard replacement tag is replaced with the DN of the parent entry of the entry being generated, but with an underscore used instead of a comma between DN components. This should always be available.

This tag does not take any arguments. It can only be used in template definitions. It cannot be used in branch definitions.

Attribute Value Reference Tags

Attribute value reference tags can be used to replace the tag with the value of a specified attribute from the same entry. They are used by enclosing the name of the desired attribute in curly braces. For example, {cn} will be replaced with the value of the cn attribute, if it has already been given a value in the target entry. If the target attribute has not yet been given a value in the entry, the tag will be replaced with an empty string.

For example, consider the following excerpt from a template:

```
givenName: <first>
sn: <last>
uid: {givenName}.{sn}
cn: {givenName} {sn}
mail: {uid}@example.com
```

If the value chosen for the first name is Johnand the last name is Doe, then the resulting LDIF output would be:

```
givenName: John
sn: Doe
uid: John.Doe
cn: John Doe
mail: John.Doe@example.com
```

It is also possible to place a colon after the name of the attribute followed by a positive integer value specifying the maximum number of characters to include from the target attribute. For example, the template excerpt:

```
givenName: <first>
sn: <last>
initials: {givenName:1}{sn:1}
```

would cause the following LDIF to be generated:

```
givenName: John
sn: Doe
initials: JD
```

If the specified length is longer than the value of the named attribute, the entire value is used with no padding added. Otherwise, the specified number of characters are taken from the value.

Tag Evaluation Order

All tags in the `make-ldif` syntax are currently given equal priority. As such, they are evaluated in the order that they appear in the template definition, from top to bottom, and from left to right within a given line. It is not possible to embed one tag within another.

Defining Custom Tags

The make-ldif utility has been designed in an extensible manner so that new tags can be defined and used in template files.

All tags must be subclasses of the `org.opends.server.tools.makeldif.Tag` abstract class. Custom tag definitions must include the following methods:

`public String getName()`
: This retrieves the name that should be used to reference the tag. The value that it returns must be unique among all other tags in use by the server.

`public boolean allowedInBranch()`
: This indicates whether the tag will be allowed in branch definitions. If it returns a value of `true`, then the tag may be used in both branch and template definitions. If it returns a value of `false`, then the tag may be used in template definitions but not branch definitions.

`public void initializeForBranch(TemplateFile templateFile, Branch branch, String[] arguments, int lineNumber, List<String> warnings)`
: This performs any initialization that may be required if the tag is to be used in a branch definition. This does not need to be implemented if `allowedInBranch()` returns `false`.

`public void initializeForTemplate(TemplateFile templateFile, Template template, String[] arguments, int lineNumber, List<String> warnings)`
: This performs any initialization that may be required of the tag is to be used in a template definition.

`public void initializeForParent(TemplateEntry parentEntry)`
: This performs any initialization that may be required before starting to generate entries below a new parent. This does not need to be implemented if no special initialization is required.

`public TagResult generateValue(TemplateEntry templateEntry, TemplateValue templateValue)`
: This generates the value that will be used to replace the associated tag when generating entries.

All of the tags available in `make-ldif` are included in the `org.opends.server.tools.makeldif` package. They may be used for reference to understand what is involved in implementing a custom tag.

Note – If you define a custom tag, ensure that it is available for use in any template file that might need it. This is done using the `include` statement, that should appear at the top of the template file. For more information, see "Custom Tag Includes" on page 203.

Importing Large Data Sets

The topics in this section provide tips on improving performance when importing large data sets to the directory server. By default, the server imports data with a fixed set of parameters. You can change the default behavior in two ways:

- Specify certain options when you run the `import-ldif` command.

  For more information, see "Setting the Import Options" on page 217.
- Use the `dsjavaproperties` command to set the appropriate Java arguments before running the `import-ldif` command.

  For more information, see "Tuning the JVM and Java Arguments" on page 218.

Setting the Import Options

The following options of the `import-ldif` command are useful when you are importing particularly large databases:

- `--skipDNValidation`

  This option significantly speeds up a large import because no DN validation or database loading is performed during the first phase of the import. The DNs in the LDIF file are treated as regular indexes and are written to a scratch index file that is loaded in phase two of the import.

  During the second phase of the import, limited DN parental checking is performed. During this evaluation, the DNs in the LDIF file are examined to make sure that each DN has a correct parent DN. When a DN is detected without a parent, a dummy entry is written to the reject file.

  If the `--skipDNValidation` option is specified, no duplicate DN checking is performed.

  The server does not remove bad entry IDs from the index database during phase two of the import. It is therefore essential that the LDIF import file is correct if the `--skipDNVavlidation` option is specified. Correct LDIF files are generally those that are generated by using the `make-ldif` command, LDIF files exported from an LDAP server, or LDIF files created by scripts that are historically known to generate correct LDIF files.
- `--threadCount`

  This option speeds up a large import by enabling you to specify that more threads are dedicated to the import process. By default, two threads per CPU are used for an import operation.

Increasing the `--thread-count` also increases the buffer space that is required in phase one of the LDIF import.

- `--tmpDirectory`

  In the first phase of the import, the server parses the LDIF file, sorts the index records, and writes the records to temporary files. By default, the temporary index files are written to *intall-dir*`/import-tmp`. If you are importing particularly large index files, you might want to specify another location that has more disk space.

  The amount of space required for the temporary index files depends on the following factors:

  - The number of entries in the LDIF file.
  - The size of the entries in the LDIF file.

    Entries with large numbers of attributes that require indexing will require more space in the temporary directory location, and in the database directory.
  - The number of indexes that are configured.

    The more indexes that are configured, the more disk space is required in the temporary directory location, and in the database directory. Substring indexes require more temporary disk space to process than other types of indexes.
  - Increasing the `index-entry-limit` for all indexes, or for individual indexes, requires more disk space.

    This is especially true for substring indexes. If you are importing an LDIF file with a large number of entries, you should turn off all substring indexing to prevent a number of the index records will hitting the `index-entry-limit`.

Tuning the JVM and Java Arguments

Tuning the JVM heap is essential to the performance of the `import-ldif` command. Although the `import-ldif` command attempts to limit the amount of JVM heap that it requires, you should allocate as large a JVM heap as possible to `import-ldif` if you are importing a large number of entries.

The following JVM tuning considerations have specific impact on the `import-ldif` operation:

- Performing an online import uses the JVM settings that were specified when the server was started. If you plan to import a large LDIF file by using the online import, you should provide extra JVM heap when the server is started. In general, if you need to import a large LDIF file, the best option is to perform an offline import.
- The 32-bit JVM generally performs better for smaller LDIF files and for most larger LDIF files.

  You should always try this JVM first, with as large a heap as can be spared. A minimum heap of 2 Gbytes is recommended.

- You might require a 64-bit JVM with a large JVM heap (greater than 4 Gbytes) for extremely large LDIF files, depending on the size of the entries and the indexes configured.

  The 64-bit JVM does not generally perform as well as the 32-bit JVM.
- The default JVM ergonomics might be too small for some JVMs and can seriously impact performance.

  Take note of the default ergonomic values for your JVM (these values differ by vendor and by operating system).
- If you are using replication, you should budget additional JVM heap, particularly if you plan to do a full initialization of the other replicas in the topology after an online import.

When you have calculated the memory requirement, perform the following steps:

1. Edit the `java.properties` file and set the following values:

   ```
   overwrite-env-java-args=true
   import-ldif.offline.java-args=-Xms2560M -Xmx2560M
   ```
2. Run the `dsjavaproperties` command:

   ```
   $ bin/dsjavaproperties
   ```

Note – Running the `dsjavaproperties` command, or setting the `OPENDS_JAVA_ARGS` environment variable, only has a performance impact if the import is offline. If the server is already running and you perform an online import, changing the Java arguments has no impact on the import performance because the import is performed by the server JVM.

Backing Up and Restoring Data

Oracle Unified Directory provides an extensible framework that supports a variety of repository types. The directory server uses the Berkeley DB Java Edition (JE) as its primary back end. The JE back end provides some advantages over other databases as it provides a high-performance, scalable transactional B-tree database with full support for ACID semantics for small to very large data sets. It can also store its entries in encoded form and provide indexes for fast, efficient data retrieval.

This section covers the following topics:

Overview of the Backup and Restore Process

To maintain the directory data on the JE back end, the directory server provides efficient backup and restore utilities that support full and incremental backups. A *full backup* saves the directory data files in the environment as a compressed archive file. An *incremental backup* saves and compresses just those files that have been written since the previous backup, together with a list of names of files that are unchanged since the previous backup. The directory server stores its backup information in a *backup back end* for easy restores.

Directory server backups also can be made on the local disks or on remote disks, for example, on network-attached storage (NAS). If you run a backup locally, you should then copy and store the backup on a different machine or file system for security purposes.

Before you start backing up and restoring data, consider the following:

- You must design a workable backup and restore strategy for your directory services system. For example, you can run an incremental backup daily and perform a full backup at least once a week. Test your backup process and your ability to restore regularly. For data restores, many companies restore a directory server from a replicated server, which ensures that the most update copy of the directory data is used. Backup tapes are still needed if the directory data is damaged (for example, missing entries) and the corrupted data has been replicated to other servers.
- Ensure that you have a disaster recovery plan in place. Disaster recovery is necessary when catastrophic events, data corruption, or data tampering occurs. Companies devise their own plans or out source the work to third party specialists. See "Backing Up for Disaster Recovery" on page 224 for more information.
- Ensure that you have a place to store your back ups. Store the archived data, configuration directory, schema subdirectory, and installation directory used for your server together in a single location. All these items are required when you restore the server.

Backing Up Data

The directory server provides an efficient command-line utility (`backup`) to back up databases. The `backup` command can be run immediately or scheduled as a task. If the backup is scheduled, the command contacts the server over SSL, using the administration connector, and registers a backup task. If no connection options are specified, the command runs immediately.

The following procedures show the use of the `backup` command in various backup scenarios.

▼ To Back Up All Back Ends

You can back up all back ends end by using the `--backUpAll` option.

- **Run the backup command with the `--backUpAll` option.**

  The following command is run on a standalone directory server and specifies that all databases should be backed up, compresses the backup file, and saves the file to a specified location.

  ```
  $ backup --backUpAll --compress --backupDirectory /tmp/backup
  ```

  The backup directory contains subdirectories for each back end:

  ```
  $ ls /tmp/backup
  ./ ../ config/ schema/ tasks/ userRoot/
  ```

  The `backup` utility writes the backup to the specified directory and creates a `backup.info` file that provides details about the backup. The directory server assigns a backup ID based on the current date and time. To create your own ID, use the `--backupID` option:

  ```
  $ ls /tmp/backup/config
  ./ backup.info
  ../ config-backup-20070827153501Z
  ```

  The `backup.info` file contains detailed information about the current backup.

  ```
  $ more /tmp/backup/config/backup.info
  backend_dn=ds-cfg-backend-id=config,cn=Backends,cn=config

  backup_id=20070827153501Z
  backup_date=20070827153511Z
  incremental=false
  compressed=true
  encrypted=false
  property.archive_file=config-backup-20070827153501Z
  ```

▼ To Back Up All Back Ends with Encryption and Signed Hashes

The `backup` utility provides encryption and signed hash support for secure backups. The use of the encryption and signed hash options requires a connection to an online server instance, so the appropriate connection options must be specified.

- **Run the backup command .**

  The following command backs up all back ends, compresses them, generates a hash, signs the hash, and encrypts the data.

  ```
  $ backup -h localhost -p 4444 -D "cn=directory manager" -w password --backUpAll -X \
    --compress --hash --signHash --encrypt --backupID 123 --backupDirectory /tmp/backup
  ```

▼ To Perform an Incremental Backup on All Back Ends

Incremental backups save only those changes that have occurred since the last backup (full or incremental). The main advantage of an incremental backup is the faster time to back up a system when compared to that of full backups. The disadvantage of an incremental backup is that each incremental backup must be restored, which requires more time and care than that of a full restore.

- **Run the backup command with the `--incremental` option.**

```
$ backup --backUpAll --incremental --compress --backupDirectory /tmp/backup
```

▼ To Back Up a Specific Back End

You can back up a single back end by using the `--backendID` option, which specifies the back end to save.

Note – If you back up a single back end and replication is configured, any changes made to that back end are stored in the change log on the replication server. When you restore that back end, the replication server detects that the back end is not up to date and replays the changes made after the backup. This behavior occurs even if there is only one directory server in the replicated topology, because the changes are stored on the replication server.

If you do not want this behavior, back up all back ends in a replicated environment. This ensures that the data, and the replication server are backed up. In this case when a restore is done, the directory server and the replication server are restored to their state before the back up, and no memory of subsequent changes remains.

---

1. **(Optional) List the back ends that are configured on the server, by running the `list-backends` command. For example:**

```
$ list-backends

Backend ID     Base DN
-------------- -----------------
adminRoot      cn=admin data
ads-truststore cn=trust-store
backup         cn=backups
config         cn=config
monitor        cn=monitor
schema         cn=schema
tasks          cn=tasks
userRoot       dc=example,dc=com
```

2. **Run the backup command with the `--backendID` option.**

For example, to back up the `userRoot` back end, run the following command:

```
$ backup --backendID userRoot --backupDirectory /tmp/backup
```

▼ To Perform an Incremental Backup on a Specific Back End

1 **(Optional) List the back ends that are configured on the server, by running the `list-backends` command. For example:**

```
$ list-backends

Backend ID     Base DN
-------------- -----------------
adminRoot      cn=admin data
ads-truststore cn=trust-store
backup         cn=backups
config         cn=config
monitor        cn=monitor
schema         cn=schema
tasks          cn=tasks
userRoot       dc=example,dc=com
```

2 **Run the backup command with the `--incremental` option.**

```
$ backup --incremental --backendID userRoot --backupDirectory /tmp/backup
```

▼ To Schedule a Backup as a Task

The directory server provides a task back end for processing administrative tasks, such as backups and restores. You can specify the start time for a backup or restore by using the `-t` or `--start` option. If one of these options is provided, the utility exits immediately after scheduling the task. To schedule a task for immediate execution and have the utility exit immediately after scheduling the task, specify `0` as the value for the start time. If the `-t` or `--start` option is omitted, the utility schedules the task for immediate execution and tracks the task's progress, printing log messages as they are available and exiting when the task has completed.

Access to the task back end is provided over SSL via the administration connector. If you schedule the backup as a task, you must therefore specify how the SSL certificate will be trusted. This example schedules a backup for execution at a future time. The `-X` option specifies that all certificates presented by the server are trusted. For more information, see "Managing Administration Traffic to the Server" on page 62.

1 **Run the `backup` command with the following options:**

```
$ backup --port 4444 --bindDN "cn=Directory Manager" --bindPassword password -X \
  --backUpAll --backupDirectory /tmp/backups --start 20080601121500 \
  --completionNotify admin@example.com --errorNotify admin@example.com
```

2 **(Optional) View information about the scheduled task by using the `manage-tasks` command. For example:**

```
$ manage-tasks --port 4444 --bindDN "cn=Directory Manager" --bindPassword password -X \
  --info 2008040210324704 --no-prompt
```

Backing Up the Server Configuration

All configuration settings for a directory server instance are stored in the `config.ldif` file, which is located in the `config` directory. The directory server automatically saves the `config.ldif` file to ensure that changes are properly accounted for in the configuration. The file is saved at two specific times:

- **At startup**. If the current configuration does not match the archived configuration, the server saves the `config.ldif` file.
- **At modification time**. Whenever a directory administrator makes changes to the configuration by using the `dsconfig` utility with the server online, the directory server saves the `config.ldif` file prior to the change.

You can access archived configuration files from the *install-dir*`/config/archived-configs` directory. This directory lists each saved configuration file, compresses it as a `.gz` file, and saves the configuration as `config-`*timestamp*`.gz`. For example, you can see archived `config.ldif` files as follows:

```
$ ls config/archived-configs
09/02/2007 03:43 PM 9,045 config-20070819055359Z.gz
```

Backing Up for Disaster Recovery

Directory and system administrators should have a disaster recovery plan in place in the event of a natural, human-induced, or catastrophic disaster. If your directory service is distributed over multiple individual servers, back up all the servers individually or back up all the directory data from a central location.

Alternatively, consider replication as a backup and restore strategy. Replication provides faster restores and more update data from another replicated server. For more information, see "Restoring Replicated Directory Servers" on page 228.

▼ To Back Up the Directory Server For Disaster Recovery

1 **Make a backup of all back ends by using the `--backUpAll` option, for example:**

```
$ backup --backUpAll --backupDirectory /tmp/backup
```

2 **Copy the configuration directory,** *install-dir*/**`config`.**

Make sure that the `schema` subdirectory is present within the *install-dir*`/config` directory.

3 **Copy the files in** *install-dir*/**`logs`.**

4 **Make a copy of the installation directory.**

5 **Store the archived data, configuration directory, schema subdirectory, log files and installation directory together in a single location.**

All items are required when restoring the server.

Backing up and Restoring Data Using File System Snapshots

For certain deployments, file system snapshot technologies offer a viable alternative to the traditional backup. On Solaris systems, ZFS enables file system snapshots that are space efficient, very quick to create, and portable between systems. By dedicating a Directory Server per data center, or two if your entire service runs in one data center, you deploy an effective, redundant solution for restoring data as part of your disaster recovery plan.

▼ To Take a ZFS Snapshot On a Dedicated Backup Server

1 **Because the Directory Server is dedicated to backup, configure the server as a read-only replica if you have not already done so.**

```
$ dsconfig -h host -p 4444 -D "cn=Directory Manager" -w password -X -n \
  set-global-configuration-prop --set writability-mode:internal-only
```

When you restore a server from the snapshot of the read-only replica, the restored server accepts only replication traffic until you enable writability, after the server has caught up with other replicas in the topology.

2 **Take the ZFS snapshot.**

For example, if the Directory Server files are stored in the file system corresponding to `zpool/DS_FS`, the command is:

```
$ zfs snapshot zpool/DS_FS@{todays_date}
```

3 **Back up the snapshot to other storage.**

```
$ zfs send zpool/DS_FS@{today_date} > /backups/DS_FS.{today_date}.zfs
```

Do not keep snapshots longer than the replication purge delay, because when you restore from a snapshot, the replication mechanism has to be able to replay all the missing changes on the replica.

▼ To Restore a Directory Server From a ZFS Snapshot

1 **Import the backup `zpool`.**

Create a ZFS file system to access the backup pool, using `/backups` as the mount point.

2 **Stop the Directory Server that is being restored.**

3 **Initialize the ZFS file system from `/backups`.**

```
$ dd if=/backups/DS_FS.{date_to_restore}.zfs bs=32k | zfs receive -F zpool/DS_FS
```

4 **Adapt the configuration as necessary to use the host name and port numbers of the Directory Server to restore.**

5 **Start the Directory Server.**

6 **Monitor replication until you observe that the Directory Server is in sync with other replicas in the topology.**

7 **Set the `writability-mode` to `enabled`, allowing the Directory Server to process write operations from clients.**

```
$ dsconfig -h restored-host -p 4444 -D "cn=Directory Manager" -w password -X -n \
  set-global-configuration-prop --set writability-mode:enabled
```

Restoring Data

You can restore data by using the `restore` utility. The `restore` utility allows you to restore only one back end at a time. The directory server must be stopped prior to a restore, unless you are scheduling a restore task, or you are restoring data that has been signed or hashed.

▼ To Restore a Back End

1 **Stop the server, if it is running.**

2 **(Optional) Display the backup information by running the `restore` command with the `--listBackups` option. For example:**

```
$ restore --listBackups --backupDirectory backup/userRoot
Backup ID: 20080827153501Z
Backup Date: 27/Aug/2008:10:35:11 -0500
Is Incremental: false
Is Compressed: true
Is Encrypted: false
Has Unsigned Hash: false
Has Signed Hash: false
Dependent Upon: none
```

3 **Restore the back end.**

```
$ restore --backupDirectory backup/userRoot
```

4 **Repeat the restore for the other back ends.**

▼ To Restore a Back End From Incremental Backups

Typically, system administrators run a weekly full backup with daily incremental backups. Be aware that it takes longer to restore your system from incremental backups.

1 **Restore the last full backup on your system by using the `restore` command.**

Each back end must be restored individually.

2 **Restore each incremental backup by using the `restore` command.**

Restore each incremental backup starting from the last full backup.

▼ To Schedule a Restore as a Task

The directory server provides a task back end for processing administrative tasks, such as backups and restores. You can specify the start time for a restore by using the `-t` or `--start` option. If one of these options is provided, the utility exits immediately after scheduling the task. To schedule a task for immediate execution and have the utility exit immediately after scheduling the task, specify `0` as the value for the start time. If the `-t` or `--start` option is omitted, the utility schedules the task for immediate execution and tracks the task's progress, printing log messages as they are available and exiting when the task has completed.

Access to the task back end is provided over SSL, using the administration connector. If you schedule the restore as a task, you must therefore specify how the SSL certificate will be trusted.

1 **Ensure that the server is stopped prior to the scheduled restore time.**

2 **Schedule the restore by using the `-t` or `--start` option of the `restore` command.**

The following command restores the `userRoot` back end at a scheduled start time by using the `--start` option. The restore sends a completion and error notification to `admin@example.com`. The `-X` option specifies that all certificates presented by the server are trusted.

```
$ restore -p 4444 -D "cn=Directory Manager" -w password -X \
  -d /backup/userRoot --start 20080125121500 --completionNotify admin@example.com \
  --errorNotify admin@example.com
```

3 **(Optional) You can view this scheduled task by using the `manage-tasks` utility.**

For more information, see "Configuring Commands As Tasks" on page 64.

▼ To Restore the Configuration File

You might need to restore the configuration file to transfer the configuration to another server, for disaster recovery purposes, or for other events. In general, if a server is online, the current configuration file is equivalent to the latest archived configuration file. However, you can choose to restore the `config.ldif` file from a previous date.

1 **Stop the server if it is running.**

2 **Locate the required configuration file on the system. For example:**

```
$ ls install-dir/config/archived-configs
./
../
config-20070817192057Z.gz
config-20070827153200Z.gz
config-20070817192052Z.gz
config-20070827153214Z-2.gz
```

3 **Manually decompress the archived configuration file, using a decompression utility such as `gunzip`.**

4 **Copy the file to the `config` directory, replacing the current `config.ldif` file.**

```
$ cp config-20070817182052Z install-dir/config/config.ldif
```

▼ To Restore a Directory Server During Disaster Recovery

1 **Install the same version of the directory server that was previously installed on the host.**

2 **Create a server instance by using the `setup` command.**

3 **Copy the saved `config` directory to *install-dir*`/config`.**

The `config.ldif` file should reside in this directory. The saved schema subdirectory should be located in *install-dir*`/config/schema`.

4 **Check that the configuration for the restored server is correct.**

5 **Restore the individual back ends by using the `restore` command.**

Restoring Replicated Directory Servers

Performing binary restores in replicated environments requires special care depending on your replicated topology. If possible, update your back end by using the replication mechanisms in your system instead of restoring it from a backup. Replication has distinct advantages over traditional tape backups. Data restores are much faster than tape restores, and the data is more up to date. However, tapes are still needed in the event that the replicated data is corrupt and has been propagated to other servers.

When restoring a replicated server, ensure that the configuration file *install-dir*`/config/config.ldif` is the same as when the backup was made. Restore the `config.ldif` file prior to restoring the server back ends.

You cannot restore an old backup to a master server because it might be out of date. Rather allow the replication mechanism to bring a master up to date with the other master servers by setting that master to read-only. When the master has been synchronized, you can reset it to read-write.

If you need to restore a replicated server, reinitialize the server from one of the other replicated servers by importing an LDIF file.

For very large databases (millions of entries), make a binary copy of one server and restore it on the other replicated server.

If you have a fairly recent backup (one that is not older than the maximum age of the change log contents on any of the other replicated servers), you can use that version to restore your data. When the old backup is restored, the other servers will update that server with recent updates made since the backup was saved.

Deleting Backup Data

If you run regular backups, the backup files might start to consume too much disk space. You must remove the old backup files manually to create space for new ones.

▼ To Delete Backup Files

When you delete backup files manually, make sure that you do not break any dependencies between backup sets.

1 **List the existing backups in your backup directory.**

For example, to list the backups in the default backup directory, run the following command:

```
UNIX: $ ls install-dir/bak
       backup-userRoot-20090929184101Z backup-userRoot-20091029184509Z
       backup.info backup.info.save

WINDOWS: C:\> dir install-dir\bak
         backup-userRoot-20090929184101Z backup-userRoot-20091029184509Z
         backup.info backup.info.save
```

2 **Delete the backup file from the backup directory.**

For example, to remove the oldest backup of the `userRoot` database in the preceding step, run the following command:

```
UNIX: $ rm install-dir/bak/backup-userRoot-20090929184101Z

WINDOWS C:\> del install-dir\bak\backup-userRoot-20090929184101Z
```

3 **Remove the associated backup information from the `backup.info` file.**

You can display the contents of the `backup.info`, as follows (on UNIX systems):

```
$ more install-dir/bak/backup.info
    backend_dn=ds-cfg-backend-id=userRoot,cn=Backends,cn=config

    backup_id=20090929184101Z
    backup_date=20090929184104Z
    incremental=false
    compressed=false
    encrypted=false
    property.last_logfile_name=00000000.jdb
    property.last_logfile_size=160773
    property.archive_file=backup-userRoot-20090929184101Z

    backup_id=20091029184509Z
    backup_date=20091029184512Z
    incremental=false
    compressed=false
    encrypted=false
    property.last_logfile_name=00000000.jdb
    property.last_logfile_size=160773
    property.archive_file=backup-userRoot-20091029184509Z
```

For Windows systems, use an appropriate text editor.

Searching Directory Data

The directory server provides a suite of LDAPv3-compliant command-line tools, including a sophisticated look-up operation in the form of a search function and filters. You can also use Oracle Directory Services Manager to search directory data. This section explains how to use the `ldapsearch` command-line utility and Oracle Directory Services Manager to locate entries in the directory.

Overview of the `ldapsearch` Command

The `ldapsearch` command allows you to enter a search request where you specify the host name, port, bind DN and password plus search criteria to locate entries in the directory. When an LDAP client makes a search request to the directory server, it opens a connection to the directory server over TCP/IP. The client then performs a *bind* operation to the directory server by attempting to match a given entry, which effectively authenticates the client. Most users have the option to bind as a particular user, such as a Directory Administrator or themselves, or to not bind as any user, in which case the directory server assumes that the user is bound as an *anonymous* user.

Because all access to directory data is based on how a connection is bound, the directory server checks the client's privileges to see if the client can run a particular search operation. After the directory server checks the user's access rights, the client passes a search request consisting of a set of search criteria and options to the directory server.

The directory server searches all entries that match the search criteria and options. It then returns the entries, the DN, and all attributes for each entry, in the form of LDIF text to standard output. If an error occurs, the directory server displays an error message indicating the error. Finally, the client closes the connection when the search operation has completed.

`ldapsearch` Location and Format

The `ldapsearch` utility is found in the following location:

```
(UNIX, Linux) install-dir/bin
(Windows) install-dir\bat
```

The utility has the following format:

```
ldapsearch optional-options search-filter optional-list-of-attributes
```

where:

- *optional-options* are command-line options that must appear before the search filter.
- *search-filter* is an LDAP search filter either specified on the command-line or in a file.
- *optional-list-of-attributes* is a list of attributes separated by a space. The list of attributes must appear after the search filter.

Common `ldapsearch` Options

The `ldapsearch` command has many options to search entries in the directory. Options are allowed in either their short form (for example, `-b` *baseDN*) or their long form (for example, `--baseDN`). The most common command options to use with `ldapsearch` are as follows:

`-h, --hostname` *address*

Specifies the host name or IP address of the directory server on which the search should be run. It can be an IP address or a resolvable name. If this is not provided, a default value of `localhost` is used.

`-p, --port` *port*

Specifies the directory server port. It should be an integer value between `1` and `65535`, inclusive. If this is not provided, a default port of `389` is used.

`-b, --baseDN` *baseDN*

Specifies the base DN to use for the search operation. If a file containing multiple filters is provided using the `--filename` option, this base DN is used for all of the searches. This is a required option.

`-s, --searchScope` *scope*

Sets the scope for the search operation. Its value must be one of the following:

- `base`. Searches only the entry specified by the `--baseDN` or `-b` option.

- one. Searches only the entry specified by the --baseDN or -b option and its immediate children.
- sub or subordinate. Searches the entire subtree whose base is the entry specified by the --baseDN or -b option. This is the default option when no --searchScope option is provided.

-D, --bindDN *bindDN*

Specifies the DN to use when binding to the directory server through simple authentication. This option is not required when using SASL authentication or anonymous binding.

-w, --bindPassword *bindPassword*

Specifies the password to use when binding to the directory server. This option is used for simple authentication, as well as for password-based SASL mechanisms like CRAM-MD5, DIGEST-MD5, and PLAIN. It is not required if anonymous binding is used. This option must not be used in conjunction with the --bindPasswordFile option. To prompt for the password, type -w -.

-l, --timeLimit *numSeconds*

Sets the maximum length of time in seconds that the directory server should spend processing any search request. If this is not provided, no time limit is imposed by the client. Note that the directory server may enforce a lower time limit than the one requested by the client.

-z, --sizeLimit *numEntries*

Sets the maximum number of matching entries that the directory server should return to the client. If this is not provided, no maximum size is imposed by the client. Note that the directory server may enforce a lower size limit than the one requested by the client.

-S, --sortOrder *sortOrder*

Sorts the results before returning them to the client. The sort order is a comma-delimited list of sort keys, where each sort key consists of the following elements:

- +/- (plus or minus sign). Indicates that the sort should be in ascending (+) or descending (-) order. If this value is omitted, the sort uses ascending order by default.
- Attribute name. The name of the attribute to sort the data. This element is required.

- `Name` or `OID Matching Rule`. An optional colon followed by the name or OID of the matching rule used to perform the sort. If this is not provided, the default ordering matching rule for the specified attribute type is used.

  For example, the sort order string `sn,givenName` sorts the entries in ascending order first by `sn` and then by `givenName`. Alternately, using `-modifyTimestamp`, the directory server sorts the `modifyTimestamp` attributes with the most recent values first.

Understanding Search Criteria

The `ldapsearch` command requires three sets of information to specify where and what to search in the directory information tree:

- **Base DN**. By specifying the base DN, you are defining the topmost distinguished name (DN) or starting point in the directory to conduct the search. All searches begin at or below the base DN, depending on the scope, and move down the tree, never upwards. Examples of base DNs are: `dc=example,dc=com` and `ou=People,dc=example,dc=com`.
- **Scope**. The scope determines which set of entries at or below the base DN should be evaluated by the search filter. The search scope and base DN together indicate "where" to look for entries in the directory.
- **Search filter**. The search filter specifies the conditions that the entries must meet to be returned to the client.

Specifying Filter Types and Operators

The directory server provides seven types of search filters, defined in the LDAP protocol. With each search filter type, you use operators that test the relationships between two entities, *attribute* and *value*.

The following table shows how search filters are used to return specific entries in a search query.

Search Filter	Operator	Description
Presence	`attr=*`	Return all entries that have any value associated with the specified attribute. The filter uses the wildcard character to denote zero or more characters in the string. For example, the following filter is common and returns all entries that have an object class with any value, which every entry has: `(objectclass=\*)`. **Note** – the LDAP protocol specifies that filters should have the form "(filter)", which includes parentheses surrounded by quotation marks. Although most directory servers accept filters without the parentheses and quotation marks, it is good practice to include them.
Equality	`attr=value`	Return entries containing attributes equal to a specified value. For example: `(sn=Bergin)` returns all entries that have a surname (`sn`) attribute with the value of `Bergin`. **Note** – The `sn` value is case insensitive, so entries associated with `sn=bergin` or `sn=Bergin` will be returned.

Search Filter	Operator	Description
Substring	`attr=<initial-string><any substring><final-string>`	Return entries with attributes containing a specified substring or partial substring. The filter uses the wildcard character to denote zero or more characters in the string. ■ Run an initial substring search that looks for all attribute values that have the characters `Ber` at the start of the string: `(sn=Ber\*)` ■ Specify the middle substring of an attribute value. For example: `(sn=\*erg\*)` ■ Specify the end of a substring of an attribute value. For example: `(sn=\*gin)`. Or you can specify some combination of substrings ■ Specify the initial and middle substring: `(sn=ber\*gi\*)` ■ Specify the initial and ending substrings: `(sn=be\*in)` ■ Specify the middle and end substrings: `(sn=\*er\*in)` **Note –** Substring filters do not use true wild cards such as in system listings or regular expressions. Thus, the following filter would be invalid because of too many criteria: `(sn=\*B\*rg\*n)`.
Greater than or equal to	`attr>=value`	Return entries containing attributes that are greater than or equal to the specified value. For example, `(sn>=Bergin)` returns all entries that have an attribute greater than or equal to the value, `Bergin`, based on the matching rules for attributes (see "Understanding Matching Rules" in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*).
Less than or equal to	`attr<=value`	Return entries containing attributes that are less than or equal to the specified value. For example, `(sn&lt;=Bergin)` returns all entries that have an attribute less than or equal to the value, `Bergin`, based on the matching rules for attributes.

Search Filter	Operator	Description
Approximate	`attr~=value`	Return entries containing the specified attribute with a value that is approximately equal to the value specified in the search filter. For example: `(sn~=Bergan)` could return the entry associated with `(sn=Bergin)` or `(sn=Bergan)`. The Approximate search filter works only with English language strings. It does not work with non-ASCII-based strings, such as Ja or Zn.

Extensible match	`attr= attr [":dn"] [":" matchingrule] ":=" value`
	`Or:`
	`[:dn] ":" matchingrule ":=" value`
		Return the results entries when an attribute equals the value with the specified matching rule. LDAP version 3 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, an extensible search filter enables you to add a matching rule to a search filter. For example, the following search filter compares entries containing the surname attribute with value equal to "`Jensen`" by using the matching rule designated by OID 2.5.13.5: `(sn:2.5.13.5:=Jensen)`. Another example illustrates the use of the "`:dn`" notation to indicate that the OID `2.5.13.5` should be used when making comparisons, and that the attributes of an entry 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 and evaluated by using the operator:

`(`*Boolean-Operator*`(`*filter*`)(`*filter*`)(`*filter*`))`

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

`(`*Boolean-Operator*`(`*filter*`)(`*Boolean-operator*`(`*filter*`)(`*filter*`)))`

The following table describes the Boolean operators.

Search Filter	Operator	Description
AND	`(&(`*filter*`)(`*filter*`))`	All specified filters must be true for the statement to be true. For example, `(&(sn=Carter)(l=Cupertino))` returns all entries that have the surname attribute equal to "Carter" and the location attribute equal to `Cupertino` if any.

Search Filter	Operator	Description
OR	`(|(`*filter*`)(`*filter*`))`	At least one specified filter must be true for the statement to be true. For example, `(|(sn=Carter)(l=Cupertino))` returns all entries that have the surname attribute equal to `Carter`or the location attribute equal to `Cupertino` if any.
NOT	`(!(`*filter*`)(`*filter*`))`	The specified filter must not be true for the statement to be true. For example, `(!(sn=Bergin))` returns all entries that do *not* have a surname attribute equal to the string `Smith`. The filter also returns all entries that do not have the `sn` attribute.

Using UTF-8 Encoding in Search Filters

UTF8 is a byte-order, variable-length character code for Unicode and a subset of ASCII. You use UTF-8 for multiple-language support by replacing each character of a non 7-bit ASCII character with a byte of a UTF-8 encoding. Typically, you must escape the UTF-8 encoding with a backslash.

For example, the character é has a UTF-8 representation of `c3a9` and è has a UTF-8 representation `c3a8`. A UTF-8 encoding is represented with an escaped backslash. So, `é` is represented as `\\c3\\a9` and è is represented as `\\c3\\a8`. To represent `cn=Hélène Laurent`, you would use the following encoding:

```
(cn=H\\c3\\a9l\\c3\\a8ne Laurent)
```

Using Special Characters in Search Filters

You must specify special characters (for example, a space, backslash, asterisk, comma, period, or others) by using the escape backslash.

- Asterisk. Represent an asterisk (`*`) as `\\2a`. For example, `Five*Star` would be represented as `"(cn=Five\\2aStar)"`.
- Backslash. Represent a backslash (`\`) as `\\5c`. For example, `c:\\file` would be represented as `"(cn=c:\\5c\\5cfile)"`.
- Parentheses. Represent parentheses `( )` as `\\28` and `\\29`, respectively. For example, `John Doe (II)` would be represented as `"(cn=John Doe \\28II\\29)"`.
- Null. Represent null as `\\00`. For example, 0001 would be represented as `"(bin=\\00\\00\\00\\01)"`.
- Comma. Represent a comma (`,`) by escaping it as `\\,`. For example, `"(cn=Mkt\\,Peru,dc=example,dc=com)"`.
- Space. Generally, use quotation marks around strings that contain a space. For example, `(cn="HR Managers,ou=Groups,dc=example,dc=com")`.

`ldapsearch` Examples

The following examples show the use of the `ldapsearch` command with various search options. These examples all assume that your current working directory is *install-dir*`/bin` (*install-dir*`\bat` on Windows systems).

The following points pertain to all the examples in this section:

- If the example does not specify a scope (with the `--searchScope` or `-s` option), `ldapsearch` assumes that the scope is `subordinate` or `sub`, which returns the full subtree of the base DN.
- If no attributes are specified, the command returns all attributes and their values.
- If no `--bindDN` and `--bindPassword` are specified, the search uses an anonymous bind.
- If no `--hostname` is specified, the default (`localhost`) is used.

Note – Many UNIX and Linux operating systems provide an installed version of common LDAP-client tools, such as `ldapsearch`, `ldapmodify`, and `ldapdelete` in the `/usr/bin` directory. You should use the `ldapsearch` provided with the directory server to search the directory server. You can check which version of `ldapsearch` you are using by typing the following command:

```
$ which ldapsearch
```

If you are using the `ldapsearch` in `/usr/bin`, put *install-dir*`/bin` at the beginning of your `$PATH`.

▼ To Return All Entries

You can return all entries below a specified branch DN using the presence search filter `(objectclass=*)`. The search filter looks for all entries that have one or more object classes with any value. Because all entries have several object class definitions, the filter guarantees that all entries will be returned.

● **Run the `ldapsearch` command with the filter `(objectclass=*)`.**

```
$ ldapsearch --hostname localhost --port 1389 --baseDN "dc=example,dc=com" \
  "(objectclass=*)"
dn: dc=example,dc=com
objectClass: domain
objectClass: top
dc: example

dn: ou=Groups,dc=example,dc=com
objectClass: organizationalunit
objectClass: top
ou: Groups

dn: cn=Directory Administrators,ou=Groups,dc=example,dc=com
objectClass: groupofuniquenames
objectClass: top
```

```
ou: Groups
cn: Directory Administrators
uniquemember: uid=kvaughan, ou=People, dc=example,dc=com
uniquemember: uid=rdaugherty, ou=People, dc=example,dc=com
uniquemember: uid=hmiller, ou=People, dc=example,dc=com
...
```

▼ To Search For a Specific User

You can use an equality filter to locate a specific user in the directory. This example locates an employee with the common name of "Frank Albers".

● **Run the `ldapsearch` command with the filter `"(cn=Frank Albers)"`.**

```
$ ldapsearch --port 1389 --baseDN dc=example,dc=com  "(cn=Frank Albers)"

dn: uid=falbers,ou=People,dc=example,dc=com
objectClass: person
objectClass: organizationalPerson
objectClass: inetOrgPerson
objectClass: top
givenName: Frank
uid: falbers
cn: Frank Albers
sn: Albers
telephoneNumber: +1 408 555 3094
userPassword: {SSHA}nDTQJ9DDiMUrBwR0WNKq0tgS4iB2A9QJFgpZiA==
roomNumber: 1439
ou: Accounting
ou: People
l: Sunnyvale
mail: falbers@example.com
facsimileTelephoneNumber: +1 408 555 9751
```

▼ To Search for Specific User Attributes

You can use an equality filter to locate an entry's attribute(s) in the directory. Specify one or more attributes by placing them after the search filter. This example locates the `telephoneNumber` and `mail` attributes from the user entry for `Frank Albers`.

● **Run the `ldapsearch` command with the filter `"(cn=Frank Albers)"` and the corresponding attributes.**

```
$ ldapsearch --port 1389 --baseDN dc=example,dc=com \
 "(cn=Frank Albers)" telephoneNumber mail
dn: uid=falbers,ou=People,dc=example,dc=com
telephoneNumber: +1 408 555 3094
mail: falbers@example.com
```

▼ To Perform a Search With Base Scope

Together with the search base DN, the scope determines what part of the directory information tree (DIT) is examined. A base scope examines only the level specified by the base DN (and none of its child entries). You specify a base scope by using the `--searchScope base` option or its short form equivalent `-s base`.

- **Run the `ldapsearch` command with the `--searchScope base` option.**

```
$ ldapsearch --hostname localhost --port 1389 --baseDN "dc=example,dc=com" \
  --searchScope base "(objectclass=*)"
dn: dc=example,dc=com
objectClass: domain
objectClass: top
dc: example
```

▼ To Perform a Search With One-Level Scope

A one-level scope examines only the level immediately below the base DN. You specify a one-level scope by using the `--searchScope one` option or its short form equivalent `-s one`. This example displays the entries immediately below the base DN.

- **Run the `ldapsearch` command with the `--searchScope one` option.**

```
$ ldapsearch --hostname localhost --port 1389 --baseDN "dc=example,dc=com" \
  --searchScope one "(objectclass=*)"
dn: ou=Groups,dc=example,dc=com
objectClass: top
objectClass: organizationalunit
ou: Groups
dn: ou=People,dc=example,dc=com
objectClass: top
objectClass: organizationalunit
ou: People
dn: ou=Special Users,dc=example,dc=com
objectClass: top
objectClass: organizationalUnit
ou: Special Users
description: Special Administrative Accounts
dn: ou=Company Servers,dc=example,dc=com
objectClass: top
objectClass: organizationalUnit
ou: Company Servers
description: Standard branch for Company Server registration
```

▼ To Perform a Search With Subtree Scope

The subtree scope examines the subtree below the base DN and includes the base DN level. You specify a subtree scope using the `--searchScope sub` option, or its short form equivalent `-s sub`. If you do not specify the `--searchScope`, `ldapsearch` assumes a subtree scope.

- **Run the `ldapsearch` command with the `--searchScope sub` option.**

```
$ ldapsearch --hostname localhost --port 1389 \
  --baseDN "cn=Directory Administrators,ou=Groups,dc=example,dc=com" \
  --searchScope sub "(objectclass=*)"
dn: cn=HR Managers,ou=groups,dc=example,dc=com
objectClass: groupOfUniqueNames
objectClass: top
ou: groups
description: People who can manage HR entries
cn: HR Managers
uniqueMember: uid=kvaughan, ou=People, dc=example,dc=com
uniqueMember: uid=cschmith, ou=People, dc=example,dc=com
```

▼ To Return Attribute Names Only

The `ldapsearch` command provides a convenient option to check if an attribute is present in the directory. Use the `--typesOnly` option or its short form equivalent `-A` to instruct the directory server to display the attribute names but not their values.

- **Run the `ldapsearch` command with the `--typesOnly` option.**

```
$ ldapsearch --hostname localhost --port 1389 \
  --baseDN "dc=example,dc=com" --typesOnly "(objectclass=*)"
dn: dc=example,dc=com
objectClass
dc
dn: ou=Groups,dc=example,dc=com
objectClass
ou ...
```

▼ To Return User Attributes Only

You can use `ldapsearch` to return only user attributes for entries that match the search filter, by including an asterisk *. User attributes (as opposed to operational attributes) store user information in the directory. If you do not specify the asterisk, the user attributes are returned by default. You must escape the asterisk appropriately for your shell.

- **Run the `ldapsearch` command, specifying `'*'` after the search filter.**

```
$ ldapsearch --hostname localhost --port 1389 --baseDN "dc=example,dc=com" \
  "(objectclass=*)" '*'
dn: cn=Aggie Aguirre,ou=People,dc=example,dc=com
objectClass: person
objectClass: inetorgperson
objectClass: organizationalperson
objectClass: top
postalAddress: Aggie Aguirre$15172 Jackson Street$Salt Lake City, MI  49843
postalCode: 49843
uid: user.99
description: This is the description for Aggie Aguirre.
employeeNumber: 99
initials: AGA
givenName: Aggie
pager: +1 514 297 1830
mobile: +1 030 300 0720
cn: Aggie Aguirre
telephoneNumber: +1 730 027 2062
sn: Aguirre
street: 15172 Jackson Street
homePhone: +1 229 128 3072
mail: user.99@maildomain.net
l: Salt Lake City
st: MI
```

▼ To Return Base DNs Only

You can use `ldapsearch` to return only the base DNs for entries that match the search filter by including a `1.1` string after the search filter.

- **Run the `ldapsearch` command, specifying `1.1` after the search filter.**

```
$ ldapsearch --hostname localhost --port 1389 --baseDN "dc=example,dc=com" \
  "(objectclass=*)" 1.1
version: 1
dn: cn=Richard Arnold,ou=people,dc=example,dc=com

dn: cn=Kevin Booysen,ou=people,dc=example,dc=com

dn: cn=Steven Morris,ou=people,dc=example,dc=com

dn: cn=Leila Shakir,ou=people,dc=example,dc=com

dn: cn=Emily Smith,ou=people,dc=example,dc=com
...
```

▼ To Search For Specific Object Classes

You can search all entries where the attributes are referenced by a specific object class by prepending a `@` character to the object class name. For example, to view all entries that have an object class of `groupOfUniqueNames`, include `@groupOfUniqueNames` after the search filter.

- **Run the `ldapsearch` command, specifying `@` and the object class after the search filter.**

```
$ ldapsearch --hostname localhost --port 1389 \
  --baseDN "ou=Groups,dc=example,dc=com" "(objectclass=*)" @groupOfUniqueNames
dn: ou=Groups,dc=example,dc=com
ou: Groups
objectClass: organizationalunit
objectClass: top
dn: cn=Directory Administrators,ou=Groups,dc=example,dc=com
ou: Groups
objectClass: groupofuniquenames
objectClass: top
cn: Directory Administrators
uniqueMember: uid=kvaughan, ou=People, dc=example,dc=com
uniqueMember: uid=rdaugherty, ou=People, dc=example,dc=com
uniqueMember: uid=hmiller, ou=People, dc=example,dc=com ...
```

▼ To Return a Count of All Entries in the Directory

The `ldapsearch` command provides the `--countEntries` to return the total number of entries in the directory. The directory server returns all entries that match the search filter and displays the total number on the last line. This example determines the number of employee entries whose location is Cincinnati.

- **Run the `ldapsearch` command with the `--countEntries` option.**

```
$ ldapsearch --hostname localhost --port 1389 --bindDN "cn=Directory Manager" \
  --bindPassword password --baseDN dc=example,dc=com --countEntries "l=Cincinnati"
dn: cn=Adi Adamski,ou=People,dc=example,dc=com
...
l: Cincinnati
st: OH
```

```
dn: Aggi Aguinsky,ou=People,dc=example,dc=com
objectClass: person
...
l: Cincinnati
st: OH

# Total number of matching entries: 2
```

▼ To Perform a Search With a Compound Filter

Compound search filters involve multiple tests using the boolean operators AND (&), OR (|), or NOT (!). You can combine and nest boolean operators and filters together to form complex expressions. The following example searches for all entries for employees named Jensen who work in Cupertino. The command returns two results.

- **Run the `ldapsearch` command with a compound search filter.**

```
$ ldapsearch --hostname localhost --port 1389 --bindDN "cn=Directory Manager" \
  --bindPassword password --baseDN dc=example,dc=com "(&(sn=jensen)(l=Cupertino))"
dn: uid=bjensen,ou=People,dc=example,dc=com
objectClass: person
objectClass: inetOrgPerson
objectClass: top
objectClass: organizationalPerson
ou: Product Development
ou: People
sn: Jensen
...
l: Cupertino
st: CA

dn: uid=rjensen,ou=People,dc=example,dc=com
objectClass: person
objectClass: inetOrgPerson
objectClass: top
objectClass: organizationalPerson
ou: Accounting
ou: People
sn: Jensen
...
l: Cupertino
st: CA
```

▼ To Perform a Search Using a Filter File

You can place complex or multiple filters in a file by using the `--filename` option. If the file contains multiple filters, the file should be structured with one filter per line. Searches are performed using the same connection to the directory server in the order in which they appear in the filter file. If the `--filename` option is used, any trailing options are treated as separate attributes. Otherwise, the first trailing option must be the search filter.

This example searches all entries for employees named Jensen who work in Cupertino and who do not work in the Accounting department.

1 **Create the filter file.**

For this example, create a file called `myfilter.txt` with the following content: `(&(sn=jensen)(l=Cupertino)(!(ou=Accounting)))`

2 **Run the `ldapsearch` command, specifying the file name as a filter.**

```
$ ldapsearch --hostname localhost --port 1389 --bindDN "cn=Directory Manager" \
--bindPassword password --baseDN dc=example,dc=com --filename myfilter.txt
dn: uid=bjensen,ou=People,dc=example,dc=com
objectClass: person
objectClass: inetOrgPerson
objectClass: top
objectClass: organizationalPerson
ou: Product Development
ou: People
sn: Jensen
l: Cupertino
cn: Barbara Jensen
cn: Babs Jensen
telephoneNumber: +1 408 555 1862
givenName: Barbara
uid: bjensen
mail: bjensen@example.com
```

▼ To Limit the Number of Entries Returned in a Search

You can limit the number of entries that are returned by using the `-z` or `--sizeLimit` option. If the number of entries exceeds the number that is specified, the search returns the specified number of entries, then returns an error stating that the size limit was exceeded. The following example requests a maximum of 5 entries.

● **Run the `ldapsearch` command with the `--sizeLimit` option.**

```
$ ldapsearch --hostname localhost --port 1389 -b "dc=example,dc=com" \
  --sizeLimit 5 "objectclass=*" 1.1
dn: dc=example,dc=com

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

dn: uid=user.0,ou=People,dc=example,dc=com

dn: uid=user.1,ou=People,dc=example,dc=com

dn: uid=user.2,ou=People,dc=example,dc=com

SEARCH operation failed
Result Code:  4 (Size Limit Exceeded)
Additional Information:  This search operation has sent the maximum of 5 entries
 to the client
```

Searching Data With Oracle Directory Services Manager

The Advanced Search tab of each server instance in ODSM enables you to perform complex searches on directory data, as described in the following section.

Perform a Complex LDAP Search

To perform a complex LDAP search by using the ODSM advanced search facility, complete the following steps:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Advanced Search** tab.
3. Select the appropriate network group from the **Network Group** list.
4. In the **Base Search DN** field, enter the DN that will be the starting point of the search.

   To select an entry as Base Search DN, click **Select**.

   In the **Entry Picker** window, select **Tree View** to navigate the directory tree and locate the entry, or **Search View** to search for the entry.
5. Select the scope of the search from the **Scope** list. The LDAP search scope indicates the set of entries at or below the search base DN that will be considered potential matches for a search operation. The scope can be one of:
   - **Base.** This specifies that the search operation should only be performed against the entry specified as the search base DN. No entries below it will be considered.
   - **One Level.** This specifies that the search operation should only be performed against entries that are immediate subordinates of the entry specified as the search base DN. The base entry itself is not included, nor are any entries below the immediate subordinates of the search base entry.
   - **Subtree.** This specifies that the search operation should be performed against the entry specified as the search base and all of its subordinates to any depth.
6. In the **Filter** field, enter a valid LDAP search filter.

   Alternatively, click **Filter Builder** and enter the required information for ODSM to build the LDAP search filter.

   For more information about LDAP search filters, see "Specifying Filter Types and Operators" on page 233.
7. From the **Search Results Size** list, select how you want ODSM to limit the number of entries that are returned by the search.
   - **Set Limit** enables you to specify the precise number of entries that are returned.
   - **Use Virtual List View** enables you to use a virtual list view index in the search. For more information, see "Searching Using the Virtual List View Control" on page 262.

- **Use Paging** enables you to specify that only a subset of the results should be returned at a time, and allows you to indicate the number of results on each page.. For more information, see "To Search Using the Simple Paged Results Control" on page 261.

Using Advanced Search Features

The directory server supports LDAPv3-compliant search functionality by using the `ldapsearch` command. You can use special attributes, security options, and LDAP controls with the search process, based on your system configuration. For additional information, see "Searching Directory Data" on page 230, "Using a Properties File With Server Commands" in *Oracle Fusion Middleware Command-Line Usage Guide for Oracle Unified Directory*, and "ldapsearch" in *Oracle Fusion Middleware Command-Line Usage Guide for Oracle Unified Directory*.

Searching for Special Entries and Attributes

This section describes how to search for operational attributes and how to search the Root DSE entry.

▼ To Search for Operational Attributes

Operational attributes are used for storing information needed for processing by the directory server itself or for holding any other data maintained by the directory server that was not explicitly provided by clients. Operational attributes are not included in entries returned from search operations unless they are explicitly included in the list of search attributes. You can request the directory server to return operational attributes by adding + (the plus sign) in your `ldapsearch` command.

● **Run the `ldapsearch` command with the + character.**

You must escape the character using a means appropriate to your shell.

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" \
  -w password -b "dc=example,dc=com" "(objectclass=*)" "+"
...
dn: cn=PD Managers,ou=groups,dc=example,dc=com
numSubordinates: 0
hasSubordinates: false
subschemaSubentry: cn=schema
entryDN: cn=pd managers,ou=groups,dc=example,dc=com
entryUUID: 38666d52-7a53-332e-902f-e34dd4aaa7a0
...
```

▼ To Search the Root DSE Entry

The Root DSE is a special entry that provides information about the server's name, version, naming contexts, and supported features. Because many of the attributes are operational, you must specify + (the plus sign) to display the attributes of the Root DSE entry.

- **Run the `ldapsearch` command with a baseDN of `""`.**

  Specify the scope as `base` and include the + character to display operational attributes.

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" \
  -w password -b "" --searchScope base "(objectclass=*)" "+"
dn:
supportedExtension: 1.3.6.1.4.1.4203.1.11.3
supportedExtension: 1.3.6.1.4.1.4203.1.11.1
supportedExtension: 1.3.6.1.4.1.26027.1.6.2
supportedExtension: 1.3.6.1.4.1.26027.1.6.1
supportedExtension: 1.3.6.1.1.8
supportedExtension: 1.3.6.1.4.1.1466.20037
...
```

▼ To Search for ACI Attributes

The directory server stores access control instructions (ACIs) as one or more values of the `aci` attribute on an entry to allow or deny access to the directory database. The `aci` attribute is a multi-valued operational attribute that can be read and modified by directory users and that should itself be protected by ACIs. Administrative users are usually given full access to the `aci` attribute and can view its values by running an `ldapsearch` command.

- **Run the `ldapsearch` command as follows:**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" \
  -w password -b dc=example,dc=com --searchScope base "(aci=*)" aci
dn: dc=example,dc=com
aci: (target ="ldap:///dc=example,dc=com")(targetattr h3.="userPassword")
  (version 3.0;acl "Anonymous read-search access";allow (read, search, compare)
  (userdn = "ldap:///anyone");)
aci: (target="ldap:///dc=example,dc=com") (targetattr = "*")
  (version 3.0; acl "allow all Admin group"; allow(all)
  groupdn = "ldap:///cn=Directory Administrators,ou=Groups,dc=example,dc=com";)
```

▼ To Search the Schema Entry

The directory server holds schema information in the schema entry (`cn=schema`) for the object classes and attributes defined on your instance.

- **Run the `ldapsearch` command on the `cn=schema` base DN.**

  Because the attributes in the schema are operational attributes, you must include "+" at the end of your search.

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" \
  -w password -b cn=schema --searchScope base "(objectclass=*)" "+"
dn: cn=schema
nameForms: ( 1.3.6.1.1.10.15.1 NAME 'uddiBusinessEntityNameForm' OC uddiBusiness
 Entity MUST ( uddiBusinessKey ) X-ORIGIN 'RFC 4403' )
nameForms: ( 1.3.6.1.1.10.15.2 NAME 'uddiContactNameForm' OC uddiContact MUST
 (uddiUUID ) X-ORIGIN 'RFC 4403' )
nameForms: ( 1.3.6.1.1.10.15.3 NAME 'uddiAddressNameForm' OC uddiAddress MUST
 (uddiUUID ) X-ORIGIN 'RFC 4403' )
...
attributeTypes: ( 1.3.6.1.1.1.1.12 NAME 'memberUid' EQUALITY caseExactIA5Match
 SYNTAX 1.3.6.1.4.1.1466.115.121.1.26 X-ORIGIN 'draft-howard-rfc2307bis' )
attributeTypes: ( 1.3.6.1.1.1.1.13 NAME 'memberNisNetgroup' EQUALITY caseExactIA
 5Match SUBSTR caseExactIA5SubstringsMatch SYNTAX 1.3.6.1.4.1.1466.115.121.1.26
 X-ORIGIN 'draft-howard-rfc2307bis' )
attributeTypes: ( 1.3.6.1.1.1.1.14 NAME 'nisNetgroupTriple' DESC 'Netgroup
 triple' EQUALITY caseIgnoreIA5Match SYNTAX 1.3.6.1.4.1.1466.115.121.1.26 X-ORIGIN
 'draft-howard-rfc2307bis' )
...
```

▼ To Search the Configuration Entry

The directory server stores its configuration under the cn=config entry. Direct access to this entry over LDAP is not advised. The configuration is accessible and modifiable by using the dsconfig command. dsconfig connects to the directory server over SSL via the administration connector. For more information, see "Managing Administration Traffic to the Server" on page 62.

- **To search the configuration entry using dsconfig in interactive mode, run the command as follows:**

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password
```

For more information about accessing the server configuration by using dsconfig, see "Managing the Server Configuration With dsconfig" on page 25.

▼ To Search the Monitoring Entry

The directory server monitor entry cn=monitor provides statistical information about the server performance, state, and version. You can access this information by using the ldapsearch command.

Although you can access cn=monitor using any configured LDAP connection handler, it is recommended that you use the administration connector for all access to administrative suffixes. Using the administration connector ensures that monitoring data is not polluted and that server administration takes precedence over user traffic. To use the administration connector, specify the administration port, and include the --useSSL option. For more information, see "Managing Administration Traffic to the Server" on page 62.

- **Run the ldapsearch command on the base DN cn=monitor.**

```
$ ldapsearch -h localhost -p 4444 --useSSL -D "cn=Directory Manager" \
  -w password -b cn=monitor "(objectclass=*)"
dn: cn=monitor
startTime: 20110119135658Z
objectClass: extensibleObject
objectClass: top
objectClass: ds-monitor-entry
cn: monitor
vendorName: Oracle Corporation
currentTime: 20110125145650Z
vendorVersion: Oracle Unified Directory 11.1.1.5.0
maxConnections: 3
```

```
productName: Oracle Unified Directory
currentConnections: 1
totalConnections: 22
upTime: 6 days 0 hours 59 minutes 52 seconds
...
```

Searching Over SSL

If you have configured the directory server to accept SSL connections by using a self-signed certificate or certificate, you can search using client authentication. The following procedures show how to search the directory over SSL using various authentication mechanisms.

▼ To Search Over SSL With Blind Trust

You can configure the client to automatically trust any certificate that the server presents to it. However, this method is not secure and is vulnerable to man-in-the-middle attacks. Generally, you should use this type of authentication for testing purposes only.

- **Run the `ldapsearch` command with the `--trustAll` option.**

The following command searches the Root DSE.

```
$ ldapsearch -h localhost -p 1636 --useSSL --trustAll -b "" \
  --searchScope base "(objectClass=*)"
```

▼ To Search Over SSL Using a Trust Store

You can configure the client to use a certificate trust store, which contains information about the certificates it can trust. The client can check any server certificate to those listed in its trust store. If the client finds a match, a secure communication can take place with the server. If no match is found, the server cannot be trusted. You must ensure that the presented certificate is valid and add it to the trust store, which then allows secure communication.

- **Run the `ldapsearch` command with the `--trustStorePath` option.**

The following command searches the Root DSE using a trust store.

```
$ ldapsearch -h localhost -p 1636 --useSSL \
  --trustStorePath /home/scarter/security/cert.db -b "" \
  --searchScope base "(objectClass=*)"
```

▼ To Search Over SSL With No Trust Store

If no trust store is specified, you are prompted as to whether the certificate that was presented to the client should be trusted.

- **Run the `ldapsearch` command without the `--trustStorePath` option.**

The following command searches the Root DSE without using a trust store.

```
$ ldapsearch -h localhost -p 1636 --useSSL -b "" \
  --searchScope base "(objectclass=*)"
The server is using the following certificate:
```

```
Subject DN: CN=example.com, O=Example Corp, C=US
Issuer DN: CN=example.com, O=Example Corp, C=US
Validity: Fri Mar 02 16:48:17 CST 2007 through Thu May 31 17:48:17 CDT 2007
Do you wish to trust this certificate and continue connecting to the server?
Please enter "yes" or "no": yes

dn: objectClass: ds-rootDSE
objectClass: top
```

▼ To Search Over SSL Using a Keystore

If the client is required to present its own certificate to the directory server, that client must know which certificate keystore to use. The client can determine the certificate keystore by specifying the `--keyStorePath` option with either the `--keyStorePassword` or `--keyStorePasswordFile`. This scenario typically occurs when the client performs a SASL EXTERNAL authentication or if the server always requires the client to present its own certificates.

● **Run the `ldapsearch` command with the `--keyStore...` options.**

The following command searches the Root DSE using a trust store and a key store.

```
$ ldapsearch -h localhost -p 1636 --useSSL \
  --keyStorePath /home/scarter/security/key.db \
  --keyStorePasswordFile /home/keystore.pin \
  --trustStorePath /home/scarter/security/cert.db --useSASLExternal -b "" \
  --searchScope base "(objectClass=*)"
```

▼ To Search Using StartTLS

The process for using StartTLS with the `ldapsearch` utility is very similar to the process for using SSL. However, you must do the following:

- Use the port on which the server is listening for *unencrypted* LDAP requests
- Indicate that StartTLS should be used instead of SSL (that is, use the `--startTLS` option instead of the `--useSSL` option).

● **Run the `ldapsearch` command with the `--startTLS` option.**

The following command searches the Root DSE using startTLS.

```
$ ldapsearch -h localhost -p 1389 --startTLS \
  -b "" --searchScope base "(objectClass=*)"
```

▼ To Search Using SASL With DIGEST-MD5 Client Authentication

The directory server supports a number of Simple Authentication and Security Layer (SASL) mechanisms. DIGEST-MD5 is one form of SASL authentication to the server that does not expose the clear-text password.

- **Run the `ldapsearch` command with the appropriate `--saslOption` options.**

  The `authid` option specifies the identity of the user that is authenticating to the server. The option can be in the form of a `dn` (for example, `dn:uid=scarter,dc=example,dc-com`) or a user name (for example, `authid=u:sam.carter`). The attribute can be used to indicate that the search operation should be performed under the authority of another user after authentication. The `realm` specifies the fully qualified name of the server host machine and is optional.

  This example searches the Root DSE.

```
$ ldapsearch -h localhost -p 1636 --useSSL \
  --trustStorePath /home/cert.db --certNickName "my-cert" -w - \
  --saslOption mech=DIGEST-MD5 --saslOption realm="example.com" \
  --saslOption authid="dn:uid=scarter,dc=example,dc=com" -b "" "(objectclass=*)"
```

▼ To Search Using SASL With the GSSAPI Mechanism

The GSSAPI mechanism performs authentication in a Kerberos environment and requires that the client system be configured to participate in such an environment.

- **Run the `ldapsearch` command to search as a user who already has a valid Kerberos session.**

  The `authid` attribute specifies the authentication ID that should be used to identify the user.

  This example searches the Root DSE.

```
$ ldapsearch -h localhost -p 1389 \
  --saslOption mech=GSSAPI --saslOption authid="dn:uid=scarter,dc=example,dc=com" \
  --searchScope "" -b "" "(objectclass=*)"
```

▼ To Search Using SASL With the PLAIN Mechanism

The PLAIN mechanism performs authentication in a manner similar to LDAP simple authentication except that the user is identified in the form of an authorization ID rather than a full DN.

- **Run the `ldapsearch` command to search as a user who already has a valid Kerberos session.**

  The `authid` attribute specifies the authentication ID that should be used to identify the user.

  This example searches the Root DSE.

```
$ ldapsearch -h localhost -p 1389 \
  --saslOption mech=PLAIN --saslOption authid="dn:uid=scarter,dc=example,dc=com" \
  --searchScope "" -b "" "(objectclass=*)"
```

Searching Using Controls

LDAP controls extend the functionality of LDAP commands, such as `ldapsearch`, to carry out additional operations on top of the search. Each control is defined as an object identifier (OID) that uniquely identifies the control, a criticality flag, and any associated values. If the client sets the criticality flag when sending the control to the directory server, the directory server must either perform the operation with the control or not process it. If the flag is not set by the client, the directory server is free to ignore the control if it cannot process it.

You can use multiple controls in a single operation, such as the virtual list view with server-side sorting. The virtual list view control requires additional explanation and is therefore described in its own section, following this one.

▼ To View the Available Controls

You can view the current list of controls for your directory server by searching the Root DSE entry for the `supportedControl` attribute.

● **Run the `ldapsearch` command on the Root DSE entry.**

```
$ ldapsearch -h localhost -p 1389 -b "" --searchScope base \
  "(objectclass=*)" supportedControl
dn:
supportedControl: 1.2.826.0.1.3344810.2.3
supportedControl: 1.2.840.113556.1.4.319
supportedControl: 1.2.840.113556.1.4.473
supportedControl: 1.2.840.113556.1.4.805
supportedControl: 1.3.6.1.1.12
supportedControl: 1.3.6.1.1.13.1
supportedControl: 1.3.6.1.1.13.2
supportedControl: 1.3.6.1.4.1.26027.1.5.2
supportedControl: 1.3.6.1.4.1.42.2.27.8.5.1
supportedControl: 1.3.6.1.4.1.42.2.27.9.5.2
supportedControl: 1.3.6.1.4.1.42.2.27.9.5.8
supportedControl: 1.3.6.1.4.1.4203.1.10.2
supportedControl: 1.3.6.1.4.1.4203.1.10.1
supportedControl: 2.16.840.1.113730.3.4.12
supportedControl: 2.16.840.1.113730.3.4.16
supportedControl: 2.16.840.1.113730.3.4.17
supportedControl: 2.16.840.1.113730.3.4.18
supportedControl: 2.16.840.1.113730.3.4.19
supportedControl: 2.16.840.1.113730.3.4.2
supportedControl: 2.16.840.1.113730.3.4.3
supportedControl: 2.16.840.1.113730.3.4.9
```

The controls are returned as a list of OIDs. See the following table for a description of the control that corresponds to each OID. Note that not all of these controls can be used with the `ldapsearch` command.

OID	Control
`1.2.826.0.1.3344810.2.3`	Matched Values Control
`1.2.840.113556.1.4.319`	Simple Paged Results Control
`1.2.840.113556.1.4.473`	Server-Side Sort Control
`1.2.840.113556.1.4.805`	Subtree Delete Control
`1.3.6.1.1.12`	LDAP Assertion Control

`1.3.6.1.1.13.1`	LDAP Pre-Read Control
`1.3.6.1.1.13.2`	LDAP Post-Read Control
`1.3.6.1.4.1.26027.1.5.2`	Replication Repair Control
`1.3.6.1.4.1.42.2.27.8.5.1`	Password Policy control
`1.3.6.1.4.1.42.2.27.9.5.2`	Get Effective Rights Control
`1.3.6.1.4.1.42.2.27.9.5.8`	Account Usability Request Control
`1.3.6.1.4.1.4203.1.10.2`	LDAP No-Op Control
`1.3.6.1.4.1.4203.1.10.1`	LDAP Subentry Request Control
`2.16.840.1.113730.3.4.12`	Proxied Authorization v1 Control
`2.16.840.1.113730.3.4.16`	Authorization Identity Control
`2.16.840.1.113730.3.4.17`	Real Attributes Only Control
`2.16.840.1.113730.3.4.18`	Proxied Authorization v2 Control
`2.16.840.1.113730.3.4.19`	Virtual Attributes Only Control
`2.16.840.1.113730.3.4.2`	Manage DSA IT Control
`2.16.840.1.113730.3.4.3`	Persistent Search Control
`2.16.840.1.113730.3.4.9`	Virtual List View Control

▼ To Search Using the Account Usability Request Control

The Account Usability Request Control determines if a user account can be used to authenticate to a server. If the user account is available, the control adds a message before any entry about whether the account is usable.

You can specify the Account Usability Request Control with `ldapsearch` in the following ways:

- **OID.** Use the `--control` or `-J` option with the Account Usability Request Control OID: `1.3.6.1.4.1.42.2.27.9.5.8` with no value.
- **Named constant.** Use a named constant, `accountusable` or `accountusability`, with the `--control` or `-J` option, instead of using the Account Usability Request Control OID. For example, use `-J accountusable` or `-J accountusability` with the `ldapsearch` command.

● **Use the `ldapsearch` command with the `--control` option or its short form `-J`.**

```
$ ldapsearch -h localhost -p 1389 -b "dc=example,dc=com" \
  --searchScope sub -J "accountusability:true" "(objectclass=*)"
# Account Usability Response Control
# The account is usable
dn: dc=example,dc=com
objectClass: domain
```

```
objectClass: top
dc: example
...
```

To Search Using the Authorization Identity Request Control

The Authorization Identity Request Control allows the client to obtain the authorization identity for the client connection during the LDAP bind request. The authorization ID returned by the server is displayed to the client as soon as authentication has completed. The line containing the authorization ID is prefixed with a # character, making it a comment if the output is to be interpreted as an LDIF.

You can specify the Authorization Identity Request Control with `ldapsearch` in a number of ways:

- **OID.** Use the `--control` or `-J` option with the Authorization Identity Request Control OID: `2.16.840.1.113730.3.4.16` with no value.
- **Named constant.** Use a named constant, `authzid` or `authorizationidentity` with the `-control` or `-J` option instead of using the Authorization Identity Request Control OID. For example, use `-J authzid` or `-J authorizationidentity` with the `ldapsearch` command.

● **Use the `ldapsearch` command with the `--reportAuthzID` option.**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" \
  -w password -b dc=example,dc=com --searchScope base \
  --reportAuthzID "(objectclass=*)"
# Bound with authorization ID dn:cn=Directory Manager,cn=Root DNs,cn=config
dn: dc=example,dc=com
objectClass: domain
objectClass: top
dc: example
```

To Search Using the Get Effective Rights Control

The Get Effective Rights Control enables you to evaluate existing or new ACIs and to see the effective rights that they grant for a user on a specified entry.

The response to this control is to return the effective rights information about the entries and attributes in the search results. This extra information includes read and write permissions for each entry and for each attribute in each entry. The permissions can be requested for the bind DN used for the search or for an arbitrary DN, allowing administrators to test the permissions of directory users.

The `ldapsearch` command provides two ways to use the Get Effective Rights Control:

- Use `-J effectiverights` or the OID `-J "1.3.6.1.4.1.42.2.27.9.5.2"`. The request only takes an authorization ID (`authzid`). If you specify a NULL value for the authorization ID (`authzid`), the bind user is used as the `authzid`.

- Use `-g dn:"`*dn*`"`. The command option shows the effective rights of the user binding with the given DN. You can use this option together with the `-e` option to include the effective rights on the named attributes. You can use the option to determine if a user has permission to add an attribute that does not currently exist in an entry.

Note – You cannot use the `-g` option with the `-J` option.

To view effective rights, you should specify the virtual attributes `aclRights` and `aclRightsInfo`, which are generated by the server in response to the effective rights request. Thus, you should not use these attributes in search commands of any kind.

1 Use the `ldapsearch` command to display the effective rights of all users.

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  -b dc=example,dc=com -J effectiverights "(objectclass=*)" aclRights

dn: dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0

dn: ou=Groups, dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0

dn: ou=People, dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0

dn: cn=Accounting Managers,ou=groups,dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0

dn: cn=HR Managers,ou=groups,dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0

...
```

2 Use the `ldapsearch` command to display the effective rights of a specific user.

This example uses the `--getEffectiveRightsAuthzid` option. You can also use the `--control` or `-J` option, such as `-J geteffectiverights`.

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  -b dc=example,dc=com \
  --getEffectiveRightsAuthzid "dn:uid=scarter,ou=People,dc=example,dc=com" \
  "(uid=scarter)" aclRights
dn: uid=scarter,ou=People,dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:1,proxy:0
```

3 Use the `ldapsearch` command to display effective rights information for a specific user.

The `aclRightsInfo` attribute provides more detailed logging information that explains how effective rights are granted or denied.

```
ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  -b dc=example,dc=com \
  --getEffectiveRightsAuthzid "dn:uid=scarter,ou=People,dc=example,dc=com"\
  "(uid=scarter)" aclRightsInfo
```

```
dn: uid=scarter,ou=People,dc=example,dc=com
aclRightsInfo;logs;entryLevel;add: acl_summary(main): access not allowed(add) on
entry/attr(uid=scarter,ou=People,dc=example,dc=com, NULL) to
 (uid=scarter,ou=People,dc=example,dc=com)
(not proxied) ( reason: no acis matched the subject )
aclRightsInfo;logs;entryLevel;proxy: acl_summary(main): access not allowed(proxy ) on
entry/attr(uid=scarter,ou=People,dc=example,dc=com, NULL) to
 (uid=scarter, ou=People,dc=example,dc=com)
(not proxied) ( reason: no acis matched the subject )
aclRightsInfo;logs;entryLevel;write: acl_summary(main): access allowed(write) on
entry/attr(uid=scarter,ou=People,dc=example,dc=com, NULL) to
 (uid=scarter,ou=People,dc=example,dc=com)
(not proxied) ( reason: evaluated allow , deciding_aci : Allow self entry modification)
aclRightsInfo;logs;entryLevel;read: acl_summary(main): access allowed(read) on
entry/attr(uid=scarter,ou=People,dc=example,dc=com, NULL) to
 (uid=scarter,ou=People,dc=example,dc=com)
(not proxied) ( reason: evaluated allow , deciding_aci: Anonymous extended
 operation access)
aclRightsInfo;logs;entryLevel;delete: acl_summary(main): access not allowed(delete) on
entry/attr(uid=scarter,ou=People,dc=example,dc=com, NULL) to
 (uid=scarter,ou=People,dc=example,dc=com)
(not proxied) ( reason: no acis matched the subject )
```

▼ To Search Using the LDAP Assertion Control

The LDAP Assertion Control allows you to specify a condition that must evaluate to true for the searching operation to process. The value of the control should be in the form of an LDAP search filter. The server tests the base object before searching for entries that match the search scope and filter. If the assertion fails, no entries are returned.

This example determines first if the assertion is met, and returns the entry if it matches the search filter.

- **Run the `ldapsearch` command with the `--assertionFilter` option using the assertion `(objectclass=top)`.**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  -b "cn=HR Managers,ou=Groups,dc=example,dc=com" \ -s sub \
  --assertionFilter "(objectclass=top)" "(objectclass=*)"
dn: cn=HR Managers,ou=groups,dc=example,dc=com
objectClass: groupOfUniqueNames
objectClass: top
ou: groups
description: People who can manage HR entries
uniqueMember: uid=kvaughan, ou=People, dc=example,dc=com
uniqueMember: uid=cschmith, ou=People, dc=example,dc=com
cn: HR Managers
```

▼ To Search Using the LDAP Subentry Control

The LDAP Subentry Control allows the client to request that the server return only entries with the `ldapSubEntry` object class during a search operation. LDAP subentries are *operational objects*, similar to operational attributes, that are returned only if they are explicitly requested. Typically, you can use the control when searching the schema.

You request the server to return subentries with `ldapsearch` in the following ways:

- Using the `--subEntries` option to specify the LDAP Subentry Control.
- Specifying base search scope to retrieve a specific subentry if its base DN is known.
- Using the equality filter, `(objectclass=ldapSubentry)`.

Note – Using the equality filter is not part of the standard and is supported for backward compatibility only.

- **Run the `ldapsearch` command with the `--subEntries` option.**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  -b "cn=schema" --subEntries "(objectclass=*)"
```

▼ To Search Using the Manage DSA IT Control

The Manage DSA IT Control allows the client to request that the server treat smart referrals as regular entries during the search. A *smart referral* is an entry that references another server or location in the directory information tree `DIT` and contains the `referral` object class with one or more attributes containing the LDAP URLs that specify the referral.

You can specify the Manage DSA IT Control with `ldapsearch` in a number of ways:

- **OID**. Use the `--control` or `-J` option with the Manage DSA IT Control OID: `2.16.840.1.113730.3.4.2` with no value.
- **Named constant**. Use the named constant, `managedsait` with the `--control` or `-J` option instead of the Manage DSA IT Control OID. For example, use `-J managedsait` with the `ldapsearch` command.

- **Run the `ldapsearch` command with the `-J` option.**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  -b dc=example,dc=com -J managedsait "(uid=president)" ref
dn: uid=president,ou=People,dc=example,dc=com
ref: ldap://example.com:389/dc=example,dc=com??sub?(uid=bjensen)
```

Note – Without the `-J managedsait` argument, the command returns the referred entry.

▼ To Search Using the Matched Values Filter Control

The Matched Values Filter Control allows clients to request a subset of attribute values from an entry that evaluate to TRUE. This control allows the user to selectively read a subset of attribute values without retrieving all values, and then scan for the desired set locally.

- **Run the `ldapsearch` command with the `--matchedValuesFilter` option.**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  -b ou=groups,dc=example,dc=com --matchedValuesFilter "(uniquemember=uid=kvaughan*)"
  "(objectclass=*)"
dn: ou=Groups,dc=example,dc=com
dn: cn=Directory Administrators,ou=Groups,dc=example,dc=com
uniqueMember: uid=kvaughan, ou=People, dc=example,dc=com
dn: cn=Accounting Managers,ou=groups,dc=example,dc=com
dn: cn=HR Managers,ou=groups,dc=example,dc=com
uniqueMember: uid=kvaughan, ou=People, dc=example,dc=com
dn: cn=QA Managers,ou=groups,dc=example,dc=com
dn: cn=PD Managers,ou=groups,dc=example,dc=com
```

▼ To Search Using the Password Policy Control

The Password Policy Control allows a client to request information about the current password policy information for a user entry.

You can specify the Password Policy Control with `ldapsearch` in a number of ways:

- **OID**. Use the `--control` or `-J` option with the Password Policy Control OID: `1.3.6.1.4.1.42.2.27.8.5.1` with no value.
- **Named constant**. Use the named constants, `pwpolicy` or `passwordpolicy` with the `--control` or `-J` option instead of the Password Policy Control OID. For example, use `-J pwpolicy` or `-J passwordpolicy` with `ldapsearch`.
- **Option**. Use the `--usePasswordPolicyControl` option.

Note – The `-J` or `--control` option is used to specify which controls to use in a *search* request. The `--usePasswordPolicyControl` option is used for *bind* requests.

● **Run the `ldapsearch` command with the `--usePasswordPolicyControl` option.**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  -b dc=example,dc=com -s base --usePasswordPolicyControl "(objectclass=*)"
```

▼ To Search Using the Persistent Search Control

The Persistent Search Control allows a client to receive notification when entries in the directory are changed by an add, delete, or modify operation. When a change occurs, the server sends the updated entry to the client if the entry matches the search criteria that was used by the Entry Change Notification Control.

The `ldapsearch` command provides an option to run a persistent search (`-C`) that keeps the connection open and displays the entries that match the scope and filter whenever any changes (add, delete, modify, or all) occur. You can quit the search by pressing `Control-C`.

The value for this argument must be in the form:
`ps[[:’’changetype’’[[:’’changesonly’’[[:’’entrychangecontrols’’]]]`

The elements of this value include the following:

- `ps` — Required operator.
- `changetype` — Indicates the types of changes for which the client wants to receive notification. This element can be any of `add`, `del`, `mod`, or `moddn`, or it can be `all` to register for all change types. It can also be a comma-separated list to register for multiple specific change types. If this element is not provided, it defaults to including `all` change types.
- `changesonly` — If `True`, the client should only be notified of changes that occur to matching entries after the search is registered. If `False`, the server should also send all existing entries in the server that match the provided search criteria. If this element is not provided, then it will default to only returning entries for updates that have occurred since the search was registered.
- `entrychangecontrols` — If `True`, the server should include the Entry Change Notification Control in entries sent to the client as a result of changes. If `False`, the Entry Change Notification Control should not be included. If this element is not provided, then it will default to including the Entry Change Notification Controls.

1 Run the `ldapsearch` command as follows:

```
$ ldapsearch -h localhost -p 1389 -D "cn=admin,cn=Administrators,cn=config" \
  -w password -b dc=example,dc=com --persistentSearch ps:add:true:true \
  "(objectclass=*)"
```

Note – When you use this command, the server waits for any changes made using `add`, `delete`, `modify` or `all` to return values.

---

2 Open another terminal window , and use `ldapmodify` to add a new entry.

```
$ ldapmodify -h localhost -p 1389 -b dc=example,dc=com \
  --defaultAdd --filename new_add.ldif
Processing ADD request for uid=Marcia Garza,ou=People,dc=example,dc=com
ADD operation successful for DN uid=Marcia Garza,ou=People,dc=example,dc=com
```

3 The original terminal window shows the change.

To end the session, press Control-Z (Unix/Linux) or Control-C (Windows).

```
# Persistent search change type:  add
dn: uid=Marcia Garza,ou=People,dc=example,dc=com
objectClass: person
objectClass: inetOrgPerson
objectClass: organizationalPerson
objectClass: top
givenName: Marcia
uid: mgarza
uid: Marcia Garza
cn: Marcia Garza
sn: Garza
userpassword: {SSHA}SNfL1RUm5uvTnLK+G0K3oz+Peb1i5/+YsylfBg==
roomnumber: 5484
l: Santa Clara
```

```
ou: Accounting
ou: People
mail: mgarza@example.com
```

4 **To terminate the session, press Control-D (Unix/Linux) or Control-C (Windows), and then type `Y` to quit.**

```
Terminate batch job (Y/N)?
```

▼ To Search Using the Proxied Authorization Control

The Proxied Authorization Control allows a client to impersonate another entry for a specific operation. This control can be useful in trusted applications that need to perform on behalf of many different users, so that the application does not need to re-authenticate for each operation.

● **Run the `ldapsearch` command.**

Here, `clientApp` must have the appropriate ACI permissions within the subtree to use the Proxied Authorization Control. If not granted, LDAP error 50 `insufficient access rights` will be returned to the client.

```
$ ldapsearch -h localhost -p 1389 \
  -D "uid=clientApp,ou=Applications,dc=example,dc=com" -w password \
  -s sub -b dc=example,dc=com \
  --proxyAs "dn:uid=acctgAdmin,ou=Administrators,ou=People,dc=example,dc=com" \
  "(uid=kvaughan)" mail
```

▼ To Search Using the Server-Side Sort Control

The Server-Side Sort Control allows the client to request that the server sort the search results before sending them to the client. This is convenient when the server has indexes that can satisfy the sort order requested by the client faster than the client can.

You can sort the number of entries returned by using the `--sortOrder` option. If you do not specify + (a plus sign) for ascending or `-` (a minus sign) for descending, then the default option is to sort in ascending order.

1 **Use the `ldapsearch` command to search all entries and to display the results in ascending order.**

Use the `--sortOrder` option sorted on the attributes `sn` and `givenName`.

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  --s sub -b dc=example,dc=com --sortorder sn,givenName "(objectclass)"
dn: uid=dakers,ou=People,dc=example,dc=com
objectClass: person
objectClass: organizationalPerson
...<search results>...
```

2 **Use the `ldapsearch` command to search all entries and display the results in descending order.**

Use the `--sortorder` option sorted on the attribute `sn`.

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  -s sub -b dc=example,dc=com --sortOrder -sn "(objectclass)"
dn: uid=pworrell,ou=People,dc=example,dc=com
objectClass: person
objectClass: organizationalPerson
...<search results>...
```

▼ To Search Using the Simple Paged Results Control

The Simple Paged Results Control allows a search operation to return only a subset of the results at a time. It can be used to iterate through the search results a page at a time. It is similar to the Virtual List View Control with the exception that it does not require the results to be sorted and can only be used to iterate sequentially through the search results.

● **Use the `ldapsearch` command with the `--simplePageSize` option.**

The following command also uses the `--countEntries` option to mark each page.

```
$ ldapsearch --hostname localhost --port 1389 \
 --bindDN "cn=Directory Manager" --bindPassword password \
 --searchScope sub --baseDN dc=example,dc=com \
 --simplePageSize 2 --countEntries "(objectclass=*)"

dn: ou=Groups,dc=example,dc=com
objectClass: organizationalunit
objectClass: top
ou: Groups

dn: ou=People,dc=example,dc=com
objectClass: organizationalunit
objectClass: top
ou: People

# Total number of matching entries: 2

dn: ou=Special Users,dc=example,dc=com
objectClass: organizationalUnit
objectClass: top
description: Special Administrative Accounts
ou: Special Users

dn: ou=Company Servers,dc=example,dc=com
objectClass: organizationalUnit
objectClass: top
description: Standard branch for Company Server registration
ou: Company Servers

# Total number of matching entries: 2

dn: ou=Contractors,dc=example,dc=com
objectClass: organizationalUnit
objectClass: top
ou: Contractors
ou: Product Testing
```

```
ou: Product Development
ou: Accounting

# Total number of matching entries: 1
```

Searching Using the Virtual List View Control

The Virtual List View Control allows a client to request that the server send search results in small, manageable chunks within a specific range of entries. It also allows a client to move forward and backward through the results of a search operation if configured with a GUI browser or application, or jump directly to a particular entry.

Note – The Virtual List View Control requires that the returned entries be sorted.

Together with the `--virtualListView` option or its short form `-G`, specify the following arguments:

- **before**. Specify the number of entries before the target to include in the results.

  If the `before` value is greater than or equal to the target offset, then the `before` value is adjusted so that the first entry returned is the beginning of the list.
- **after**. Specify the number of entries after the target to include in the results.
- **index**. Specify the offset of the target entry within the result set. An index of 1 always means the first entry. If `index` and `content_count` are equal, the last entry is selected.

  If the `index` value is negative, the server rejects the request.

  If the `index` value is `0`, it is adjusted to `1` so that returned values are displayed.

  If the `index` value is greater than the total number of matching values, it is adjusted to one greater than the content count.

  The value of `index` can also be an assertion value, so that the returned entry contains that value. If the returned entry is so near the end of the list that the value of `after` extends beyond the last entry, the value of `after` is adjusted to display the appropriate entries.
- **count**. Specify the expected size of the result set.
  - **count=0**. The target entry is the entry at the specified *index* position, starting from 1 and relative to the entire list of sorted results. Use this argument if the client does not know the size of the result set.
  - **count=1**. The target entry is the first entry in the list of sorted results.
  - **count>1**. The target entry is the first entry in the portion of the list represented by the fraction *index/count*. To target the last result in the list, use an *index* argument greater than the *count* argument. Client applications can use interfaces that allow users to move around a long list by using a scroll bar. For example, for an index of 33 and a count of 100, the application can jump 33 percent of the way into the list.

For example, the arguments (0:4:1:0) indicate that you want to show 0 entries before and 4 entries after the target entry at index 1. If the client does not know the size of the set, the count is 0.

▼ To Search Using the Virtual List View Control

The sort order option (`-S`) must be used with the Virtual List View control. This example uses the Virtual List View Control options to specify the following:

- **Before=0.** Specifies that 0 entries before the target should be displayed.
- **After=2.** Specifies that 2 entries after the target should be displayed.
- **Index=1.** Specifies that the offset of the target entry within the result set should be returned.
- **Count=0.** Specifies that target entry at the index position should be returned, which is the first entry.

Thus, the server returns the first entry plus two entries after the target sorted in ascending order by the `givenName` attribute.

● **Use the `ldapsearch` command with the `--virtualListView` option.**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w bindPassword \
  -b dc=example,dc=com --searchScope sub --sortOrder givenName \
  --virtualListView "0:2:1:0" "(objectclass=*)"

dn: uid=awhite,ou=People,dc=example,dc=com
objectClass: person
objectClass: organizationalPerson
objectClass: inetOrgPerson
objectClass: top
givenName: Alan
uid: awhite
cn: Alan White
sn: White
...

dn: uid=aworrell,ou=People,dc=example,dc=com
objectClass: person
objectClass: organizationalPerson
objectClass: inetOrgPerson
objectClass: top
givenName: Alan
uid: aworrell
cn: Alan Worrell
sn: Worrell
...

dn: uid=alutz,ou=People,dc=example,dc=com
objectClass: person
objectClass: organizationalPerson
objectClass: inetOrgPerson
objectClass: top
givenName: Alexander
uid: alutz
```

```
cn: Alexander Lutz
sn: Lutz
...

# VLV Target Offset: 1
# VLV Content Count: 172
```

To Search Using Virtual List View With a Specific Target

The sort order (-S) option must also be used with Virtual List View. The example command uses the Virtual List View Control options to specify the following:

- **Before=0.** Specifies that 0 entries before the target should be displayed.
- **After=4.** Specifies that 4 entries after the target should be displayed.
- **Index=jensen.** Specifies that the string `jensen` within the result set be returned.
- **Count=not specified.** Use the default `count=0`, which is the first entry.

Thus, the server returns the first `sn` attribute that matches `jensen` plus four `sn` attributes after the target sorted in ascending order by the `sn` attribute.

- **Use the `ldapsearch` command with the `--virtualListView` option.**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  -b dc=example,dc=com --searchScope sub --sortOrder sn \
  --virtualListView "0:4:jensen" "(objectclass=*)" sn

dn: uid=kjensen,ou=People,dc=example,dc=com
sn: Jensen

dn: uid=bjensen,ou=People,dc=example,dc=com
sn: Jensen

dn: uid=gjensen,ou=People,dc=example,dc=com
sn: Jensen

dn: uid=jjensen,ou=People,dc=example,dc=com
sn: Jensen

dn: uid=ajensen,ou=People,dc=example,dc=com
sn: Jensen

# VLV Target Offset: 56
# VLV Content Count: 172
```

To Search Using Virtual List View With a Known Total

The sort order (-S) option must also be used with Virtual List View. The example command uses the Virtual List View Control options to specify the following:

- **Before=0.** Specifies that 0 entries before the target should be displayed.
- **After=2.** Specifies that 2 entries after the target should be displayed.
- **Index=57.** Specifies that the index of 57 within the result set should be returned. This is roughly one-third of the list.

- **Count=172.** Use the total count.

Thus, the server returns the first sn attribute that is one-third within the list, plus two sn attributes sorted in ascending order by the sn attribute.

● **Use the `ldapsearch` command with the `--virtualListView` option.**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  -b dc=example,dc=com -s sub --sortOrder sn \
  --virtualListView "0:2:57:172" "(objectclass=*)" sn

dn: uid=bjensen,ou=People,dc=example,dc=com
sn: Jensen

dn: uid=gjensen,ou=People,dc=example,dc=com
sn: Jensen

dn: uid=jjensen,ou=People,dc=example,dc=com
sn: Jensen

# VLV Target Offset: 57
# VLV Content Count: 172
```

Searching in Verbose Mode and With a Properties File

This section describes how to search in verbose mode and how to search by using a properties file.

To Search in Verbose Mode

Verbose mode displays the processing information that is transmitted between client and server. This mode is convenient for debugging purposes.

● **Use the `ldapsearch` command as follows:**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
   -b dc=example,dc=com -s base --verbose "(objectclass=*)"
LDAP: C>S 01:43:46.140 (0ms) LDAPMessage(msgID=1, protocolOp=BindRequest
  (version =3, dn=cn=Directory Manager, password=password))
ASN1: C>S 01:43:46.140 (0ms) ASN.1 Sequence
  BER Type: 30
  Decoded Values:
  ASN1Integer(type=02, value=1)
  ASN1Sequence(type=60, values={ ASN1Integer(type=02, value=3),
    cn=Directory Manager, opends })
  Value:
  02 01 01 60 23 02 01 03   04 14 63 6E 3D 64 69 72     ‘#  cn=directory
  65 63 74 6F 72 79 20 6D   61 6E 61 67 65 72 80 08         manager
  70 61 73 73 77 6F 72 64                                   password
...
```

▼ To Search Using a Properties File

The directory server supports the use of a properties file that holds default argument values used with the `ldapsearch` command. The properties file is convenient when working in different configuration environments, especially in scripted or embedded applications. For more information, see "Using a Properties File With Server Commands" in *Oracle Fusion Middleware Command-Line Usage Guide for Oracle Unified Directory*.

1 **Create a properties file in any text editor, with the following content:**

```
hostname=localhost
port=1389
bindDN=cn=Directory Manager
bindPassword=password
baseDN=dc=example,dc=com
searchScope=sub
sortOrder=givenName
virtualListView=0:2:1:0
```

2 **Save the file as `tools.properties`.**

3 **Use the `ldapsearch` with the `--propertiesFilePath` option.**

```
$ ldapsearch --propertiesFilePath tools.properties "(objectclass=*)"
```

Searching Internationalized Entries

Oracle Unified Directory supports collation rules that match entries and can be used with the server-side sorting control to sort search results. The collation rule is specified in the search filter as a matching rule, delimited by colons, as shown here:

locale.*matchingRule*

where:

- *locale* is specified in one of the following ways
  - Locale OID
  - Locale character suffix (such as `ar`, `en`, or `fr-CA`).

    See "Supported Collation Rules" on page 269 at the end of this section for a list of supported locales, their OIDs, and tags.
- *matchingRule* can specified as either a numeric suffix or a character suffix appended to the *locale*, as listed in Table 7–1.

Note – If the locale is specified by its OID, then the matching rule must be specified by its numeric suffix. In this case, the matching rule cannot be specified by the character suffix.

TABLE 7–1 Matching Rule Suffixes

Matching Rule	Numeric Suffix	Character Suffix
Less than	.1	.lt
Less than or equal to	.2	.lte
Equality	.3	.eq (default)
Greater than or equal to	.4	.gte
Greater than	.5	.gt
Substring	.6	.sub

`Equality` is the default matching rule. That is, when no matching rule suffix is specified, the collation rule uses `equality` matching rule. The two following examples are equivalent and specify the English collation rule and the equality matching rule, but the second example specifies the equality matching rule explicitly with the `.eq` suffix:

```
"cn:en:=sanchez"
"cn:en.eq:=sanchez"
```

The next example shows the same search filter, but specified using the locale's character suffix and the matching rule's numeric code:

```
"cn:en.3:=sanchez"
```

The following example shows the same search filter specified using the locale OID and the matching rule numeric suffix:

```
"cn:1.3.6.1.4.1.42.2.27.9.4.34.1.3:=sanchez"
```

The following examples specify the same search filter but with a Spanish collation rule.

```
"cn:es.eq:=sanchez"
"cn:1.3.6.1.4.1.42.2.27.9.4.49.1.3:=sanchez"
"cn:es.3:=sanchez"
```

The following examples specify a similar search filter that uses a greater-than matching rule with the Spanish collation rule.

```
"cn:es.gt:=sanchez"
"cn:1.3.6.1.4.1.42.2.27.9.4.49.1.5:=sanchez"
"cn:es.5:=sanchez"
```

Examples

EXAMPLE 7–1 Equality Search

The following search uses a filter with the en (en-US) locale OID to perform an equality search to return any entry with a cn value of sanchez:

```
$ ldapsearch -D "cn=directory manager" -w password -b "o=test" \
  "cn:1.3.6.1.4.1.42.2.27.9.4.34.1:=sanchez"
```

The following filters return the same results:

- "cn:en:=sanchez"
- "cn:en.3:=sanchez"
- "cn:en.eq:=sanchez"
- "cn:1.3.6.1.4.1.42.2.27.9.4.34.1.3:=sanchez"

EXAMPLE 7–2 Less-Than Search

The following search uses a filter with the es (es-ES) locale and performs a less-than search and returns the entry with a departmentnumbervalue of abc119:

```
$ ldapsearch -D "cn=directory manager" -w password -b "o=test" \
  "departmentnumber:1.3.6.1.4.1.42.2.27.9.4.49.1.1:=abc120"
```

The following filters return the same results:

- "departmentnumber:es.1:=abc120"
- "departmentnumber:es.lt:=abc120"

EXAMPLE 7–3 Less-Than-or-Equal-To Search

The following search uses a filter with the es (es-ES) locale and performs a less-than-or-equal-to search that returns the entry with a departmentnumbervalue of abc119:

```
$ ldapsearch -D "cn=directory manager" -w password -b "o=test" \
  "departmentnumber:1.3.6.1.4.1.42.2.27.9.4.49.1.2:=abc119"
```

The following filters return the same results:

- "departmentnumber:es.2:=abc119"
- "departmentnumber:es.lte:=abc119"

EXAMPLE 7–4 Greater-Than-or-Equal-To Search

The following search uses a filter with the fr (fr-FR) locale and performs a greater-than-or-equal-To search that returns an entry with a departmentnumber value of abc119

```
$ ldapsearch -D "cn=directory manager" -w password -b "o=test" \
  "departmentnumber:fr.4:=abc119"
```

EXAMPLE 7–4 Greater-Than-or-Equal-To Search *(Continued)*

The following filters return the same results:

- `"departmentnumber:1.3.6.1.4.1.42.2.27.9.4.76.1.4:=abc119"`
- `"departmentnumber:fr.gte:=abc119"`

EXAMPLE 7–5 Greater-Than Search

The following search uses a filter with the `fr` (`fr-FR`) locale and performs a greater-than search:

```
$ ldapsearch -D "cn=directory manager" -w password -b "o=test" \
  "departmentnumber:fr.5:=abc119"
```

The above search should *not* return an entry with a `departmentnumber` value of `abc119`.

The following filters return the same results:

- `"departmentnumber:1.3.6.1.4.1.42.2.27.9.4.76.1.5:=abc119"`
- `"departmentnumber:fr.gt:=abc119"`

EXAMPLE 7–6 Substring Search

The following search uses a filter with the `en` (`en-US`) locale and performs a substring search that returns an entry with an `sn` value of "Quebec":

```
$ ldapsearch -D "cn=directory manager" -w password -b "o=test" \
  "sn:en.6:=*u*bec"
```

The following filters return the same results:

- `"sn:1.3.6.1.4.1.42.2.27.9.4.34.1.6:=*u*bec"`
- `"sn:en.sub:=*u*bec"`

Supported Collation Rules

The following table lists the internationalization locales supported by Oracle Unified Directory, alphabetized by character suffix.

TABLE 7–2 Supported Collation Rules

Locale	Character Suffix	OID
Arabic	ar	1.3.6.1.4.1.42.2.27.9.4.3.1
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

TABLE 7–2 Supported Collation Rules *(Continued)*

Locale	Character Suffix	OID
Arabic India	ar-IQ	1.3.6.1.4.1.42.2.27.9.4.9.1
Arabic Jordanar	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 Lybia	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
Bulgaria	bg	1.3.6.1.4.1.42.2.27.9.4.23.1
Catalan	ca	1.3.6.1.4.1.42.2.27.9.4.25.1
Czech	cs	1.3.6.1.4.1.42.2.27.9.4.26.1
Danish	da	1.3.6.1.4.1.42.2.27.9.4.27.1
German	de	1.3.6.1.4.1.142.2.27.9.4.28.1
German Germany	de-DE	1.3.6.1.4.1.142.2.27.9.4.28.1
German Austria	de-AT	1.3.6.1.4.1.42.2.27.9.4.29.1
German Swiss	de-CH	1.3.6.1.4.1.42.2.27.9.4.31.1
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
English	en	1.3.6.1.4.1.42.2.27.9.4.34.1
English US	en-US	1.3.6.1.4.1.42.2.27.9.4.34.1
English Australia	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

TABLE 7–2 Supported Collation Rules *(Continued)*

Locale	Character Suffix	OID
English Great Britain	en-GB	1.3.6.1.4.1.42.2.27.9.4.37.1
English Ireland	en-IE	1.3.6.1.4.1.42.2.27.9.4.39.1
English India	en-IN	1.3.6.1.4.1.42.2.27.9.4.40.1
English New Zealand	en-NZ	1.3.6.1.4.1.42.2.27.9.4.42.1
English South Africa	en-ZA	1.3.6.1.4.1.42.2.27.9.4.46.1
Spanish	es	1.3.6.1.4.1.42.2.27.9.4.49.1
Spanish Spain	es-ES	1.3.6.1.4.1.42.2.27.9.4.49.1
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
Spanish Costa Rica	es-CR	1.3.6.1.4.1.42.2.27.9.4.54.1
Spanish Dominican Republic	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 Salvador	es-SV	1.3.6.1.4.1.42.2.27.9.4.65.1
Spanish Uraguay	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
Finnish	fi	1.3.6.1.4.1.42.2.27.9.4.74.1
French	fr	1.3.6.1.4.1.42.2.27.9.4.76.1

TABLE 7–2 Supported Collation Rules *(Continued)*

Locale	Character Suffix	OID
French	fr-FR	1.3.6.1.4.1.42.2.27.9.4.76.1
French	fr-BE	1.3.6.1.4.1.42.2.27.9.4.77.1
French	fr-CA	1.3.6.1.4.1.42.2.27.9.4.78.1
French	fr-CH	1.3.6.1.4.1.42.2.27.9.4.79.1
French	fr-LU	1.3.6.1.4.1.42.2.27.9.4.80.1
Hebrew	he	1.3.6.1.4.1.42.2.27.9.4.85.1
Croatian	hr	1.3.6.1.4.1.42.2.27.9.4.87.1
Hungarian	hu	1.3.6.1.4.1.42.2.27.9.4.88.1
Icelandic	is	1.3.6.1.4.1.42.2.27.9.4.91.1
Italian	it	1.3.6.1.4.1.42.2.27.9.4.92.1
Italian-Swiss	it-CH	1.3.6.1.4.1.42.2.27.9.4.93.1
Japanese	ja	1.3.6.1.4.1.42.2.27.9.4.94.1
Korean	ko	1.3.6.1.4.1.42.2.27.9.4.97.1
Lithuanian	lt	1.3.6.1.4.1.42.2.27.9.4.100.1
Latvian	lv	1.3.6.1.4.1.42.2.27.9.4.101.1
Macedonian	mk	1.3.6.1.4.1.42.2.27.9.4.102.1
Dutch	nl	1.3.6.1.4.1.42.2.27.9.4.105.1
Dutch Netherlands	nl-NL	1.3.6.1.4.1.42.2.27.9.4.105.1
Dutch Belgium	nl-BE	1.3.6.1.4.1.42.2.27.9.4.106.1
Norwegian	no	1.3.6.1.4.1.42.2.27.9.4.107.1
Norwegian Norway	no-NO	1.3.6.1.4.1.42.2.27.9.4.107.1
Norwegian Nynorsk	no-NO-NY	1.3.6.1.4.1.42.2.27.9.4.108.1
Polish	pl	1.3.6.1.4.1.42.2.27.9.4.114.1
Portuguese	pt	1.3.6.1.4.1.42.2.27.9.4.115.1
Portuguese Portugal	pt-PT	1.3.6.1.4.1.42.2.27.9.4.115.1
Portugues 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
Russian	ru	1.3.6.1.4.1.42.2.27.9.4.118.1

TABLE 7–2 Supported Collation Rules *(Continued)*

Locale	Character Suffix	OID
Russian Russia	ru-RU	1.3.6.1.4.1.42.2.27.9.4.118.1
Slovak	sk	1.3.6.1.4.1.42.2.27.9.4.121.1
Slovenia	sl	1.3.6.1.4.1.42.2.27.9.4.122.1
Albanian	sq	1.3.6.1.4.1.42.2.27.9.4.127.1
Serbian	sr	1.3.6.1.4.1.42.2.27.9.4.128.1
Swedish	sv	1.3.6.1.4.1.42.2.27.9.4.129.1
Swedish Sweden	sv-SE	1.3.6.1.4.1.42.2.27.9.4.129.1
Thai	th	1.3.6.1.4.1.42.2.27.9.4.136.1
Turkish	tr	1.3.6.1.4.1.42.2.27.9.4.140.1
Ukrainian	uk	1.3.6.1.4.1.42.2.27.9.4.141.1
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
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 Taiwan	zh-TW	1.3.6.1.4.1.42.2.27.9.4.148.1

Adding, Modifying, and Deleting Directory Data

The directory server provides a full set of LDAPv2- and LDAPv3-compliant client tools to manage directory entries. You can add, update, or remove entries by using the `ldapmodify` and `ldapdelete` utilities. The LDAP command-line utilities require LDAP Data Interchange Format (LDIF)-formatted input, entered through the command line or read from a file.

Before you make modifications to directory data, make sure that you understand the following concepts:

- The privilege and access control mechanisms.

  For information about setting privileges, Chapter 9, “Controlling Access To Data.”
- The structure of your directory server.
- The schema of your directory server.

Adding Directory Entries

You can add one or more entries to a directory server by using the ldapmodify command. ldapmodify opens a connection to the directory server, binds to it, and performs the modification to the database (in this case, an "add") as specified by the command-line options.

ldapmodify enables you to add entries in one of two ways:

- **Using the --defaultAdd option**. Use the --defaultAdd option to add new entries to the directory when data is entered on the command line. Press Ctrl-D (UNIX, Linux) or Ctrl-Z (Windows) when finished, or use an input file with your changes.
- **Using LDIF update statements**. LDIF update statements define how ldapmodify changes the directory entry. LDIF update statements contain the DN of the entry to be modified, *changetype* that defines how a specific entry is to be modified (add, delete, modify, modrdn), and a series of attributes and their changed values.

Note – Any newly added entry must conform to the directory's schema. If you add any entry that does not conform to the schema, the server responds with an Object Class Violation error. You can view the details of the error in the errors log.

▼ To Create a Root Entry

The root entry is the topmost entry in the directory and must contain the naming context, or root suffix. You can set up the root entry when you first install the directory server using the graphical user interface (GUI) or the command-line. If you install the directory without any data, create a root entry using the ldapmodify command with the --defaultAdd option.

1 Create the root entry using ldapmodify.

```
$ ldapmodify --hostname localhost --port 1389 --defaultAdd \
  --bindDN "cn=Directory Manager" --bindPassword password
dn: dc=example,dc=com
objectclass: domain
objectclass: top
dc: example
(Press Ctrl-D on Unix, Linux)
(Press Ctrl-Z on Windows), then press ENTER.

Processing ADD request for dc=example,dc=com
ADD operation successful for DN dc=example,dc=com
```

Note – The `--bindDN` and `--bindPassword` options specify the bind DN and password, respectively, of the user with permissions to add new entiries. You can provide the clear-text version of the password. The server encrypts this value and store only the encrypted one. Be sure to limit read permissions to protect clear passwords that appear in LDIF files. To avoid this security issue, use SSL or startTLS.

2 **Verify the change by using the `ldapsearch` command.**

```
$ ldapsearch --hostname localhost --port 1389 --baseDN "dc=example,dc=com" \
  --searchScope base --bindDN "cn=Directory Manager" --bindPassword password \
  "(objectclass=*)"
dn: dc=example,dc=com
objectClass: domain
objectClass: top
dc: example
```

▼ To Add an Entry Using the `--defaultAdd` Option With `ldapmodify`

1 **Create your directory entry in LDIF format.**

Before you add an entry, ensure that the suffix to which you want to add the entry exists in your database (for example, `ou=People,dc=example,dc=com`).

For this example, create an input file called `new.ldif` with the following contents:

```
dn: uid=Marcia Garza,ou=People,dc=example,dc=com
cn: Marcia Garza
sn: Garza
givenName: Marcia
objectClass: top
objectClass: person
objectClass: organizationalPerson
objectClass: inetOrgPerson
ou: Accounting
ou: People
l: Santa Clara
uid: mgarza
mail: mgarza@example.com
roomnumber: 5484
userpassword: donuts
```

2 **Add the entry using `ldapmodify` with the `--defaultAdd` option.**

```
$ ldapmodify --hostname localhost --port 1389 --bindDN "cn=Directory Manager" \
  --bindPassword password --defaultAdd --filename /tmp/new.ldif
```

▼ To Add Entries Using an LDIF Update Statement With `ldapmodify`

1 **Create the entry in LDIF format with the `changetype:add` element.**

Make sure that there are no trailing spaces after `add`. If a space exists after `add`, the server base-64 encodes the value to represent the space, which can cause problems.

For this example, create an input LDIF file named `new.ldif`.

```
dn: uid=Marcia Garza,ou=People,dc=example,dc=com
changetype: add
cn: Marcia Garza
sn: Garza
givenName: Marcia
objectClass: top
objectClass: person
objectClass: organizationalPerson
objectClass: inetOrgPerson
ou: Accounting
ou: People
l: Santa Clara
uid: mgarza
mail: mgarza@example.com
roomnumber: 5484
userpassword: donuts
```

2 **Add the entry using `ldapmodify`.**

Do not include the `-a` option as the `changetype` attribute specifies the action.

```
$ ldapmodify --hostname localhost --port 1389 --bindDN "cn=Directory Manager" \
  --bindPassword password --filename /tmp/new.ldif

Processing ADD request for uid=Marcia Garza,ou=People,dc=example,dc=com
ADD operation successful for DN uid=Marcia Garza,ou=People,dc=example,dc=com
```

Adding Attributes

The LDIF `changetype:add` statement adds an entry to the directory. To add attributes to an entry, use the `changetype:modify` statement, as shown in the following examples. You can combine multiple commands within a file by separating each command with a dash ("-").

▼ To Add an Attribute to an Entry

1 **Create the entry in LDIF format with the `changetype:modify` element.**

Use the `modify` change type, because you are modifying an existing entry with the addition of a new attribute. Make sure that there are no trailing spaces after `modify`. After the `changetype`, specify `add:` *newAttributeName* and, on the following line, the value of the new attribute.

For this example, create an input LDIF file called `add_attribute.ldif`, as follows:

```
dn: uid=Marcia Garza,ou=People,dc=example,dc=com
changetype: modify
add: telephonenumber
telephonenumber: +1 408 555 8283
```

Note – To add multiple attributes, separate the attributes with a dash (-), for example:

```
dn: uid=Marcia Garza,ou=People,dc=example,dc=com
changetype: modify
add: telephonenumber
telephonenumber: +1 408 555 8283
-
add: building
building: sc09
```

2 **Add the attribute by using `ldapmodify`.**

```
$ ldapmodify --hostname localhost --port 1389 --bindDN "cn=Directory Manager" \
  --bindPassword password --filename /tmp/add_attribute.ldif

Processing MODIFY request for uid=Marcia Garza,ou=People,dc=example,dc=com
MODIFY operation successful for DN uid=Marcia Garza,ou=People,dc=example,dc=com
```

▼ To Add an ACI Attribute

You can use `ldapmodify` to add access control instructions (ACIs) to manage access rights for a user's account. For more information, see Chapter 9, “Controlling Access To Data,” and “ACI Syntax” in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

The following example allows a user to modify her own directory attributes.

1 **Create the LDIF file containing the ACI.**

```
dn: uid=Marcia Garza,ou=People,dc=example,dc=com
changetype: modify
add: aci
aci: (target="ldap:///uid=Marcia Garza,ou=People,dc=example,dc=com")
 (targetattr="*")(version 3.0; acl "mgarza rights"; allow (write)
 userdn="ldap:///self";)
```

2 **Add the attribute by using `ldapmodify`.**

```
$ ldapmodify --hostname localhost --port 1389 --bindDN "cn=Directory Manager" \
  --bindPassword password --filename /tmp/add_aci.ldif

Processing MODIFY request for uid=Marcia Garza,ou=People,dc=example,dc=com
MODIFY operation successful for DN uid=Marcia Garza,ou=People,dc=example,dc=com
```

▼ To Add an International Attribute

The directory server represents international locales using a language tag in the form *attribute;language-subtype*. For example, `homePostalAddress;lang-jp:address` specifies the postal address with the locale in Japan (`subtype=jp`).

- **Use `ldapmodify` to add the attribute.**

Affix the language subtype, `lang-`*cc*, where *cc* is the country code.

```
$ ldapmodify --hostname localhost --port 1389 --bindDN "cn=Directory Manager" \
  --bindPassword password
dn: uid=jarrow,ou=People,dc=example,dc=com
changetype: modify
add: homePostalAddress;lang-jp
homePostalAddress;lang-jp: 1-8-15 Azuchimachi, Chuo-ku
(Press Ctrl-D on Unix, Linux)
(Press Ctrl-Z on Windows), then press ENTER.
```

Note – If the attribute value contains non-ASCII characters, they must be UTF-8 encoded.

Modifying Directory Entries

Use the LDIF update statement `changetype:modify` to make changes to existing directory data. The following procedures provide examples of modifying directory entries.

For more information, see "ldapmodify" in *Oracle Fusion Middleware Command-Line Usage Guide for Oracle Unified Directory*.

▼ To Modify an Attribute Value

- **Use `ldapmodify` to change the entry, using the `changetype:modify` and `replace` elements.**

Ensure that there are no trailing spaces after `modify`.

This example modifies a user's existing telephone number.

```
$ ldapmodify -h localhost -p 1389 D "cn=Directory Manager" -w password \
dn: uid=Marcia Garza,ou=People,dc=example,dc=com
changetype: modify
replace: telephonenumber
telephonenumber: +1 408 555 8288

Processing MODIFY request for uid=Marcia Garza,ou=People,dc=example,dc=com
MODIFY operation successful for DN uid=Marcia Garza,ou=People,dc=example,dc=com
```

Note – To modify multiple attributes, separate the attributes with a dash (-), for example:

```
dn: uid=Marcia Garza,ou=People,dc=example,dc=com
changetype: modify
replace: telephonenumber
telephonenumber: +1 408 555 6465
-
add: facsimiletelephonenumber
facsimiletelephonenumber: +1 408 222 4444
-
replace: l
l: Sunnyvale
```

▼ To Modify an Attribute With Before and After Snapshots

The `ldapmodify` command provides the options, `--preReadAttribute` and `--postReadAttribute`, that return the modified attribute value with a *before* and *after* snapshot, respectively.

- **Use `ldapmodify` with the `--preReadAttribute` and `--postReadAttribute` options.**

This example modifies a user's existing telephone number.

```
$ ldapmodify -h localhost -p 1389 D "cn=Directory Manager" -w password \
  --preReadAttributes telephoneNumber --postReadAttributes telephoneNumber
dn: uid=Marcia Garza,ou=People,dc=example,dc=com
changetype: modify
replace: telephonenumber
telephonenumber: +1 408 555 8288

Processing MODIFY request for uid=Marcia Garza,ou=People,dc=example,dc=com
MODIFY operation successful for DN uid=Marcia Garza,ou=People,dc=example,dc=com

Target entry before the operation:
dn: uid=Marcia Garza,ou=People,dc=example,dc=com
telephonenumber: +1 408 555 4283

Target entry after the operation:
dn: uid=Marcia Garza,ou=People,dc=example,dc=com
telephonenumber: +1 408 555 8288
```

▼ To Delete an Attribute

This example deletes the location (l) attribute from an entry.

- **Use the `ldapmodify` to delete the attribute.**

```
$ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password
dn: uid=Marcia Garza,ou=People,dc=example,dc=com
changetype: modify
delete: l
(Press CTRL-D for Unix, Linux) (Press CTRL-Z for Windows), then press ENTER.

Processing MODIFY request for uid=Marcia Garza,ou=People,dc=example,dc=com
MODIFY operation successful for DN uid=Marcia Garza,ou=People,dc=example,dc=com
```

Note – Type control-D (UNIX, Linux) or control-Z (Windows) to complete the input.

▼ To Change an RDN

The distinguished name (DN) of an entry uniquely identifies and describes that entry. A distinguished name consists of the name of the entry itself as well as the names, in order from bottom to top, of the objects above it in the directory.

The relative distinguished name (RDN) is the leftmost element in an entry DN. For example, the RDN for `uid=Marcia Garza,ou=People,dc=example,dc=com` is `uid=Marcia Garza`. To change an RDN, use the `changetype:moddn` LDIF update statement.

You can specify if the old RDN should be retained in the directory by using the `deleteoldrdn` attribute. A `deleteoldrdn` value of `0` indicates that the existing RDN should be retained in the directory. A value of `1` indicates that the existing RDN should be replaced by the new RDN value.

Note – You cannot rename an RDN if it has any children, due to the possible orphaning of the subtree elements. This is a violation of the LDAP protocol.

1 **Use the `ldapmodify` command to rename the entry.**

In this example, an employee `Marcia Garza` wants to change to her married name, `Marcia Peters`.

```
$ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password
dn: uid=Marcia Garza,ou=Marketing,dc=example,dc=com
changetype: moddn
newrdn: uid=Marcia Peters
deleteoldrdn: 1
Processing MODIFY DN request for uid=Marcia Garza,ou=People,dc=example,dc=com
MODIFY DN operation successful for DN uid=Marcia Garza,ou=People,dc=example,dc=com
```

2 **Change any other attributes as necessary.**

In this example, certain attributes might still list the user's previous name.

```
$ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password
dn: uid=Marcia Peters,ou=People,dc=example,dc=com
changetype: modify
replace: sn
sn: Peters
-
replace: cn
cn: Marcia Peters
-
replace: uid
uid: mpeters
uid: Marcia Peters
-
replace: mail
```

```
mail: mpeters@example.com
(Press Ctrl-D on Unix, Linux)
(Press Ctrl-Z on Windows), then press ENTER.

Processing MODIFY request for uid=Marcia Peters,ou=People,dc=example,dc=com
MODIFY operation successful for DN uid=Marcia Peters,ou=People,dc=example,dc=com
```

▼ To Move an Entry

If you are moving an entry from one parent to another, extend the access control instruction (ACI) rights on the parent entries. On the current parent entry of the entry to be moved, ensure that the ACI allows the export operations by using the syntax `allow(export ...)`. On the future parent entry of the entry to be moved, ensure that the ACI allows the import operations by using the syntax `allow(import...)`.

In this example, move `uid=sgarza` from the `ou=Contractors,dc=example,dc=com` suffix to the `ou=People,dc=example,dc=com` subtree.

1 **Use `ldapmodify` with the `moddn` changetype to move the entry.**

```
$ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password
dn: uid=sgarza,ou=Contractors,dc=example,dc=com
changetype: moddn
newrdn: uid=sgarza
deleteoldrdn: 0
newsuperior: ou=People,dc=example,dc=com
--filename move_entry.ldif
Processing MODIFY DN request for uid=sgarza,ou=Contractors,dc=example,dc=com
MODIFY DN operation successful for DN uid=sgarza,ou=Contractors,dc=example,dc=com
```

2 **Change any other attribute values, as required.**

The following example provides before and after snapshot changes for the `ou` attribute.

```
$ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  --preReadAttributes ou --postReadAttributes ou
dn: uid=sgarza,ou=People,dc=example,dc=com
changetype: modify
replace: ou
ou: People
ou: Product Testing
(Press Ctrl-D on Unix, Linux)
(Press Ctrl-Z on Windows), then press ENTER.

Processing MODIFY request for uid=sgarza,ou=People,dc=example,dc=com
MODIFY operation successful for DN uid=sgarza,ou=People,dc=example,dc=com

Target entry before the operation:
dn: uid=sgarza,ou=People,dc=example,dc=com
ou: Contractors
ou: Product Testing

Target entry after the operation:
dn: uid=sgarza,ou=People,dc=example,dc=com
ou: People
ou: Product Testing
```

Deleting Directory Entries

You can use `ldapmodify` and `ldapdelete` to remove entries from the directory. The `ldapmodify` command removes entries and attributes by using the LDIF update statements `changetype:delete` and `changetype:modify` with the `delete` attribute, respectively. The `ldapdelete` tool removes only entries.

Note – You cannot delete an entry that has children entries. If you want to delete an entry that has children, first delete all the children entries below the targeted entry, then delete the entry.

For more information, see "ldapdelete" in *Oracle Fusion Middleware Command-Line Usage Guide for Oracle Unified Directory*.

▼ To Delete an Entry With `ldapmodify`

● **Use the `ldapmodify` command with the `changetype:delete` statement.**

```
$ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password
dn: uid=Marcia Garza,ou=People,dc=example,dc=com
changetype: delete
(Press CTRL-D for Unix)
(Press CTRL-Z for Windows), then press ENTER.

Processing DELETE request for uid=Marcia Garza,ou=People,dc=example,dc=com
DELETE operation successful for DN uid=Marcia Garza,ou=People,dc=example,dc=com
The number of entries deleted was 1
```

▼ To Delete an Entry With `ldapdelete`

● **Use the `ldapdelete` command and specify the entry that you want to delete.**

```
$ ldapdelete -h localhost -p 1389 -D "cn=Directory Manager" -w password
"uid=mgarza,ou=People,dc=example,dc=com"

Processing DELETE request for uid=Marcia Garza,ou=People,dc=example,dc=com
DELETE operation successful for DN uid=Marcia Garza,ou=People,dc=example,dc=com
```

▼ To Delete Multiple Entries by Using a DN File

1. **Create a file that contains a list of DNs to be deleted.**

   In this example, the file is named `delete.ldif`. The file must list each DN on a separate line, for example:

```
uid=mgarza,ou=People,dc=example,dc=com
uid=wsmith,ou=People,dc=example,dc=com
uid=jarrow,ou=People,dc=example,dc=com
uid=mbean,ou=People,dc=example,dc=com
```

2 **Delete the entries by passing the file as an argument to the `ldapdelete` command.**

```
$ ldapdelete -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  --continueOnError --filename delete.ldif

Processing DELETE request for uid=mgarza,ou=People,dc=example,dc=com
DELETE operation successful for DN uid=mgarza,ou=People,dc=example,dc=com
Processing DELETE request for uid=wsmith,ou=People,dc=example,dc=com
DELETE operation successful for DN uid=wsmith,ou=People,dc=example,dc=com
Processing DELETE request for uid=jarrow,ou=People,dc=example,dc=com
DELETE operation successful for DN uid=jarrow,ou=People,dc=example,dc=com
Processing DELETE request for uid=mbean,ou=People,dc=example,dc=com
DELETE operation successful for DN uid=mbean,ou=People,dc=example,dc=com
```

Note – The `--continueOnError` option specifies that if an error occurs, the command continues to the next search item.

Indexing Directory Data

This section describes how to index attributes using the `dsconfig` command-line tool. Indexes are configured per server and index configuration is not replicated.

You can use `dsconfig` to create local database indexes and Virtual List View (VLV) indexes. A local database index is used to find entries that match search criteria. A VLV index is used to process searches efficiently with VLV controls.

Unindexed searches are denied by default, unless the user has the `unindexed-search` privilege. For more information, see “To Change a Root User's Privileges” on page 386.

You can determine whether a search is indexed in two ways:

- Try to perform the search anonymously. (The server rejects unindexed anonymous searches by default.)
- Use the `debugsearchindex` operational attribute. This attribute provides the indexes used in the search, the number of candidate entries from each index, and the final indexed status. Include the `debugsearchindex` attribute in your `ldapsearch` command, as follows:

```
$ ldapsearch -h localhost -p 1389 -b "dc=example,dc=com" "(objectClass=*)" debugsearchindex
```

Configuring Indexes on the Local DB Back End

The Local DB back end supports the following index types:

- `approximate` — Improves the efficiency of searches using approximate search filters.
- `equality` - Improves the efficiency of searches using equality search filters.

- `ordering` - Improves the efficiency of searches using "greater than or equal to" or "less than or equal to" search filters. In the future, this index type might also be used for server-side sorting.
- `presence` - Improves the efficiency of searches using presence search filters.
- `substring` - Improves the efficiency of searches using substring search filters.

The directory server supports indexing for only a subset of extensible matching operations, including indexes based on collation matching rules and the relative time and partial date and time matching rules. For more information, see "Searching Internationalized Entries" on page 266 and "Relative Time Matching Rules" and "Partial Date Or Time Matching Rules" in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

When you create a new local DB back end with `dsconfig`, the following default indexes are created automatically:

- `aci` (presence index)
- `ds-sync-hist` (ordering index)
- `entryuuid` (equality index)
- `objectclass` (equality index)

▼ To Create a New Local DB Index

This procedure demonstrates the steps for creating a new local DB index.

Note – After you have created a new index, you must rebuild the indexes using the `rebuild-index` utility. The directory server cannot use the new index until the indexes have been rebuilt. For more information, see "rebuild-index" in *Oracle Fusion Middleware Command-Line Usage Guide for Oracle Unified Directory*.

---

1. **Create the new index.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X -n \
  create-local-db-index \
  --backend-name backend --index-name attribute \
  --set index-type:index-type
```

2. **Check that the index was created by listing the local DB indexes for that back end.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X -n \
  list-local-db-indexes \
  --backend-name backend
```

3. **Configure any specific index properties.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X -n \
  set-local-db-index-prop \
  --backend-name backend --index-name attribute \
  --set property:value
```

4 **List the index properties to verify your change.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X -n \
  get-local-db-index-prop \
  --backend-name backend --index-name attribute
```

5 **Rebuild the index.**

- **Either stop the server, rebuild the index, then restart the server.**

  ```
  $ stop-ds
  $ rebuild-index --baseDN baseDN --index attribute
  $ start-ds
  ```

- **Or, rebuild the index online by running the rebuild-index command as a task.**

  ```
  $ rebuild-index -h localhost -p 4444 -D "cn=Directory manager" -w password -X \
    --baseDN dc=example,dc=com --index aci
  Rebuild Index task 20110201162742312 scheduled to start immediately
  ...
  Rebuild Index task 20110201162742312 has been successfully completed
  ```

Example 7–7 Creating a New Equality Index

This example creates a new equality index for the `employeeNumber` attribute, verifies the index properties, and sets the index entry limit to 5000.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X -n \
  create-local-db-index \
  --backend-name userRoot --index-name employeeNumber \
  --set index-type:equality
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X -n \
  list-local-db-indexes \
  --backend-name userRoot
Local DB Index : Type    : index-type
---------------:---------:-----------
...
employeeNumber : generic : equality
...
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X -n \
  get-local-db-index-prop \
  --backend-name userRoot --index-name employeeNumber
Property                       : Value(s)
-------------------------------:---------------
attribute                      : employeenumber
index-entry-limit              : 4000
index-extensible-matching-rule : -
index-type                     : equality
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X -n \
  set-local-db-index-prop \
  --backend-name userRoot --index-name employeeNumber --set index-entry-limit:5000
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X -n \
  get-local-db-index-prop \
  --backend-name userRoot --index-name employeeNumber
Property                       : Value(s)
-------------------------------:---------------
```

```
attribute                      : employeenumber
index-entry-limit              : 5000
index-extensible-matching-rule : -
index-type                     : equality
$ rebuild-index -h localhost -p 4444 -D "cn=Directory manager" -w password -X \
  --baseDN dc=example,dc=com --index employeeNumber
```

Example 7–8 Adding a Substring Index

This example adds a substring index to the index created in the previous example.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X -n \
  set-local-db-index-prop \
  --backend-name userRoot --index-name employeeNumber \
  --add index-type:substring
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X -n \
  get-local-db-index-prop \
  --backend-name userRoot --index-name employeeNumber
Property                       : Value(s)
-------------------------------:--------------
attribute                      : employeenumber
index-entry-limit              : 5000
index-extensible-matching-rule : -
index-type                     : equality, substring
$ rebuild-index -h localhost -p 4444 -D "cn=Directory manager" -w password -X \
  --baseDN dc=example,dc=com --index employeeNumbe
```

Configuring VLV Indexes

A VLV index applies to a particular search on a given base entry and its subtree. The sort order, scope of the index, base DN, and filter must be defined when you create the index.

Note – After you have created a new VLV index, you must rebuild the indexes using the `rebuild-index` command, appending `vlv.` in front of the index name. The directory server cannot use the new index until the indexes have been rebuilt. For more information, see “rebuild-index” in *Oracle Fusion Middleware Command-Line Usage Guide for Oracle Unified Directory*.

▼ To Create a New VLV Index

1 **Use `dsconfig` to create a new VLV index as follows:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  create-local-db-vlv-index \
  --backend-name backend --index-name name --set sort-order:attributes \
  --set scope:scope --set base-dn:baseDN --set filter:filter
```

where:

- `index-name` specifies a unique index name, which cannot be altered after the VLV index is created.
- `sort-order` specifies the names of the attributes by which the entries are sorted and their order of precedence, from highest to lowest.
- `scope` specifies the LDAP scope of the query being indexed and can be one of `base-object`, `single-level`, `subordinate-subtree`, or `whole-subtree`.
- `base-dn` specifies the base DN used in the search query being indexed.
- `filter` specifies the LDAP filter used in the query being indexed and can be any valid LDAP filter.

2 **Check that the index was created by listing the existing VLV indexes.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  list-local-db-vlv-indexes \
  --backend-name backend
```

3 **Display the index properties to verify your change.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  get-local-db-vlv-index-prop \
  --backend-name backend --index-name name
```

4 **Rebuild the index.**

- **Either stop the server, rebuild the index, then restart the server.**

```
$ stop-ds
$ rebuild-index --baseDN baseDN --index vlv.name
$ start-ds
```

- **Or, rebuild the index online by running the rebuild-index command as a task.**

```
$ rebuild-index -h localhost -p 4444 -D "cn=Directory manager" -w password -X \
  --baseDN baseDN --index vlv.name
```

Example 7–9 Creating a New VLV Index

The following example creates a new VLV index to sort entries first by surname and then by common name for queries `sn=*`. The example then rebuilds the index online.

```
$ dsconfig -D "cn=directory manager" -w password -n create-local-db-vlv-index \
  --backend-name userRoot --index-name myVLVIndex --set sort-order:"sn cn" \
  --set scope:base-object --set base-dn:dc=example,dc=com --set filter:sn=*
$ rebuild-index -h localhost -p 4444 -D "cn=Directory manager" -w password -X \
  -b "dc=example,dc=com" --index vlv.myVLVIndex
```

Reducing Stored Data Size

The directory server provides two mechanisms for reducing the size of stored data:

- **Compact encoding**. When compact encoding is enabled, the back end uses a compact form when encoding entries by compressing the attribute descriptions and object class sets. This property applies only to the entries themselves and does not impact the index data. Compact encoding is enabled by default but can be disabled if required. You might want to disable compact encoding where user-supplied capitalization is required because user-supplied capitalization is not preserved in compacted entries. The compaction does, however, provide a performance gain and is therefore beneficial in deployments where user-supplied capitalization can be sacrificed for performance, or is not required.
- **Entry compression**. Entry compression uses a deflater to compress the data before it is stored. When entry compression is enabled, the back end attempts to compress entries before storing them in the database. This property also applies only to the entries themselves and does not impact the index data. The effectiveness of entry compression is based on the type of data contained in the entry.

You can enable one or both of these mechanisms to reduce the size of the stored data. Because enabling these mechanisms affects future writes only, the database might contain a mixture of compressed and uncompressed records. Either type of record can be read regardless of the compression settings.

▼ To Enable or Disable Compact Encoding

Compact encoding is configured by setting the `compact-encoding` property of a back end. Changes to this setting will only take effect for writes that occur after the change is made. Existing data is not changed retroactively.

● **Disable compact encoding on the "userRoot" back end.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X -n \
  set-backend-prop --backend-name="userRoot" --set compact-encoding:false
```

▼ To Enable or Disable Entry Compression

Entry compression is configured by setting the `entries-compressed` property of a back end. Changes to this setting will only take effect for writes that occur after the change is made. Existing data is not changed retroactively.

● **Enable entry compression on the "userRoot" back end.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X -n \
  set-backend-prop --backend-name="userRoot" --set entries-compressed:true
```

Ensuring Attribute Value Uniqueness

A directory's structure requires that distinguished names be unique to identify the object and its place in the directory information tree. The directory server provides a *Unique Attribute* plug-in, which ensures that the value of an attribute is unique when the attribute is added, modified, or moved within the directory.

Overview of the Unique Attribute Plug-In

The unique attribute plug-in is disabled by default. You can enable the plug-in by using the `dsconfig` command and can define the suffix and attributes that it should check. When it is enabled, the plug-in identifies whether an LDAP add, modify, or modify DN operation causes two entries to have the same attribute value before the database is updated by the operation. If the server recognizes a conflict, the operation is terminated and an `LDAP_CONSTRAINT_VIOLATION` error is returned to the client.

When you enable attribute uniqueness on an existing directory, the server does not check for uniqueness among existing entries. After the plug-in is enabled, uniqueness is enforced when an entry is added, modified, or moved.

The unique attribute plug-in can be configured to enforce uniqueness in one or more subtrees in the directory or among entries of a specific object class. You can define several instances of the unique attribute plug-in if you want to enforce the uniqueness of other attributes. Typically, you define one plug-in instance for each attribute whose value must be unique. You can also have several plug-in instances for the same attribute to enforce "separate" uniqueness in several sets of entries.

The unique attribute plug-in is disabled by default, so that multi-master replication configuration is not affected. When the plug-in is enabled, it checks that the `uid` attribute is unique prior to any add, modify, or modify DN operations for stand-alone systems and checks for uniqueness after synchronization in replicated environments.

Like other plug-ins, the unique attribute plug-in is configured by using the `dsconfig` command. For more information, see “Configuring Plug-Ins With `dsconfig`” on page 51. The easiest way to configure plug-ins is to use `dsconfig` in interactive mode. Interactive mode functions like a wizard and walks you through the plug-in configuration. Because the interactive mode is self-explanatory, the examples in this section do not demonstrate interactive mode, but provide the equivalent complete `dsconfig` commands.

Configuring the Unique Attribute Plug-In Using `dsconfig`

The following procedures explain how to configure attribute value uniqueness.

▼ To Ensure Uniqueness of the Value of the `uid` Attribute

The unique attribute plug-in checks the `uid` attribute by default. The following task enables the unique attribute plug-in, and sets the base DN under which attribute value uniqueness for the `uid` attribute should be checked.

1 (Optional) Display the plug-ins that are currently defined in the server.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  list-plugins
```

Depending on your installation, the output will be similar to the following.

```
Plugin                           : Type                             : enabled
---------------------------------:----------------------------------:--------
7-Bit Clean                      : seven-bit-clean                  : false
Change Number Control            : change-number-control            : true
Entry UUID                       : entry-uuid                       : true
LastMod                          : last-mod                         : true
LDAP Attribute Description List : ldap-attribute-description-list : true
Password Policy Import           : password-policy-import           : true
Profiler                         : profiler                         : true
Referential Integrity            : referential-integrity            : false
UID Unique Attribute             : unique-attribute                 : false
```

2 (Optional) Display the properties that are configured for the unique attribute plug-in

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  get-plugin-prop \
  --plugin-name "UID Unique Attribute" \
Property : Value(s)
---------:---------
base-dn  : -
enabled  : false
type     : uid
```

3 Enable the unique attribute plug-in.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-plugin-prop \
  --plugin-name "UID Unique Attribute" --set enabled:true
```

4 Set the base DN under which uniqueness is checked.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-plugin-prop \
  --plugin-name "UID Unique Attribute" --set base-dn:ou=People,dc=example,dc=com
```

▼ To Ensure Uniqueness of the Value of Any Other Attribute

The unique attribute plug-in checks the `uid` attribute by default. If you want to ensure uniqueness for a different attribute, create a new instance of the unique attribute plug-in and set its `type` property.

This example creates a new instance of the unique attribute plug-in and ensures uniqueness of the `mail` attribute.

1 **Create and enable a new instance of the unique attribute plug-in.**

Set the `type` property to the name of the attribute that should be unique (in this case, `mail`.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  create-plugin \
  --type unique-attribute --plugin-name "MAIL unique attribute"
  --set enabled:true --set type:mail
```

2 **Enable the new unique attribute plug-in.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-plugin-prop \
  --plugin-name "MAIL Unique Attribute" --set enabled:true
```

3 **Set the base DN under which uniqueness is checked.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-plugin-prop \
  --plugin-name "MAIL Unique Attribute" --set base-dn:ou=People,dc=example,dc=com
```

4 **Specify the attribute whose value must be unique.**

This example specifies the `mail` attribute.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-plugin-prop \
  --plugin-name "MAIL Unique Attribute" --set type:mail
```

Next Steps To ensure that the values of more than one attribute are unique, create and enable multiple instances of the unique attribute plug-in.

Replication and the Unique Attribute Plug-In

The Unique Attribute plug-in does not check attribute uniqueness when an update is performed as part of a replication operation. To ensure attribute value uniqueness in a replication environment, enable the unique attribute plug-in for the same attribute in the same subtree on all servers in the topology.

Configuring Virtual Attributes

Virtual attributes are attributes whose values do not exist in persistent storage but are dynamically generated in some way.

Oracle Unified Directory supports the following virtual attribute types:

- `entryDN` virtual attribute
- `entryUUID` virtual attribute
- `hasSubordinates` virtual attribute
- `isMemberOf` virtual attribute

- member virtual attribute
- numSubordinates virtual attribute
- subschemaSubentry virtual attribute
- User-defined virtual attributes

Virtual attributes are configured by using the dsconfig command. dsconfig accesses the plug-in configuration over SSL via the “Managing Administration Traffic to the Server” on page 62. The easiest way to configure virtual attributes is to use dsconfig in interactive mode. Interactive mode functions like a wizard and walks you through the virtual attribute configuration. Because the interactive mode is self-explanatory, the examples in this section do not demonstrate interactive mode, but provide the equivalent complete dsconfig commands.

For more information about using dsconfig, see “Managing the Server Configuration With dsconfig” on page 25.

▼ To List the Existing Virtual Attributes

The directory server provides a number of virtual attribute rules by default. This example lists all configured virtual attributes rules.

● **Run the dsconfig command as follows:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
 list-virtual-attributes

Virtual Attribute           : Type                : enabled : attribute-type
----------------------------:---------------------:---------:------------------
entryDN                     : entry-dn            : true    : entrydn
entryUUID                   : entry-uuid          : true    : entryuuid
hasSubordinates             : has-subordinates    : true    : hassubordinates
isMemberOf                  : is-member-of        : true    : ismemberof
numSubordinates             : num-subordinates    : true    : numsubordinates
subschemaSubentry           : subschema-subentry  : true    : subschemasubentry
Virtual Static member       : member              : true    : member
Virtual Static uniqueMember : member              : true    : uniquemember
```

The output of this command shows the following (from left to right):

- Virtual Attribute. The name of the virtual attribute, usually descriptive of what it does.
- Type. The type of virtual attribute. It is possible to define more then one virtual attribute of a specific type.
- enabled. Virtual attributes can either be enabled or disabled. Disabled virtual attributes remain in the server configuration, but their values are never generated.
- attribute-type. Specifies the type of attribute for which virtual values are generated.

▼ To Create a New Virtual Attribute

This example creates and enables a virtual attribute rule that adds a virtual fax number of +61 2 45607890 to any user entry with a location of Sydney (unless they already have a fax number in their entry):

- **Run the dsconfig command as follows:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  create-virtual-attribute \
  --type user-defined --name "Sydney Fax Number" \
  --set attribute-type:facsimiletelephonenumber --set enabled:true \
  --set value:+61245607890 --set filter:"(&(objectClass=person)(l=Sydney))"
```

▼ To Enable or Disable a Virtual Attribute

To enable a virtual attribute, set the enabled property to true. To disable a virtual attribute, set the enabled property to false. This example disables the virtual attribute created in the previous example:

- **Run the dsconfig command as follows:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-virtual-attribute-prop \
  --name="Sydney Fax Number" --set enabled:false
```

▼ To Display the Configuration of a Virtual Attribute

Use the get-*-prop subcommand of dsconfig to display the virtual attribute configuration. This example displays the properties of the virtual attribute created in the previous example:

- **Run the dsconfig command as follows:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  get-virtual-attribute-prop \
  --name="Sydney Fax Number"
Property          : Value(s)
------------------:---------------------------------
attribute-type    : facsimiletelephonenumber
base-dn           : -
conflict-behavior : real-overrides-virtual
enabled           : false
filter            : (&(objectClass=person)(l=Sydney))
group-dn          : -
value             : +61245607890
```

▼ To Change the Configuration of a Virtual Attribute

Use the `set-*-prop` subcommand of `dsconfig` to change the virtual attribute configuration. This example changes the behavior of the virtual attribute if a conflict occurs. By default, the value of a real attribute overwrites the value of the virtual attribute. With this change, the value of the real attribute and that of the virtual attribute are merged.

- **Run the `dsconfig` command as follows:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-virtual-attribute-prop \
  --name="Sydney Fax Number" --set conflict-behavior:merge-real-and-virtual
```

Using Collective Attributes

Collective attributes are attributes whose values are shared across a collection of entries. Collective attributes provide similar functionality to the Oracle Directory Server Enterprise Edition Class of Service feature.

Oracle Unified Directory collective attributes are much like virtual attributes but are defined and stored with the user data as LDAP subentries. As part of the user data, collective attributes can be replicated to other servers in the topology.

This section describes the collective attribute implementation in Oracle Unified Directory and explains how to configure collective attributes. The section covers the following topics:

- "Extensions to the Collective Attributes Standard" on page 294
- "Configuring Collective Attributes" on page 296
- "Inherited Collective Attributes" on page 299

Extensions to the Collective Attributes Standard

The Oracle Unified Directory implementation of collective attributes is based on RFC 3671 and RFC 3672, with a few specific extensions. These extensions make Oracle Unified Directory collective attributes more transparent for LDAP client applications, and are described in the following sections:

- "Naming Collective Attributes" on page 294
- "Collective Attributes and Conflict Resolution" on page 295
- "Excluding Collective Attributes From Specific Entries" on page 295

Naming Collective Attributes

According to RFC 3671, collective attributes *must* have the COLLECTIVE attribute type, be derived from regular user attributes defined in the schema, and have the `c-` prefix. For example `c-l` is a collective attribute for the standard `l` attribute, and affected user entries have `c-l` added to them on the fly.

This specification can cause problems for many client applications, which are typically not aware of collective attributes and might need to be modified or extended to handle collective attributes. Oracle Unified Directory therefore removes this restriction and supports the definition of any regular attribute defined in the schema as a collective attribute. This extension is facilitated by adding the required attribute to the related collective attribute subentry and marking the attribute with the collective option.

Collective Attributes and Conflict Resolution

Because of the way in which collective attributes can be named, a conflict resolution mechanism is provided, for cases where affected user entries already contain related real attributes. Oracle Unified Directory provides the same conflict resolution options for collective attributes as it does for virtual attributes: `real-overrides-virtual`, `virtual-overrides-real`, and `merge-real-and-virtual`.

The default conflict resolution rule is `real-overrides-virtual`. If an entry already has the same attribute type defined, the explicitly defined attribute takes precedence over the collective attribute. This behavior can be changed for each collective attribute subentry (to `virtual-overrides-real` or `merge-real-and-virtual`) by using `collectiveConflictBehavior` attribute.

The following example dynamically adds the `l` collective attribute with a value of `Paris` to each applicable user entry under `ou=people`. The value of the collective attribute overrides any value for `l` that is specific to the entry:

```
dn: cn=People Locale,dc=example,dc=com
objectClass: top
objectClass: subentry
objectClass: collectiveAttributeSubentry
objectClass: extensibleObject
cn: People Locale
l;collective: Savoie
subtreeSpecification: {base "ou=people", minimum 1}
collectiveConflictBehavior: virtual-overrides-real
```

Excluding Collective Attributes From Specific Entries

In some instances, it might be necessary to avoid having collective attributes in specific user entries. You can add the `collectiveExclusions` operational attribute to such entries to achieve this behavior. To exclude specific collective attributes, list the attribute names as values of the `collectiveExclusions` attribute. To exclude all collective attributes, set the value of `collectiveExclusions` to `excludeAllCollectiveAttributes`.

The following example excludes the `preferredLanguage` attribute from being applied to the entry for `user.0`:

```
dn: uid=user.0,ou=People,dc=example,dc=com
objectclasses and other user attributes
collectiveExclusions: preferredLanguage
```

The following example excludes the `c-l` attribute from being applied to the entry for `user.1`:

```
dn: uid=user.1,ou=People,dc=example,dc=com
objectclasses and other user attributes
collectiveExclusions: c-l
```

The following example excludes both the `preferredLanguage` and `c-l` attributes from being applied to the entry for `user.2`:

```
dn: uid=user.2,ou=People,dc=example,dc=com
objectclasses and other user attributes
collectiveExclusions: preferredLanguage
collectiveExclusions: c-l
```

The following example excludes all collective attributes from being applied to the entry for `user.0`:

```
dn: uid=user.0,ou=People,dc=example,dc=com
objectclasses and other user attributes
collectiveExclusions: excludeAllCollectiveAttributes
```

Configuring Collective Attributes

Collective attributes are defined using LDAP subentries within the directory tree where they are applicable. The following examples use a simple tree with multiple user entries.

```
dn: dc=example,dc=com
    dn: ou=People,dc=example,dc=com
        dn: uid=user.0,ou=People,dc=example,dc=com
        dn: uid=user.1,ou=People,dc=example,dc=com
        dn: uid=user.2,ou=People,dc=example,dc=com
        ...
```

To add a common `preferredLanguage` attribute for all users, create and add a collective attribute subentry similar to the following:

```
dn: cn=People Preferred Language,dc=example,dc=com
objectClass: top
objectClass: subentry
objectClass: collectiveAttributeSubentry
objectClass: extensibleObject
cn: People Preferred Language
preferredLanguage;collective: fr
subtreeSpecification: {base "ou=people", minimum 1}
```

The `preferredLanguage` attribute-value pair is dynamically added to all user entries under `ou=people`, as shown in the following example:

```
dn: uid=user.0,ou=People,dc=example,dc=com
objectclasses and other user attributes
preferredLanguage: fr
```

```
dn: uid=user.1,ou=People,dc=example,dc=com
objectclasses and other user attributes
preferredLanguage: fr

...
```

The same procedure applies for *collective* attribute types. For example, the `c-l` collective attribute type specifies a locality name for a collection of entries. The following example adds a common `c-l` collective attribute:

```
dn: cn=People Locale,dc=example,dc=com
objectClass: top
objectClass: subentry
objectClass: collectiveAttributeSubentry
objectClass: extensibleObject
cn: People Locale
c-l: Paris
subtreeSpecification: {base "ou=people", minimum 1}
```

The `c-l: Paris` attribute is added to applicable entries, as shown in this example:

```
dn: uid=user.0,ou=People,dc=example,dc=com
objectclasses and other user attributes
c-l: Paris

dn: uid=user.1,ou=People,dc=example,dc=com
objectclasses and other user attributes
c-l: Paris

...
```

You can define multiple collective attributes in the subentry of any collective attribute in the following ways:

- by adding the *collective* attribute types to the subentry
- by adding regular attribute types with the collective option
- by adding a combination of the two

Collective attribute subentries allow for flexible and complex definitions. For information about collective attribute scoping and the `subtreeSpecification` syntax, see RFC 3671 and RFC 3672.

▼ To Create a New Collective Attribute

1 Create an LDIF file with the `changetype: add` element that specifies the collective attribute subentry.

Make sure that there are no trailing spaces after `add`. If a space exists after add, the server base-64 encodes the value to represent the space, which can cause problems.

This example uses an input LDIF file named `add_collective_attr.ldif`.

```
dn: cn=People Preferred Language,dc=example,dc=com
changetype: add
objectClass: top
objectClass: subentry
objectClass: collectiveAttributeSubentry
objectClass: extensibleObject
cn: People Preferred Language
preferredLanguage;collective: fr
subtreeSpecification: {base "ou=people", minimum 1}
```

2 **Use the `ldapmodify` command to add the collective attribute, as shown in the following example.**

```
$ ldapmodify -p 1389 -h localhost -D "cn=Directory Manager" -w password \
-f /usr/local/add_collective_attr.ldif
Processing ADD request for cn=People Preferred Language,dc=example,dc=com
ADD operation successful for DN cn=People Preferred Language,dc=example,dc=com
```

▼ To Delete a Collective Attribute

You can delete a collective attribute by using either the `ldapdelete` command or the `ldapmodify` command. This example uses the `ldapmodify` command.

- **Use the `ldapmodify` command with the `changetype: delete` element, as shown in the following example.**

```
$ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password
dn: cn=People Preferred Language,dc=example,dc=com
changetype: delete
deleting entry cn=People Preferred Language,dc=example,dc=com
```

▼ To List the Collective Attributes That Apply to an Entry

To list the collective attribute subentries that apply to a specific user entry, request the `collectiveAttributeSubentries` operational attribute for that entry.

- **Use the `ldapsearch` command to list the collective attribute subentries that apply to the `user.0` entry:**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
-b "uid=user.0,ou=People,dc=example,dc=com" \
"objectclass=*" "collectiveAttributeSubentries"

version: 1
dn: uid=user.0,ou=People,dc=example,dc=com
collectiveAttributeSubentries: cn=People Preferred Language,dc=example,dc=com
```

Inherited Collective Attributes

Inherited attributes enable a common set of attributes to be shared by nature of their inheritance. Inherited collective attributes provide flexible scoping mechanisms using the standard subentry subtree specification, and support any attribute type for RDN definition and construction.

The main difference between collective attributes and inherited collective attributes is the source of attribute values:

- A collective attribute always derives its value from its definition entry.
- An inherited collective attribute can inherit, either directly or indirectly, the collective attribute values from other entities.

The inherited collective attributes functionality is built upon and extends collective attributes. Inherited attributes are defined as a specific type of collective attributes subentry `inheritedCollectiveAttributeSubentry`. This type is further divided into the following two distinct subtypes :

- `inheritedFromDNCollectiveAttributeSubentry`
- `inheritedFromRDNCollectiveAttributeSubentry`

Each subtype has its own set of configuration attributes. The subtypes cannot be mixed in a single definition, so an inherited attribute definition can only be of one subtype.

Specifying Inherited Collective Attributes

Like regular collective attributes, inherited collective attributes are defined using LDAP subentries within the directory tree where they are applicable.

The following examples use a simple tree with multiple user entries.

```
dn: dc=example,dc=com
     dn: ou=People,dc=example,dc=com
         dn: uid=hpollock,ou=People,dc=example,dc=com
         dn: uid=cventer,ou=People,dc=example,dc=com
         dn: uid=sdonnelly,ou=People,dc=example,dc=com
         ...
```

To add an inherited `postalAddress` attribute for all users, create and add an inherited collective attribute subentry similar to the following:

```
dn: cn=indirectCOS,dc=example,dc=com
objectClass: top
objectClass: subentry
objectClass: inheritedCollectiveAttributeSubentry
objectClass: inheritedFromDNCollectiveAttributeSubentry
cn: indirectCOS
subtreeSpecification: {base "ou=people"}
inheritFromDNAttribute: manager
inheritAttribute: postalAddress
```

This subentry specifies that the user entry inherits its postalAddress value from the entry referenced by the manager attribute in the user's entry.

The manager's entry contains the real value for the postalAddress attribute:

```
dn: uid=dsmith,ou=People,dc=example,dc=com
... objectclasses and other user attributes
postalAddress: 650 Granger Parkway, Redwood Shores, CA 94065
```

Each user entry references the manager entry, and inherits its postalAddress from that entry:

```
dn: uid=hpollock,ou=People,dc=example,dc=com
... objectclasses and other user attributes
manager: uid=dsmith,ou=People,dc=example,dc=com
postalAddress: 650 Granger Parkway, Redwood Shores, CA 94065

dn: uid=cventer,ou=People,dc=example,dc=com
... objectclasses and other user attributes
manager: uid=dsmith,ou=People,dc=example,dc=com
postalAddress: 650 Granger Parkway, Redwood Shores, CA 94065

dn: uid=sdonnelly,ou=People,dc=example,dc=com
... objectclasses and other user attributes
manager: uid=dsmith,ou=People,dc=example,dc=com
postalAddress: 650 Granger Parkway, Redwood Shores, CA 94065
```

Configuring Referrals

A *referral* is a pointer that is used to redirect a client's request to another server. Typically, referrals indicate to the client application that the requested entry or branch of the directory tree is not present on the server but is located on another remote server or at another branch of the directory tree. The client must then perform the operation again on the remote server named in the referral.

Referrals can be used in the following cases:

- When a client application requests an entry that does not exist on the local server, and the server has been configured to return the default referral.
- When an entire suffix has been disabled for maintenance, backup, or security reasons. The server will return the referrals defined by that suffix.
- When an object should be identified by different names. Referrals are useful to accommodate namespace changes.
- When "search paths" are needed for collecting results from multiple servers.

Configuring LDAP URLs

In all cases, a referral is an LDAP URL that contains the host name, port number, and optionally a DN on the local host or on another server.

Note – Unless an LDAP client provides authentication, any search request initiated by means of an LDAP URL is anonymous (unauthenticated).

The format of an LDAP URL is described in RFC 4516 and is summarized as follows:

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

An LDAP URL includes the following components:

`ldap[s]` Indicates whether to connect to the server (`ldap:`), or connect to the server over SSL (`ldaps:`).

hostname Specifies the host name or IP address of the LDAP server.

port Specifies the port number of the LDAP server. If no port is specified, the default LDAP port (389) or LDAPS port (636) is used.

base_dn Specifies the 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.

attributes Returns the specified attributes. Use commas to separate more than one attribute. If no attributes are specified, the search returns all attributes.

scope Specifies the scope of the search:

- **base.** Search only the base entry specified by *base_dn*.
- **one.** Search one level below the base entry specified by base_dn
- **sub.** Search the base entry and all entries below the specified base_dn

If no scope is specified, the server performs a base search.

filter Specifies the search filter to apply to entries within the specified scope of the search. If no filter is specified, the server uses the default (`objectclass=*`).

Note – Any spaces must be escaped using a character appropriate to your shell.

Example LDAP URLs

- The following LDAP URL specifies a search for all entries that have the surname `Jensen` at any level under `dc=example,dc=com`. No port is specified, so the default (`389`) is used. No attributes are specified, so all attributes will be returned.

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

- The following LDAP URL specifies a search for the `cn` and `telephoneNumber` attributes at any level under `dc=example,dc=com`. The server contacts the remote server at port `2389`. Because no search filter is specified, the server uses the default filter `(objectclass=*)`.

```
ldap://example.com:2389/dc=example,dc=com?cn,telephoneNumber?sub
```

▼ To Create a Referral

You can create a referral by adding a new entry that contains a `referral` object class and a `ref` attribute. The `ref` attribute must contain an LDAP URL.

This example creates a referral on server B for a user entry that exists on server A.

1 Locate the user entry on server A by running the following search command:

```
$ ldapsearch -h serverA -p 1389 -b dc=example,dc=com "uid=user.199" cn
dn: uid=user.199,ou=People,dc=example,dc=com
cn: Alfred Altay
```

2 Add a referral entry to the directory on server B.

```
$ ldapmodify -h serverB -p 2389 -D "cn=directory manager" -w password
dn: uid=aaltay,ou=People,dc=example,dc=com
changetype: add
objectclass: top
objectclass: extensibleObject
objectclass: referral
uid: aaltay
ref: ldap://serverA:1389/dc=example,dc=com??sub?(uid=user.199)

Processing ADD request for uid=aaltay,ou=People,dc=example,dc=com
ADD operation successful for DN uid=aaltay,ou=People,dc=example,dc=com
```

3 As a user with sufficient access rights, search for the user entry on server B.

```
$ ldapsearch -h serverB -p 2389 -D "cn=directory manager" -w password \
  -b dc=example,dc=com "uid=aaltay"
SearchReference(referralURLs={ldap://localhost:1389/dc=example,dc=com??sub?})
```

▼ To Modify a Referral

You can view or modify a referral by using `ldapsearch` or `ldapmodify` with the `manageDsaIT` control. This control informs the server that you intend to manage the referral object as a regular entry and prevents the server from sending a referral result for requests that read or update referral objects.

1 Use the `ldapsearch` command to view the referral.

```
$ ldapsearch -h serverB -p 2389 -D "cn=Directory Manager" -w password \
  -b dc=example,dc=com --control managedsait "(uid=aaltay)" ref
dn: uid=aamar,ou=People,dc=example,dc=com
ref: ldap://serverA:1389/dc=example,dc=com??sub?(uid=user.199)
```

2 **Use the `ldapmodify` command to modify the referral.**

This example changes the server to which the referral points and the base DN under which the entry is located.

```
$ ldapmodify -h serverB -p 2389 -D "cn=Directory Manager" -w password \
  --control managedsait
dn: uid=aaltay,ou=People,dc=example,dc=com
changetype: modify
replace: ref
ref: ldap://serverC:1389/ou=People,dc=example,dc=com??sub?(uid=user.199)
Processing MODIFY request for uid=aaltay,ou=People,dc=example,dc=com
MODIFY operation successful for DN uid=aaltay,ou=People,dc=example,dc=com
```

▼ To Delete a Referral

You can delete a referral by using `ldapdelete` with the `manageDsaIT` control. This control informs the server that you intend to manage the referral object as a regular entry and prevents the server from sending a referral result for requests that read or update referral objects.

1 **Use the `ldapsearch` command to view the referral.**

```
$ ldapsearch -h serverB -p 2389 -D "cn=Directory Manager" -w password \
  -b dc=example,dc=com --control managedsait "(uid=aaltay)" ref
dn: uid=aamar,ou=People,dc=example,dc=com
ref: ldap://serverA:1389/dc=example,dc=com??sub?(uid=user.199)
```

2 **Use the `ldapdelete` command to delete the referral.**

```
$ ldapdelete -h serverB -p 2389 -D "cn=Directory Manager" -w password \
  --control managedsait "uid=aaltay,ou=People,dc=example,dc=com"
Processing DELETE request for uid=aaltay,ou=People,dc=example,dc=com
DELETE operation successful for DN uid=aaltay,ou=People,dc=example,dc=com
```

Managing Data With Oracle Directory Services Manager

The Data Browser tab of each server instance in ODSM enables you to perform a basic search on the directory data, and to add, delete, and modify entries. The following sections describe how to manage data with ODSM.

Display Entries

To display directory entries by using the ODSM data browser, complete the following steps:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Data Browser** tab.
3. Select the appropriate network group from the **Network Group** list.

4. Expand the entries in the **Entry** pane to display all of the entries in the required subtree.

   A maximum of 200 entries is displayed at a time.

5. To restrict the entries to a specific entry set, select the subtree (for example, `ou=People`) and click the **Filter** icon.

   In the **Filter** field, type the required filter (for example, `surname=a*`) and click **OK**.

6. Select the entry that you want to view in the left hand pane.

   The entry details are displayed in the tabs on the right.

See also "View the Attributes of an Entry" on page 304.

View the Attributes of an Entry

To view the attributes of an entry:

1. Display the entry as described in "Display Entries" on page 303.
2. Select the entry that you want to view in the left hand pane.

   The entry details are displayed in the tabs on the right.

   Every entry has a corresponding Properties tab, that displays all the possible attributes of the entry (mandatory and optional). In addition, the following types of entries have a customized tab that displays the mandatory attributes of the entry in a layout that is logical for the entry type:

   - `inetorgperson` entries have a corresponding User Page tab.
   - `group` entries have a corresponding Group Page tab.
   - `country` entries have a corresponding Country Page tab.
   - `domain` entries have a corresponding Domain Page tab.
   - `organization` entries have a corresponding Organization Page tab.
   - `organization unit` entries have a corresponding Organization Unit Page tab.

Search for Entries

The basic search function on the Data Browser tab enables you to search for user or group entries. To perform a basic search on the directory data, complete the following steps:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Data Browser** tab.
3. Select the appropriate network group from the **Network Group** list.
4. Select the **Search** tab on the left hand pane.

5. From the **For** list, select whether you are searching for a user entry or a group entry.
6. Enter any part of the entry name and click the right arrow button. For example, to search for user John Smith, you might enter `Smith`, or `Smi`, or `John`, and so forth.
7. When the entry is displayed in the left pane, double-click on the entry to display its details in the right pane.

Add an Entry

To add or delete entries with Oracle Directory Services Manager, you must have write access to the parent entry and you must know the DN to use for the new entry. To add an entry by using the ODSM data browser, complete the following steps:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Data Browser** tab.
3. Select the appropriate network group from the **Network Group** list.
4. Click the **Add Entry** icon and select the kind of entry that you want to add, for example User Entry.
5. Enter the DN of the parent entry. This is the entry beneath which the new entry will appear in the directory tree, for example, `ou=people,dc=example,dc=com`.

   To select an existing entry as the parent entry, click **Select**.

   In the **Entry Picker** window, select **Tree View** to navigate the directory tree and locate the entry, or **Search View** to search for the entry.
6. Enter any additional information for the new entry.
7. When the required details have been entered, click **Create**.

Add an Entry Based on an Existing Entry

To add an entry that is based on an existing entry by using the ODSM data browser, complete the following steps:

1. Display the existing entries as described in "Display Entries" on page 303.
2. Select the entry on which you want to base the new entry and click the **Create like entry** icon.

   The details of the existing entry are displayed in the right pane.
3. Provide a new **Common Name** and **User Name** for the entry.
4. Modify any other details of the entry.

5. Click **Create**.

Delete an Entry

To delete an entry by using the ODSM data browser, complete the following steps:

1. Display the existing entries as described in “Display Entries” on page 303.
2. Select the entry that you want to delete and click the **Delete** icon.
3. On the Delete Entry dialog, verify that you are deleting the correct entry and click **OK**.

Delete an Entry and its Subtree

To delete an entry and all entries beneath it in the directory tree, complete the following steps:

1. Display the existing entries as described in “Display Entries” on page 303.
2. Select the entry that you want to delete and click the **Delete Entry and its Subtree** icon.
3. On the Delete Subtree dialog, verify that you are deleting the correct entry and click **OK**.

Modify an Entry's RDN

To modify the RDN of an entry by using the ODSM data browser, complete the following steps:

1. Display the existing entries as described in “Display Entries” on page 303.
2. Select the entry whose RDN you want to modify on which you want to base the new entry and click the **Edit RDN** icon.
3. Provide a new RDN in the **New RDN value** field.
4. Select **Delete Old RDN** if you want the values that formed the old RDN to be deleted from the entry. If you do not select this checkbox, the values that formed the old RDN are retained as non-distinguished attribute values of the entry.
5. Optionally, click the **Refresh subtree entries** icon to verify the RDN change.

Import Data From an LDIF File

You can import entries from an LDIF file, as follows:

1. Connect to the directory server from ODSM, as described in “Connecting to the Server From Oracle Directory Services Manager” on page 188.
2. Select the **Data Browser** tab.

3. Select the appropriate network group from the **Network Group** list.
4. Click the **Import LDIF** icon.
5. On the **Import Entry(ies)** dialog, click **Choose File**.
6. Locate the LDIF file on your system and click **OK**.
7. On the **LDIF Import Progress** dialog, monitor the progress of the import and click **OK** when the export has completed.
8. The Data Browser tree refreshes to show the new entries.

Export Data to an LDIF File

You can export entries to an LDIF file, by using ODSM, as follows:

To export entries to an LDIF file, by using the ODSM data browser, complete the following steps:

1. Display the entries as described in "Display Entries" on page 303.
2. Navigate to the top level DN of the subtree you want to export and click the **Export LDIF** icon.
3. On the **Export Entry** dialog, select **Export Operational Attributes** if you want the operational attributes to be exported.
4. Click **OK**.
5. Click **Click here to open the LDIF file**.

   The complete LDIF file is displayed in a separate tab of the browser window in which ODSM is running.
6. Save the LDIF file to a writable location.
7. Click **OK** on the Export Entry dialog to exit the export.

◆ ◆ ◆ CHAPTER 8

Replicating Directory Data

Replication enables copies of identical data to be available across multiple servers. The directory server uses a multi-master replication model, which means that all the directory servers within a replication topology can accept read and write operations.

The multi-master replication model is *loosely consistent* by default. This means that changes made on one server are replayed asynchronously to the other servers in the topology. The same entries can be modified simultaneously on different servers. When updates are sent between the two servers, any conflicting changes must be resolved. Various attributes of a WAN, such as latency, can increase the chance of replication conflicts. Conflict resolution generally occurs automatically. A number of conflict rules determine which change takes precedence. In some cases conflicts must be resolved manually.

Note – In certain deployment scenarios, the default loose consistency model might not be adequate. In these situations, you can configure replication to function in *assured* mode. For more information, see "Configuring Assured Replication" on page 323.

Replication always occurs over a secure connection. Both parties of a replication session must authenticate to the other using SSL certificates. No access control or privileges are enforced. The following sections describe how to configure replication in the directory server.

For information about the mechanics of the replication process see Chapter 5, "Directory Server Replication," in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

This chapter covers the following topics:

- "Configuring Schema Replication" on page 343
- "Replicating to a Read-Only Server" on page 345
- "Detecting and Resolving Replication Inconsistencies" on page 345
- "Purging Historical Replication Data" on page 349
- "Using Isolated Replicas" on page 350
- "Replicating Between Oracle Directory Server Enterprise Edition and Oracle Unified Directory" on page 354

Configuring Data Replication With `dsreplication`

You can set up replication automatically using the graphical setup utility when you first install Oracle Unified Directory, if you configure all of the directory servers in the same manner. You cannot use the `setup` command to configure replication in command-line mode. If you set up your directory servers by using the `setup` command, you must use the `dsreplication` command to configure replication between the servers.

`dsreplication` accesses the server configuration over SSL through the administration connector. For more information, see "Managing Administration Traffic to the Server" on page 62

In any topology, you should have two replication servers for availability, in case one replication server fails. Replication servers are responsible for keeping track of all changes in the environment. Each replication server contains a list of all other replication servers in the topology.

The examples in this section assume that you have already installed two directory servers and populated one with data. The directory servers can be installed on the same host machine, but if they are, they must have different port numbers.

▼ To Enable Replication Between Two Servers

Note – You cannot run more than one instance of the `dsreplication enable` command to set up replication between multiple servers in parallel. Rather, run the `dsreplication enable` command successively for each pair of replicated servers in the topology.

● **To enable replication, use the `dsreplication enable` command.**

The following command enables replication of the data under "`dc=example,dc=com`" between two directory servers, `host1` and `host2`. Both servers use the default administration port (`4444`). The command creates a replication server instance on `host1`, port `8989`, and a second replication server instance on `host2`, port `8989`.

```
$ dsreplication enable \
  --host1 host1 --port1 4444 --bindDN1 "cn=Directory Manager" \
  --bindPassword1 password --replicationPort1 8989 \
  --host2 host2 --port2 4444 --bindDN2 "cn=Directory Manager" \
  --bindPassword2 password --replicationPort2 8989 \
  --adminUID admin --adminPassword password --baseDN "dc=example,dc=com" -X -n
```

The `--adminUID` and `--adminPassword` options refer to the Global Administrator for the replication domain. For more information, see "Managing Global Administrators" on page 387. The `-X` option specifies that all server certificates should be trusted and the `-n` (`--no-prompt`) option specifies that the command should be run in non-interactive mode. For information about all the global options for the `dsreplication` command, type `dsreplication –help` at the command-line.

More Information

Controlling Where Replication Servers are Created

Using `dsreplication enable` between two servers automatically configures a replication server on each host. You might want to configure replication between two directory servers without creating a replication server on each host. Use the `--noReplicationServer1` or `--noReplicationServer2` options to add a directory server to a topology without creating an additional replication server. Remember that a replicated topology must contain at least two replication servers to avoid a single point of failure.

You can also enable replication between two servers and specify that one of the servers should only contain a replication server (not a directory server). Use the `--onlyReplicationServer1` or `--onlyReplicationServer2` options to achieve this. Specifying this option will configure a change log and replication port on the server the server will not contain replicated data.

▼ To Initialize a Replicated Server

- **To initialize a replicated server with the data from another replicated server, use the `dsreplication initialize` command.**

  The following command initializes the base DN "`dc=example,dc=com`" on host2 with the data contained on host1:

```
$ dsreplication initialize --baseDN "dc=example,dc=com" \
  --adminUID admin --adminPassword password \
  --hostSource host1 --portSource 4444 \
  --hostDestination host2 --portDestination 4444 -X -n
```

▼ To Initialize an Entire Topology

- **If there are more than two directory servers in the topology, use the `dsreplication intialize-all` command to initialize all replicas simultaneously.**

  This command takes the details of the source host as arguments, and initializes all other servers for which replication is enabled.

The following command initializes all servers on which replication is enabled, from the contents of the base DN "`dc=example,dc=com`" on host1:

```
$ dsreplication initialize-all --hostname host1 --port 4444 \
  --baseDN "dc=example,dc=com" --adminUID admin --adminPassword password
```

▼ To Test Replication

The easiest way to test that replication is working is to apply changes on one directory server and to check that those changes have been replicated on another directory server. To test the replication topology set up in the previous procedures, do the following:

1. **Use `ldapmodify` to change an entry on host1.**

2. **Use `ldapsearch` to verify that the change was propagated to host2.**

▼ To Obtain the Status of a Replicated Topology

You can use the connection details of any directory server in the topology to obtain the status of the entire topology.

- **Use the `dsreplication status` command to display a list of the directory servers in the topology, along with any missing changes between those servers.**

  The following command displays the status of the topology set up in the previous procedures:

```
$ dsreplication status --adminUID admin --adminPassword password -X \
 --hostname host1 --port 4444

dc=example,dc=com - Replication Enabled
=======================================
Server     :Entries:M.C.[1]:A.O.M.C.[2]:Port[3]:Encryption[4]:Trust[5]:U.C.[6]:Status[7]
-----------:-------:-------:-----------:-------:-------------:--------:-------:---------
host1:4444 :2003   :0      :N/A        :8989   :Disabled     :Trusted :N/A    :Normal
host2:4444 :2003   :0      :N/A        :8989   :Disabled     :Trusted :N/A    :Normal

[1] The number of changes that are still missing on this server (and that have been applied
    to at least one other server).
[2] Age of oldest missing change: the age (in seconds) of the oldest change that has not yet
    arrived on this server.
[3] The port used to communicate between the servers whose contents are being replicated.
[4] Whether the replication communication through the replication port is encrypted or not.
[5] Whether this directory server is trusted or not. Updates coming from an untrusted server
    are discarded and not propagated.
[6] The number of untrusted changes. These are changes generated on this server while it is
    untrusted.
    Those changes are not propagated to the rest of the topology but are effective on the
    untrusted server.
[7] The status of the replication domain on this directory server.
```

▼ To Merge Two Existing Replicated Topologies

You can merge two replicated topologies by enabling replication between one server of each topology.

Note the following limitations:

- All of the servers in both topologies must be up and running when you perform the merge.

  If a server its offline, `dsreplication` cannot update its configuration. If a server is offline when a merge is done, that server will not include the references to the replication servers in the other topology when it comes back online.
- The merge cannot be performed if there are conflicting domain IDs or replication server IDs between the two topologies.

  That is, a server in topology A cannot have the same replication server ID or domain ID as a server in topology B.

  If there are conflicting IDs, the ID of the first server (`--host1`) is used to resolve the conflict. You must then re-initialize any servers that are out of date, using a server from the same topology as `--host1` as the source.
- Both replication topologies must have the same global administrators defined.

1 To merge two replicated topologies, use the `dsreplication enable` command.

For example, if you have a replicated topology (topology A) that includes host1, host2 and host3 and a replicated topology (topology B) that includes host4, host5, and host6, the following command effectively merges the two topologies:

```
$ dsreplication enable \
  --host1 host1 --port1 4444 --bindDN1 "cn=Directory Manager" \
  --bindPassword1 password --replicationPort1 8989 \
  --host2 host4 --port2 4444 --bindDN2 "cn=Directory Manager" \
  --bindPassword2 password  --replicationPort2 8989 \
  --adminUID admin --adminPassword password --baseDN "dc=example,dc=com" -X -n
```

Note – This example assumes that both the hosts (host1 and host4) include a directory server and a replication server. If they do not, a directory server or replication server is automatically configured.

2 (Optional) To ensure high availability, you must perform the following steps on all servers that were offline or unavailable during a merge:

a. Initialize the contents of the suffix `cn=admin data` by using `dsreplication enable`

You can initialize the servers individually, using one of the servers that was available during the merge, or you can use `dsreplication initialize-all`.

b. Use the `dsconfig` command to update the list of replication servers.

▼ To Disable Replication For a Specific Replication Domain

1 **To disable replication on a specific domain, use the `dsreplication disable` command.**

The following command disables replication of the data under "`dc=example,dc=com`".

```
$ dsreplication disable --hostname host1 --port 4444 --adminUID admin \
  --adminPassword password --baseDN "dc=example,dc=com" -X -n
```

This command removes the replication configuration from the directory server for that domain. If the domain that is disabled is the only replicated domain on this directory server instance, the command also disables the replication server on that instance. If the replication server is disabled, other directory servers that were connected to that replication server are disconnected and automatically reconnect to another replication server in the topology.

2 **To disable the replication server itself (including the change log and the replication port) use the following command:**

```
$ dsreplication disable --hostname host1 --port 4444 -X -n \
  --adminUID admin --adminPassword password --baseDN "dc=example,dc=com" \
  --disableReplicationServer
```

When the replication server is disabled, other directory servers that were connected to that replication server are disconnected and automatically reconnect to another replication server in the topology.

More Information

Notes About Disabling the Replication Server

Disabling a replication server deletes the replication configuration but does *not* delete the replication server databases. You can therefore retrieve replication changes in the event that the replication server was disabled in error. If you have no requirement for re-enabling replication on this suffix, remove the replication server databases manually, for example: `$ rm changelogDB/*`.

If replication is disabled, and then re-enabled, any changes made on that server in the interim are not replicated. You must therefore either forbid changes on the server on which replication is disabled (for the period that replication is disabled) or resynchronize the rest of the topology from that server in the event that changes have occurred.

Configuring Large Replication Topologies

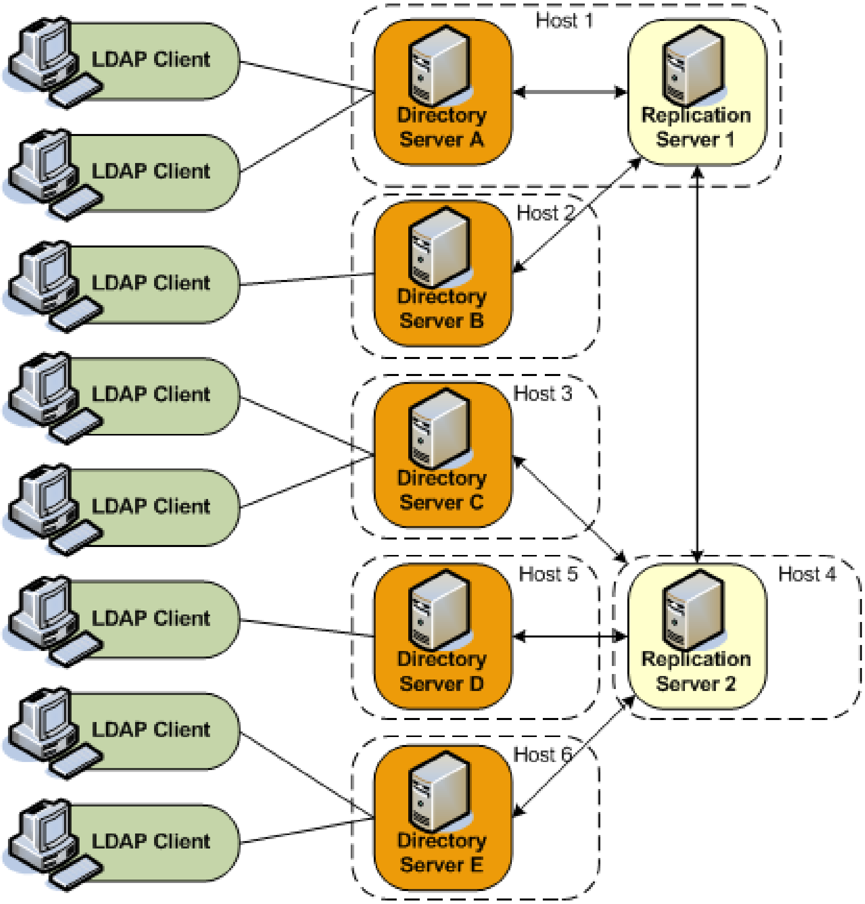
In particularly large topologies, it is often simpler to configure dedicated replication servers (servers that do not include a directory server) and dedicated directory servers (servers that do not included a replication server).

A dedicated directory server contains replicated data but does not contain a change log with the modifications made to that replicated data. A dedicated directory server also has no configured replication port. A dedicated replication server has a configured replication port. The server does not contain replicated data but does contain a change log with the modifications made to the replicated data on other servers in the topology.

Note – Each topology must have at least two replication servers to avoid a single point of failure.

For more information and sample topologies, see Chapter 6, "Example Deployments Using the Directory Server," in *Oracle Fusion Middleware Deployment Planning Guide for Oracle Unified Directory*.

The following diagram illustrates a large replication topology with one dedicated replication server (Replication Server 2), four dedicated directory servers, and one servers that contains both a replication and a directory server (Host 1).



▼ To Configure a Dedicated Replication Server

- **To configure a dedicated replication server, use the `--onlyReplicationServer1` or `--onlyReplicationServer2` option when you enable replication between two servers. \**

  The following example configures replication between Directory Server C and Replication Server 2 in the previous illustration.

```
$ dsreplication enable \
  --host1 host3 --port1 4444 --bindDN1 "cn=Directory Manager" \
  --bindPassword1 password --noReplicationServer1 \
  --host2 host4 --port2 4444 --bindDN2 "cn=Directory Manager" \
  --bindPassword2 password --onlyReplicationServer2 \
  --replicationPort2 8989 --adminUID admin --adminPassword password \
  --baseDN "dc=example,dc=com" -X -n
```

Modifying the Replication Configuration With `dsconfig`

This section describes how to change certain advanced properties of a replication configuration by using the `dsconfig` command. Advanced properties are usually optional, or have a default value that is acceptable in most cases. For general information about using `dsconfig`, see "Managing the Server Configuration With `dsconfig`" on page 25.

You cannot use `dsconfig` to set up replication between directory servers. Replication can be set up automatically using the GUI install utility, or manually, using the `dsreplication` command. For more information, see "Configuring Data Replication With `dsreplication`" on page 310.

This section covers the following topics:

- "Retrieving the Replication Domain Name" on page 317
- "Changing the Replication Purge Delay" on page 318
- "Changing the Window Size" on page 318
- "Changing the Initialization Window Size" on page 319
- "Changing the Heartbeat Interval" on page 320
- "Changing the Isolation Policy" on page 321
- "Configuring Encrypted Replication" on page 321
- "Configuring Replication Groups" on page 322
- "Configuring Assured Replication" on page 323
- "Configuring Fractional Replication" on page 328
- "Configuring Replication Status" on page 331
- "Configuring the Replication Server Weight" on page 332

Retrieving the Replication Domain Name

The *replication domain name* is generated by the directory server and includes the base DN and a numeric unique identifier.

To obtain a list of the configured replication domains, use the `list-replication-domains` subcommand. For example:

```
$ dsconfig -h host1 -p 4444 -D "cn=directory manager" -w password -n \
  list-replication-domains --provider-name "Multimaster Synchronization"

Replication Domain : Type    : server-id : replication-server     : base-dn
-------------------:---------:-----------:------------------------:--------------------
cn=admin data      : generic : 13981     : host1:8989, host2:8989 : cn=admin data
cn=schema          : generic : 20284     : host1:8989, host2:8989 : cn=schema
dc=example,dc=com  : generic : 26560     : host1:8989, host2:8989 : "dc=example,dc=com"
```

Changing the Replication Purge Delay

The replication changes database maintains a record of updates, which might or might not have been replicated. The replication purge delay is a property of the replication server, and specifies the period of time after which internal purge operations are performed on the replication changes database.

How Replication Changes Are Purged

Any change that is older than the purge delay is removed from the replication changes database, irrespective of whether that change has been applied. The default purge delay is one day. If the replication changes database is backed up less frequently than the purge delay, changes will be cleared before the changes database has been backed up. Changes can therefore be lost if you use the backup to restore data.

▼ To Change the Replication Purge Delay

1 **(Optional) Display the current value of the replication purge delay.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  get-replication-server-prop \
  --provider-name "Multimaster Synchronization" --advanced \
  --property replication-purge-delay

Property                : Value(s)
------------------------:---------
replication-purge-delay : 1 d
```

2 **Change the purge delay.**

The following command changes the purge delay to one week:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-replication-server-prop \
  --provider-name "Multimaster Synchronization" --set replication-purge-delay:1w
```

Changing the Window Size

The window size is a property of the replication server and specifies the number of change requests that are sent to directory servers, without the replication server having to wait for an acknowledgment from the directory server before continuing.

The window size represents the maximum number of update messages that can be sent without immediate acknowledgment from the directory server. It is more efficient to send many messages in quick succession instead of waiting for an acknowledgment after each one. Using the appropriate window size, you can eliminate the time replication servers spend waiting for acknowledgments to arrive. The default window size is 100. If you notice that some directory servers are lagging behind in terms of replicated changes, increase the window size to a higher value and check replication performance again before making further adjustments.

▼ To Change the Window Size

1 **(Optional) Display the current value of the window size:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X -n \
  get-replication-server-prop \
  --provider-name "Multimaster Synchronization" --advanced --property window-size

Property    : Value(s)
------------:---------
window-size : 100
```

2 **Change the window size.**

The following command changes the window size to 200.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X -n \
  set-replication-server-prop \
  --provider-name "Multimaster Synchronization" --set window-size:200
```

Changing the Initialization Window Size

During a data import in a replicated topology, it can occur that the importing server is too slow to keep up with the data that is sent by the exporting server. The importing server can therefore block not only the import, but can also stop any other replication changes from being propagated by the exporting server.

An initialization window size enables an exporting server to detect acknowledgements from the slowest importing server and to send data on the replication network *only* when the slow importer is available to receive them.

The initialization window size is set to `100` by default. If there are no slow servers in your topology, you can increase the initialization window size so that exporting servers send more updates before waiting for an acknowledgement. If your topology includes a particularly slow server, you can decrease the initialization window size to ensure that replication is not blocked by this server.

▼ To Change the Initialization Window Size

1 **(Optional) Display the current value of the initialization window size:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X -n \
  get-replication-domain-prop --provider-name "Multimaster Synchronization" \
  --domain-name dc=example,dc=com --advanced --property initialization-window-size
Property                   : Value(s)
---------------------------:---------
initialization-window-size : 100
```

2 **Change the initialization window size.**

The following command changes the initialization window size to 50.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-replication-domain-prop --provider-name "Multimaster Synchronization" \
  --domain-name dc=example,dc=com --set initialization-window-size:50
```

Changing the Heartbeat Interval

The heartbeat interval is a property of the replication domain and specifies the frequency with which the replication domain communicates with the replication server. The replication domain expects a regular heartbeat at this interval from the replication server. If the heartbeat is not received, the domain closes its connection and connects to another replication server in the topology.

The default heartbeat interval is ten seconds. If replication is running over a WAN or a network with slow response times, you might want to increase the heartbeat interval. In addition, if you observe an error similar to the following in the logs, it is probably necessary to increase the heartbeat interval.

```
[26/May/2011:16:32:50 +0200] category=SYNC severity=NOTICE msgID=15138913
 msg=Replication Heartbeat Monitor on RS rserver/192.157.197.62:8989 30382 for
 dc=example,dc=com in DS 10879 is closing the session because it could not
 detect a heartbeat
```

The heartbeat interval is sensitive to the settings of your JVM. If you require a lower heartbeat interval than the default, you must configure your JVM to have a low pause time during garbage collection by setting the `-XX:+UseConcMarkSweepGC` option. For more information, see Chapter 6, “Configuring the JVM, Java Options, and Database Cache,” in *Oracle Fusion Middleware Installation Guide for Oracle Unified Directory*.

▼ To Change the Heartbeat Interval

1 **(Optional) Display the current value of the heartbeat interval.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  get-replication-domain-prop \
  --provider-name "Multimaster Synchronization" \
  --domain-name "dc=example,dc=com (domain 15853)" --advanced \
  --property heartbeat-interval
Property           : Value(s)
-------------------:---------
heartbeat-interval : 10 s
```

2 **Change the heartbeat interval.**

The following command changes the heartbeat interval to 5 seconds.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-replication-domain-prop \
  --provider-name "Multimaster Synchronization" \
  --domain-name "dc=example,dc=com (domain 15853)" --set heartbeat-interval:5s
```

Changing the Isolation Policy

The isolation policy is a property of the replication domain and specifies the behavior of the directory server if replication is configured but none of the replication servers are up and running when an update is received. The default behavior of the directory server in this situation is to reject all updates.

▼ To Change the Isolation Policy

1 **(Optional) Display the current isolation policy.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password \
 get-replication-domain-prop \
  --provider-name "Multimaster Synchronization" \
  --domain-name "dc=example,dc=com (domain 15853)" \
  --advanced --property isolation-policy -n

Property         : Value(s)
-----------------:-------------------
isolation-policy : reject-all-updates
```

2 **Change the isolation policy.**

The following command specifies that the directory server should accept all updates in this situation.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password \
  set-replication-domain-prop \
  --provider-name "Multimaster Synchronization" \
  --domain-name "dc=example,dc=com (domain 15853)" \
  --set isolation-policy:accept-all-updates -n
```

Configuring Encrypted Replication

By default, replication traffic is not encrypted. You can enable encryption by configuring the crypto manager.

▼ To Configure Encrypted Replication

● **Set the properties of the crypto manager.**

The following command specifies that replication traffic should be encrypted.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-crypto-manager-prop \
  --set ssl-encryption:true
```

Configuring Replication Groups

Replication groups are designed to support multi-data center deployments and disaster recovery scenarios. For information about the design and implementation of replication groups in the directory server, see "Replication Groups" in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

Note – Changing the replication group configuration has an impact on assured replication. For more information, see "Assured Replication" in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

▼ To Configure a Replication Group

A replication group is configured on each directory server and replication server that should be part of the same group. On directory servers, a replication group is configured *per replicated domain*. On replication servers, the group is configured for the entire replication server.

Replication groups are configured by giving each replicated domain and replication server the same group ID. This example configures a replication group (1) for the replicated domain `dc=example,dc=com`.

1 On each directory server that will be part of this group, set the group ID for the domain `dc=example,dc=com`.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-replication-domain-prop \
  --provider-name "Multimaster Synchronization" \
  --domain-name "dc=example,dc=com (domain 10233)" --advanced \
  --set group-id:1
```

2 On each replication server that will be part of this group, set the group ID.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-replication-server-prop \
  --provider-name "Multimaster Synchronization" --advanced \
  --set group-id:1
```

Configuring Assured Replication

In most deployment scenarios, the loosely consistent multi-master replication model is sufficient. However, certain scenarios might require tighter consistency between replicas. In such cases, you can configure *assured replication*, which provides the following benefits:

- **High availability of data.** If a server crashes immediately after a modification is received on that server, there is a risk that the modification will be lost before it is replayed to other servers in the topology. With assured replication, any modification is replayed to another server in the topology *before* an acknowledgement is sent to the client application. The risk of losing data in the event of a server crash is therefore minimized.
- **Immediacy of data availability.** Some applications might require modifications to be available on additional servers in the topology immediately after a modification is made.

Assured replication is an extension of the replication protocol and is configured *per replicated domain*. For more information, see "Retrieving the Replication Domain Name" on page 317.

Assured replication is not the same as *synchronous replication*. That is, changes do not occur simultaneously on all servers in the topology. However, assured replication can mimic the functionality of synchronous replication to an extent, as far as LDAP clients are concerned. This is achieved by delaying acknowledgements to the client application until a modification has been propagated to additional servers in the topology.

Note – Assured replication relies on *replication groups*. All replication servers and directory servers that function together in an assured replication configuration must be part of the same replication group.

Assured replication can function in two modes:

- **Safe data mode.** Any update must be propagated to a defined number of replication servers before the client receives an acknowledgement that the update has been successful.

  The number of replication servers that must be reached defines the *safe data level*. The higher the safe data level, the higher the overall data availability.
- **Safe read mode.** Any update must be propagated to all the directory servers in the topology before the client receives an acknowledgement that the update has been successful.

In both safe data mode and safe read mode, you can configure a timeout interval to prevent LDAP client calls from hanging if certain servers in the topology are not available.

- On each *directory server*, you can configure a global timeout that comes into effect when the directory server sends an update to its replication server, either safe data mode or safe read mode. If this timeout is reached, the LDAP client call returns immediately and a message is written to the replication log to track the event.

- On each *replication server*, you can configure a global timeout that comes into effect when the replication server sends an update to a peer replication server or to another directory server, either in safe data mode or in safe read mode. If this timeout is reached, the acknowledgement message that is returned to the initiating server (either a directory server or a replication server) includes a message that indicates the timeout. The initial directory server then logs a message that the timeout occurred for that update.

Note – The default timeout of two seconds for a directory server and one second for a replication server should be satisfactory for most deployments. *Only* change the timeout if you are viewing timeouts in the logs and if you have a complete understanding of the impact of such a change. The value of the timeout should reflect the anticipated time that an update requires to go through its full path to reach its destination.

The timeout value on a directory server should always be higher than the value on the replication server. For example: `DS1(timeout 2s) -> RS1(timeout 1s) -> RS2(timeout 1s) -> DS2`.

For a detailed explanation of the assured replication mechanism and the various configurable options, see “Assured Replication” in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

▼ To Configure Assured Replication in Safe Data Mode

This procedure configures assured replication in safe data mode for a topology. The procedure assumes that replication has already been configured.

1 On each directory server in the topology:

a. Set the assured replication mode.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-replication-domain-prop \
  --provider-name "Multimaster Synchronization" \
  --domain-name "dc=example,dc=com (domain 10233)" --advanced \
  --set assured-type:safe-data
```

b. Set the safe data level.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-replication-domain-prop \
  --provider-name "Multimaster Synchronization" \
  --domain-name "dc=example,dc=com (domain 10233)" --advanced \
  --set assured-sd-level:2
```

If you have configured replication by using `setup` or `dsreplication`, your replication servers and directory servers will be on the same virtual machine. In this case, you must set the safe data level to 2 or higher.

c. **(Optional) Set the assured replication timeout.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-replication-domain-prop \
  --provider-name "Multimaster Synchronization" \
  --domain-name "dc=example,dc=com (domain 10233)" --advanced\
  --set assured-timeout:5s
```

Only change the timeout if you are viewing timeouts in the logs and if you have a complete understanding of the impact of such a change.

d. **Verify the directory server group ID.**

This should be the same for all replication servers and directory servers that form part of this replication group. For instructions on configuring the group ID, see "Configuring Replication Groups" on page 322.

e. **(Optional) Display the current assured replication configuration.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  get-replication-domain-prop \
  --provider-name "Multimaster Synchronization" \
  --domain-name "dc=example,dc=com (domain 10233)" --advanced \
  --property assured-type --property assured-sd-level --property assured-timeout

Property          : Value(s)
------------------:------------
assured-sd-level : 2
assured-timeout  : 5 s
assured-type     : safe-data
```

2 **(Optional) On each replication server in the topology:**

a. **Display the current assured replication configuration.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  get-replication-server-prop \
  --provider-name "Multimaster Synchronization" --advanced \
  --property assured-timeout --property group-id

Property                  : Value(s)
--------------------------:---------
assured-timeout           : 1 s
group-id                  : 1
```

b. **Set the assured replication timeout.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-replication-server-prop \
  --provider-name "Multimaster Synchronization" --advanced \
  --set assured-timeout:5s
```

Only change the timeout if you are viewing timeouts in the logs and if you have a complete understanding of the impact of such a change.

c. Verify the replication server group ID.

This should be the same for all replication servers and directory servers that form part of this replication group. For instructions on configuring the group ID, see "Configuring Replication Groups" on page 322.

To Configure Assured Replication in Safe Read Mode

Assured replication is configured *per replicated domain*. This procedure configures assured replication in safe read mode for a topology. The procedure assumes that replication has already been configured.

1 On each directory server in the topology:

a. Set the assured replication mode.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-replication-domain-prop \
  --provider-name "Multimaster Synchronization" \
  --domain-name "dc=example,dc=com (domain 10233)" --advanced \
  --set assured-type:safe-read
```

b. (Optional) Set the assured replication timeout.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-replication-domain-prop \
  --provider-name "Multimaster Synchronization" \
  --domain-name "dc=example,dc=com (domain 10233)" --advanced \
  --set assured-timeout:5s
```

Only change the timeout if you are viewing timeouts in the logs and if you have a complete understanding of the impact of such a change.

c. Verify the directory server group ID.

This should be the same for all replication servers and directory servers that form part of this replication group. For instructions on configuring the group ID, see "Configuring Replication Groups" on page 322. For more information about groups and assured replication, see "Assured Replication" in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

d. (Optional) Display the current assured replication configuration.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  get-replication-domain-prop \
  --provider-name "Multimaster Synchronization" \
  --domain-name "dc=example,dc=com (domain 10233)" --advanced \
  --property assured-type --property assured-timeout --property group-id

Property         : Value(s)
-----------------:------------
assured-timeout  : 5 s
assured-type     : safe-read
group-id         : 1
```

2 (Optional) On each replication server in the topology:

a. Display the current assured replication configuration.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  get-replication-server-prop \
  --provider-name "Multimaster Synchronization" --advanced \
  --property assured-timeout --property degraded-status-threshold \
  --property group-id

Property                  : Value(s)
--------------------------:---------
assured-timeout           : 1 s
degraded-status-threshold : 5000
group-id                  : 1
```

b. Set the assured replication timeout.

Only change the timeout if you are viewing timeouts in the logs and if you have a complete understanding of the impact of such a change.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-replication-server-prop \
  --provider-name "Multimaster Synchronization" --advanced \
  --set assured-timeout:5s
```

c. Set the degraded status threshold.

The degraded status threshold defines the stage at which the server is regarded as “too slow”, based on the number of updates queued in the replication server for that directory server. For more information, see “Degraded Status” in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

Do *not* adjust this value unless you observe timeouts in the logs.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-replication-server-prop \
  --provider-name "Multimaster Synchronization" --advanced \
  --set degraded-status-threshold:2000
```

d. Verify the replication server group ID.

This should be the same for all replication servers and directory servers that form part of this replication group. For instructions on configuring the group ID, see “Configuring Replication Groups” on page 322. For more information about groups and assured replication, see “Assured Replication” in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

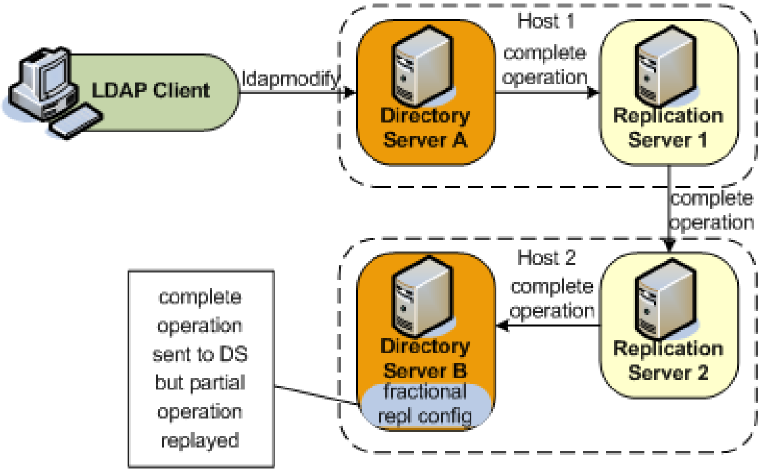
Configuring Fractional Replication

Fractional replication enables you to replicate specific parts of directory data to other replicas in the topology. This feature is particularly useful in the following scenarios:

- **Limited disk space.** Restricting the data that is replicated can significantly cut down on the amount of disk space that is required on certain replicas, particularly if you restrict the replication of attributes such as jpeg photos, which represent large data volumes.
- **Security concerns.** Certain data, such as user passwords, might be sensitive and not required on certain replicas, especially if there is a risk of inappropriate access on these replicas.

This section describes how to configure fractional replication on one or more servers in a topology. For information about the architecture of the fractional replication mechanism, see "Fractional Replication" in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

Fractional replication is configured on the directory server that receives the partial data, and is attribute-based. Consider the following scenario:



Fractional replication is configured on Directory Server B. An `ldapmodify` operation is sent to Directory Server A. The entire operation is forwarded to Replication Server 1, then to Replication Server 2, then to Directory Server B. When the operation is replayed on Directory Server B, certain attributes from the operation are filtered out, based on that server's fractional configuration.

Fractional replicas remain writable directly from client applications. However, if an add or modify operation that includes certain “forbidden attributes” is attempted on a fractional replica, the operation is denied and the server returns an “Unwilling to perform” error.

Fractional replication can be configured in one of two modes:

- **Exclusive mode.** In this mode, the multi-valued `fractional-exclude` attribute is used to filter out the specified attributes from an incoming LDAP add or modify operation.

  Excluded attributes must be *optional* attributes of an object class.
- **Inclusive mode.** In this mode, the multi-valued `fractional-include` attribute is used to filter in only the specified attributes from an incoming LDAP add or modify operation.

  All other attributes (except for those that are mandatory in the object class) are removed from the change that is replayed on the server.

The two modes are mutually exclusive, that is, you can include only one of these attributes in a domain configuration.

Fractional replication is configured *per replicated domain* (see “Retrieving the Replication Domain Name” on page 317). A *fractional domain* implies that certain attributes are entirely absent from the domain. These attributes are filtered out at operation replay time but are also absent from the existing data in the domain.

To ensure coherency of the data across a replicated topology, it is necessary to identify whether a particular data set is fractional. The configuration of a new fractional domain therefore implies specific steps to ensure that the domain is free of forbidden attributes, and recognizable as a fractional domain. For more information, see “To Configure and Initialize a Fractional Domain” on page 331.

Use the `dsconfig` command to configure fractional replication in a domain, as follows.

To Configure Exclusive Fractional Replication

The following example configures a replica to exclude the `photo` and `jpegPhoto` attributes from any creation or modification of an entry whose object class is `inetOrgPerson`.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X \
  set-replication-domain-prop --provider-name "Multimaster Synchronization" \
  --domain-name "dc=example,dc=com (domain 10233)" \
  --set fractional-exclude:inetOrgPerson:photo,jpegPhoto
```

Object classes and attributes can be specified by their names, or by their OIDs, so the following example has the same effect as the previous example:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X \
  set-replication-domain-prop --provider-name "Multimaster Synchronization" \
  --domain-name "dc=example,dc=com (domain 10233)" \
  --set fractional-exclude:2.16.840.1.113730.3.2.2:0.9.2342.19200300.100.1.7, \
  0.9.2342.19200300.100.1.60
```

If you use object class or attribute names *and* OIDs, both values are added. For example, the following command adds both the attribute name and its OID to the list of excluded attributes:

```
$ dsconfig set-replication-domain-prop ...
  --set fractional-exclude:*:jpegPhoto,*:0.9.2342.19200300.100.1.60
```

If you wanted to remove this attribute from the list, you would need to remove both the attribute name and the OID.

To specify that the `photo` and `jpegPhoto` attributes should be removed from any creation or modification of any entry (regardless of its object class), use an asterisk in place of the object class. For example:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X \
  set-replication-domain-prop --provider-name "Multimaster Synchronization" \
  --domain-name "dc=example,dc=com (domain 10233)" \
  --set fractional-exclude:*:photo,jpegPhoto
```

To Configure Inclusive Fractional Replication

The following example configures a replica to include only the `uid` and `employeeNumber` attributes from any creation or modification of an entry whose object class is `inetOrgPerson`. All other attributes are ignored in the modification, except those that are mandatory for the object class.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X \
  set-replication-domain-prop --provider-name "Multimaster Synchronization" \
  --domain-name "dc=example,dc=com (domain 10233)" \
  --set fractional-include:inetOrgPerson:uid,employeeNumber
```

Object classes and attributes can be specified by their names, or by their OIDs, so the following example has the same effect as the previous example:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X \
  set-replication-domain-prop --provider-name "Multimaster Synchronization" \
  --domain-name "dc=example,dc=com (domain 10233)" \
  --set fractional-include:2.16.840.1.113730.3.2.2:0.9.2342.19200300.100.1.1, \
  2.16.840.1.113730.3.1.3
```

If you use object class or attribute names *and* OIDs, both values are added. For example, the following command adds both the attribute name and its OID to the list of included attributes:

```
$ dsconfig set-replication-domain-prop ...
  --set fractional-include:*:jpegPhoto,*:0.9.2342.19200300.100.1.60
```

If you wanted to remove this attribute from the list, you would need to remove both the attribute name and the OID.

To specify that a particular attribute should be included in the creation or modification of any entry (regardless of its object class), use an asterisk in place of the object class. The following example includes only the description attribute in a creation or modification operation on any entry.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X \
  set-replication-domain-prop --provider-name "Multimaster Synchronization" \
  --domain-name "dc=example,dc=com (domain 10233)" \
  --set fractional-include:*:description
```

To Configure and Initialize a Fractional Domain

The following steps are required when you initialize a new fractional domain:

1. Configure exclusive or inclusive fractional replication, as described in the previous two sections.

   At this point, the domain obtains a *bad generation ID* status. For more information, see "Replication Status" in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

   This means that all modifications on the domain are blocked until the data is synchronized with the rest of the topology.

2. Import a new data set from one of the other servers in the topology.

   The new data set can be imported online, by using `dsreplication initialize` or by using `import-ldif` in online or offline mode. The server from which you import the data must either be an entire replica (that is, not a fractional replica) or must have the same fractional configuration as the server to which you are importing the data. During the import, all entries will be filtered with the fractional configuration set up in the previous step.

   For information about how to import a data set, see "Initializing a Single Replicated Server" on page 333 and "Importing and Exporting Data" on page 191.

3. After the data import, the domain returns to *normal* status.

   For more information, see "Replication Status" in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

   The domain is now able to accept new entries from local LDAP operations, or synchronization operations with other servers in the topology. The data in the domain is free of any "forbidden" attributes.

Configuring Replication Status

Each replicated domain in a replicated topology has a certain *replication status*, depending on its connections within the topology, and on how up to date it is with regard to the changes that have occurred throughout the topology. For more information, see "Replication Status" in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

Replication status is generated automatically, based on how up to date a server is within the replicated topology. The only parameter that can be configured is the degraded status threshold. This parameter defines the maximum number of changes that can be in the replication server's queue for all domains of the directory servers that are connected to this replication server. When this number is reached, for a specific directory server, that server is assigned a degraded status. The degraded status remains until the number of changes drops beyond this value.

Note – The default value of the degraded status threshold should be adequate for most deployments. Only modify this value if you observe several timeout messages in the logs when assured replication is configured.

▼ To Configure the Degraded Status Threshold

The default number of changes defined by this threshold is 5000. This example sets the threshold to 6000, to take into account a network with more latency.

- **On the replication server, use `dsconfig` to set the degraded status threshold.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-replication-server-prop \
  --provider-name "Multimaster Synchronization" --set degraded-status-threshold:6000
```

Configuring the Replication Server Weight

In large topologies with several directory servers and several replication servers, it is more efficient to spread the directory servers out across the replication servers in a predefined manner. You can specify how many directory servers should connect to each replication server in a topology according to the relative capacity of the machine on which the replication server is running. For more information, see “Replication Server Load Balancing” in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

To configure the replication server weight, run the `dsconfig` command as follows:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-replication-server-prop \
  --provider-name "Multimaster Synchronization" --set weight:2
```

By default, the weight of each replication server in the topology is 1.

Initializing a Replicated Server With Data

This section describes how to initialize a replicated server with data by using the "dsreplication" in *Oracle Fusion Middleware Command-Line Usage Guide for Oracle Unified Directory* command. dsreplication accesses the server configuration over SSL via the administration connector. For more information, see "Managing Administration Traffic to the Server" on page 62.

This section references some of the information covered in "Populating a Stand-Alone Directory Server With Data" on page 192. It is recommended that you read that section before this one.

Initializing a Single Replicated Server

The easiest way to initialize a single directory server in a replicated topology is to use the dsreplication command to copy the data over from another directory server in the topology. This command requires replication to have been enabled between the source server and the destination server. The command replaces all data under the specified base DN on the destination server with the data from the source server.

For example, the following command initializes the base DN "dc=example,dc=com" on host2 with the data on host1.

```
$ dsreplication initialize --baseDN "dc=example,dc=com" \
  --adminUID admin --adminPassword password \
  --hostSource host1 --portSource 4444 \
  --hostDestination host2 --portDestination 4444 --trustAll
```

Initializing a New Replicated Topology

To initialize all directory servers in a new replicated topology, use one of the following options:

- Initialize all directory servers individually with the same data, using one of the methods described in "Populating a Stand-Alone Directory Server With Data" on page 192. When you have initialized all directory servers with data, enable replication between the servers.
- Initialize a single directory server using one of the methods described in "Populating a Stand-Alone Directory Server With Data" on page 192. Enable replication for all directory servers, then use the dsreplication intialize-all command to initialize all the remaining servers simultaneously. This command takes the details of the source server as arguments, and initializes all other servers for which replication is enabled.

  For example, the following command initializes all directory servers from the contents on host1.

  ```
  $ dsreplication initialize-all --hostname localhost --port 4444 --trustAll \
    --baseDN "dc=example,dc=com" --adminUID admin --adminPassword password
  ```

Adding a Directory Server to an Existing Replicated Topology

When you add a directory server to an existing replicated topology, the new server must be populated with the same *generation* of data as the existing directory servers in the topology. The data generation is an ID stored within the root entry of the replication domain. When the data generation does not exist, it is computed by the replication mechanism and stored. To ensure that the new directory server has the same data generation as the other servers in the topology, use one of the following methods to populate the directory server with data:

- Use the same original LDIF file, backup file, or binary copy that was used to populate the other directory servers.
- Use the result of an export, backup, or binary copy from another directory server in the topology.

If you install the new directory server using the GUI install and specify that it will be part of the replicated topology, the server is initialized with the correct data generation automatically.

If you do not install the directory server using the GUI install, and you use the `dsreplication` command to enable replication, you must initialize the server manually using one of the methods described in the previous section.

Note – If a directory server in the topology does not contain the same data generation as the rest of the topology, data cannot be replicated to or from the server. However, the directory server remains connected to the topology, enabling it to be initialized using the replication protocol. Replication on this directory server is said to be *downgraded*.

When a directory server with the correct data generation is added to an existing topology, the replication mechanism automatically replays any changes that occurred since the first directory server in the topology was initialized with data. This action ensures that the new directory server is synchronized with the rest of the topology.

Changing the Data Set in an Existing Replicated Topology

Changing the data set implies importing an entirely new set of data to every directory server in the topology. When the data set is changed, two tasks are performed:

- The new data is applied to each directory server in the topology.
- The replication servers are cleared of any changes they might contain. This task includes resetting the data generation on the directory servers so that the new data generation is used.

If you change the data set using the dsreplication initialize command, both of these tasks are performed automatically. However, if you use the import-ldif command or the binary copy method to change the data set, you must perform these tasks manually, as described in the following section.

▼ To Change the Data Set With import-ldif or Binary Copy

1 **Clear the generation ID from the directory servers by running the dsreplication pre-external-initialization command.**

It is sufficient to run this command on only one directory server in the topology. All directory servers in the topology will be updated, unless you specify that only one server should be updated. For example, the following command prepares all servers in the topology for initialization by using import-ldif or binary copy:

```
$ dsreplication pre-external-initialization -h host1 -p 4444 -X \
  -b dc=example,dc=com -I admin -w password

Are you going to initialize only the contents of server host1:4444 (type
’no’ if you will initialize contents of all replicated servers for the given
Base DNs)? (yes / no) [no]:
Preparing base DN dc=example,dc=com to be initialized externally ..... Done.
Now you can proceed to the initialization of the contents of the base DNs on
all the replicated servers. You can use the command import-ldif or the binary
copy to do so. When the initialization is completed you must use the subcommand
{post-external-initialization} for replication to work with the new base DNs contents.
```

2 **Use import-ldif or binary copy to initialize all directory servers in the topology with data.**

3 **Reset the generation ID by running the dsreplication post-external-initialization command.**

It is sufficient to run this command on only one directory server in the topology. All other directory servers are updated. For example, the following command resets the generation ID for all directory servers in the topology after initialization using import-ldif or binary copy:

```
$ dsreplication post-external-initialization -h localhost \
  -p 4444 -b dc=example,dc=com -I admin -w password -X
Updating replication information on base DN dc=example,dc=com ..... Done.
Post initialization procedure completed successfully.
```

Appending Data in an Existing Replicated Topology

The easiest way to import a large number of entries to an existing replicated topology that already contains a large number of entries is to use the import-ldif command with the -a or --append option.

When you import data by using the import-ldif command, the imported data is not replicated automatically. You must therefore run import-ldif --append on every directory server in the topology. This strategy enables you to import the data with no downtime in the directory service.

You can also use the `dsreplication initialize-all` command after you have imported the data to a single directory server in the topology. However, this strategy will result in the directory service being unavailable for a certain period of time.

Using the External Change Log

The External Change Log (ECL) publicizes all changes that have occurred in a directory server database and is particularly useful for synchronizing the LDAP directory with other subsystems. The ECL logs the changes made in replicated suffixes only — changes made in non-replicated suffixes are not logged.

This topic describes how to enable the ECL in your directory service and how to configure client applications so that they can access the ECL.

For information about the architecture of the ECL, see "External Change Log" in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*. For a description of the ECL internals that will enable you to port applications relying on other change logs, see "Porting Applications That Rely on Other Change Logs" in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

This section covers the following topics:

- "Enabling the External Change Log in Oracle Unified Directory" on page 336
- "External Change Log APIs" on page 337
- "How a Client Application Uses the External Change Log in Cookie Mode" on page 337
- "Format of External Change Log Entries" on page 339
- "Initializing Client Applications to Use the External Change Log" on page 340
- "Controlling Access to the External Change Log" on page 342
- "Purging the External Change Log" on page 343
- "To Disable the External Change Log for a Domain" on page 343

Enabling the External Change Log in Oracle Unified Directory

The ECL is available by default when replication is configured in one of the following ways:

- By configuring a directory server as part of a replicated topology during installation. For more information, see "Setting Up Replication During Installation" in *Oracle Fusion Middleware Installation Guide for Oracle Unified Directory*.

  By using this method, you can conceivably set up replication on a standalone server, which will enable you to have access to an ECL on a standalone server.
- By configuring replication after installation, by using the `dsreplication` command. For more information, see "Configuring Data Replication With `dsreplication`" on page 310.

Note – The ECL is *not* available if you configured replication with the `--onlyReplicationServer` or `--noReplicationServer` options.

To verify that the ECL is configured on a directory server instance, run the following search command:

```
$ ldapsearch -h localhost -p 1389 -D "cn=directory manager" -w password \
  -s base -b "" "objectclass=*" namingContexts
dn:
namingContexts: cn=changelog
namingContexts: dc=Europe,dc=com
namingContexts: dc=us,dc=com
```

External Change Log APIs

The ECL can function supports two APIs, which enable two distinct *modes* of operation:

- **Cookie mode.** This is the recommended API that you should use to access the ECL.

  In cookie mode, the client application provides an ECL exchange control in its request to the server. In this mode, the DIT and schema provided in the entries that are returned by the server are not compatible with the LDAP change log draft (`http://tools.ietf.org/html/draft-good-ldap-changelog-04`).
- **Draft-compatible mode.** This mode should be used only by existing applications that rely on the LDAP change log draft.

  In this mode, the DIT and schema provided in the entries that are returned by the server are compatible with the LDAP change log draft.

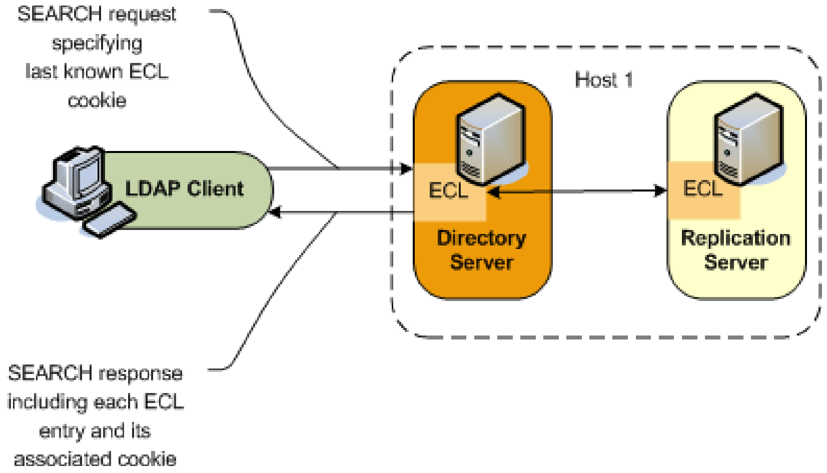
  For improved performance and for simplicity, you should port client applications to use the cookie mode. For more information, see “Porting Applications That Rely on Other Change Logs” in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

How a Client Application Uses the External Change Log in Cookie Mode

Each entry in the ECL has an associated cookie. When a client application sends a SEARCH request, the application provides either the cookie of the last message that was read from the ECL (in a previous SEARCH), or an empty value. The server returns the ECL entries associated with that cookie.

Each entry is returned with its associated cookie. When the application disconnects, it stores the last cookie that it received, and provides this cookie to the server with its next SEARCH request.

This transmission of ECL cookies is illustrated in the following diagram.


SEARCH request specifying last known ECL cookie
Host 1
LDAP Client
ECL
Directory Server
ECL
Replication Server
SEARCH response including each ECL entry and its associated cookie

The content of the cookie is *not* a public interface for the client application. The client application sends the cookie as a request control and the server sends the cookie as a response control.

The cookie exchange control has an OID of `1.3.6.1.4.1.26027.1.5.4`. If the server identifies that the cookie provided by the application is corrupted, the request is rejected. The request is also rejected if the server identifies that the configuration of the ECL has changed since the server sent this cookie to the application, or that the ECL has been purged and the oldest change stored is newer than the cookie value. In this case, additional information is returned, indicating that a full resynchronization of the external application is recommended.

Note – If a server is disconnected from the replication topology and processes changes from clients connected to it, convergence cannot be guaranteed.

The following request and response examples indicate how the client application searches using the external change log and how the ECL responds.

Request One To start reading the ECL, the client sends the first SEARCH request on `cn=changelog`, specifying an empty value in the cookie exchange control.

```
$ ldapsearch -h localhost -p 1389 -D "cn=directory manager" -w password \
  --control "1.3.6.1.4.1.26027.1.5.4:false:;" -b "cn=changelog" "(objectclass=*)" "*" +
```

Response One The server sends each change to the client in a `SearchResultEntry`. The cookie attribute specifies the new cookie value. This value is also sent in a cookie exchange control, along with the entry.

```
# Public changelog exchange control(1.3.6.1.4.1.26027.1.5.4):
  dc=europe,dc=com:0000012187eae081456200000001;o=example:;
dn: replicationcsn=0000012187eae081456200000001,dc=europe,dc=com,cn=changelog
objectClass: top
objectClass: changeLogEntry
replicationCSN: 0000012187eae081456200000001
replicaIdentifier: 17762
targetDN: cn=chek-piao chea,ou=unit1,o=people,dc=europe,dc=com
changeTime: 20090528155105Z
changes:: cmVwbGFjZTogc2VlQWxzbwpzZWVBbHNvOiBjbj1tY29uZmlnCi0KcmVwbGFjZTogbW9kaW
  ZpZXJzTmFtZQptb2RpZmllcnNOYW1lOiBjbj1EaXJlY3RvcnkgTWFuYWdlcixjbj1Sb290IEROcyxjb
  j1jb25maWcKLQpyZXBsYWNlOiBtb2RpZnlUaW1lc3RhbXAKbW9kaWZ5VGltZXN0YW1wOiAyMDA5MDUy
  ODE1NTEwNVoKLQo=
changeType: modify
changeLogCookie: dc=europe,dc=com:0000012187eae081456200000001;
targetEntryUUID: 08d1830c-02f1-34a6-9cf4-8d1270ec1db0
changeNumber: 0
```

Request Two To read the ECL from the last returned entry, the client sends the SEARCH request on `cn=changelog`, specifying the last cookie value that it received in the cookie exchange control.

```
$ ldapsearch -h localhost -p 1389 -D "cn=directory manager" -w password
  --control "1.3.6.1.4.1.26027.1.5.4:false:dc=europe,dc=com:0000012187eae081456200000001;"
  -b "cn=changelog" "(objectclass=*)"
```

Format of External Change Log Entries

The DN for entries that are returned in the ECL is of the form:

`replicationcsn=`*replicationCSN*`,`*replication-domain-DN*`,cn=changelog`

For example:

```
dn: replicationcsn=0000012187eae081456200000001,dc=europe,dc=com,cn=changelog
```

The following attributes are returned for ECL entries:

```
targetDN / MUST
changeType / MUST
changeTime / MUST
changeNumber / MUST // used only for compatibility mode

changes / MAY, MUST for add, mod
newRDN / MAY, MUST for modrdn
deleteOldRDN / MAY, MUST for modrdn
newSuperior / MAY, MUST for modrdn

replicaIdentifier / MAY, OPERATIONAL / specific OUD value
replicationCSN / MAY, OPERATIONAL / specific OUD value
targetEntryuuid / MAY, OPERATIONAL / specific OUD value
changelogcookie / MAY, OPERATIONAL
```

▼ To Specify the Attributes to be Included in the External Change Log

By default, attributes are included in the ECL only if they are affected by a change operation. So, for example, if the sn attribute of an entry is modified, only that attribute will appear in the ECL. You can, however, specify a list of attributes that will be included in the ECL regardless of whether they are affected by a change operation.

Use the following procedure to specify the list of attributes that must be included in the ECL.

- **Use the `dsconfig` command to set the value of the `ecl-include` property.**

  For example, to specify that the cn, and sn attributes always be included in the ECL if an entry is modified, run the following command:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -Q -n -X \
  --provider-name "Multimaster Synchronization" --domain-name dc=example,dc=com \
  --add ecl-include:cn --add ecl-include:sn
```

Note – In the ECL entry that is returned by the server, the attribute name is prefixed with target. For example, in the previous example, the ECL entries for changes on dc=example,dc=com will always contain the attributes targetcn and targetsn. The values of these attributes will be the values of the cn and sn attributes of the entry before it was modified or moved.

Initializing Client Applications to Use the External Change Log

No specific server configuration is required for clients to use the ECL. However, any client application that needs to use the ECL must be initialized as described in the following sections.

▼ To Initialize a Client Application to Use the External Change Log

1 **Read the last ECL cookie value from the LDAP server.**

This is the value of the lastExternalChangelogCookie attribute of the root DSE. For example:

```
$ ldapsearch -h localhost -p 1389 -D "cn=directory manager" -w password \
  -s base -b "" "objectclass=*" lastExternalChangelogCookie
  dn:
  objectClass: top
  objectClass: ds-root-dse
  lastExternalChangelogCookie: dc=europe:00000121cea5221c04b100000005 \
    00000121cea5319e04b400000009;
```

2 **Export the Oracle Unified Directory database.**

3 **Initialize the application from the exported database.**

The application can now start reading the ECL by providing the last cookie value as the value of the search control. For example:

```
$ ldapsearch -h localhost -p 1389 -D "cn=directory manager" -w password
  --control "1.3.6.1.4.1.26027.1.5.4:false:dc=europe:00000121cea5221c04b100000005 \
    00000121cea5319e04b400000009" -b "cn=changelog" "(objectclass=*)"
```

Reinitializing a Client Application When a Domain is Added

When a new replication domain is added to a topology, the ECL is enabled on that domain by default. Client applications that use the ECL must be reinitialized for the new domain.

The server enforces this requirement by rejecting SEARCH operations if the cookie that is provided does not refer to the new domain. The operation result code is `UNWILLING TO PERFORM`. The server provides a detailed message that includes a list of the domains that are missing and a cookie value for a possible partial initialization.

The client application must be reinitialized using one of the following methods:

- **Full reinitialization.** The application is reinitialized for all domains.
  1. Read the value of the `lastExternalChangelogCookie` attribute. This value refers to all domains in the topology, including the new domain.
  2. Export the database for all domains, including the new domain.
  3. Initialize the application for all domains from the export output. For more information, see "To Initialize a Client Application to Use the External Change Log" on page 340.
  4. The application can now search the ECL using the `last_cookie_from_dse_root`.
- **Partial reinitialization.** The application is reinitialized only for the new domain.
  1. Export the database for the new domain only.
  2. Initialize the application from the export output, which contains only the entries in the new domain. For more information, see "To Initialize a Client Application to Use the External Change Log" on page 340.
  3. The application can now search the ECL, using the cookie value for a possible partial initialization that was returned by the server in its `UNWILLING TO PERFORM` error. Note that this might result in some updates that have already been processed being replayed, because the cookie value represents the initial state of the database.

Note – In draft compatibility mode, the draft API does not allow the server to enforce the application to be properly initialized. Therefore, in draft compatibility mode, any changes on the new domain are published in the ECL as soon as the new domain is added.

To prevent the server from publishing changes for the new domain, follow the instructions in "To Disable the External Change Log for a Domain" on page 343. To ensure that an application is notified of changes to a particular domain only, specify this domain either in the base DN (in cookie mode only) or as a search filter on the `targetDN` attribute.

Reinitializing a Client Application When a Domain is Removed or Disabled

When a replication domain is removed from a topology (or when the ECL is disabled for a specific domain), client applications must be alerted to the fact that no more changes will occur on that domain.

The server enforces this requirement by rejecting SEARCH operations if the cookie that is provided refers to the removed domain. The operation result code is `UNWILLING TO PERFORM`. The server provides a detailed message, that includes a list of the domains that are present in the cookie but have been removed (or for which the ECL has been disabled), and a cookie value for a possible continuation.

The client application can use one of the following methods to handle the removed domain:

- **Smooth continuation.** In this case, the application applies its own policy of what to do when a domain is removed. To assist with the formulation of this policy, the application can search the ECL by providing the cookie value for a possible continuation that is returned by the server in the error message.
- **Full reinitialization.** The application is reinitialized for all domains.
  1. Read the value of the `lastExternalChangelogCookie` attribute. This value refers to all domains in the topology, excluding the removed domain.
  2. Export the database for all domains.
  3. Initialize the application for all domains from the export output. For more information, see "To Initialize a Client Application to Use the External Change Log" on page 340.
  4. The application can now search the ECL using the `lastExternalChangelogCookie`.

Controlling Access to the External Change Log

Access to the ECL is ruled by global ACIs that can be configured on the server. By default, only the root user can access the ECL.

For information about configuring global ACIs, see "Managing Global ACIs With `dsconfig`" on page 357.

Purging the External Change Log

The ECL is purged simultaneously with the replication change log. For information about changing the interval at which the replication change log is purged, see "Changing the Replication Purge Delay" on page 318.

Sometimes, an application might submit a search request on the ECL, providing a cookie value that is older than the oldest change stored on the server (because a purge has occurred since the last request from that application). In this case, the server rejects the requests and indicates that the cookie is too old and that a full resync is required.

▼ To Disable the External Change Log for a Domain

In certain situations, you might want to exclude changes on a specific domain from the external change log. You can disable the ECL for a specific replication domain, which prevents changes to this domain from being published in the ECL.

1. **Obtain the domain name, as described in "Retrieving the Replication Domain Name" on page 317.**

2. **Set the external changelog domain properties for that domain.**

   For example, to prevent changes to the schema from being published in the ECL, run the following `dsconfig` command:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-external-changelog-domain-prop \
  --provider-name "Multimaster Synchronization" --domain-name cn=schema \
  --set enabled:false
```

Configuring Schema Replication

Schema replication is enabled by default. When you configure replication as part of the server setup, the schema of the new server is automatically initialized with the schema of the existing server in the topology.

Specifying the Schema Source

When you configure replication with the `dsreplication enable` command, you can specify that the schema of the second directory server be used to initialize the schema of the first server. If you do not specify an option, the schema of the first directory server is used by default.

In the following example, the data of `host1` is used to initialize `host2` but the schema of `host2` is used to initialize the schema on `host1`:

```
$ dsreplication enable --host1 host1 --port1 4444 --bindDN1 "cn=Directory Manager" \
  --bindPassword1 password --replicationPort1 8989 --host2 host2 --port2 4444 \
  --bindDN2 "cn=Directory Manager" --bindPassword2 password --replicationPort2 8989 \
  --adminUID admin --adminPassword password --baseDN "dc=example,dc=com" \
  --useSecondServerAsSchemaSource -X
```

Disabling Schema Replication

In certain circumstances, you might not want the schema to be replicated. The schema is replicated under a separate base DN, "`cn=schema`".

To Specify That Schema Should Not Be Replicated

When you configure replication with the `dsreplication enable` command, you can specify that the schema should not be replicated, using the `--noSchemaReplication` option.

Note – If you use QuickSetup to enable replication, you cannot specify that the schema should not be replicated.

To Disable Schema Replication

In an existing topology in which the schema are being replicated, you can disable this functionality by disabling replication of the schema base DN. The following example disables schema replication from the directory server running on the local host on port `1389`:

```
$ dsreplication disable -h localhost -p 1389 -D "cn=directory manager" \
  -w password -b "cn=schema" -X
```

Note – The previous example does not disable schema replication for the entire topology. To disable schema replication for the entire topology, you must run the equivalent command for each directory server in the topology.

Replicating to a Read-Only Server

The Oracle Unified Directory replication model is a multi-master model, that is, all the replication servers in the topology can process both read and write operations. However, you can configure a directory server to be read-only, in which case add, modify, and delete operations from LDAP clients are rejected on this server.

Note – A read-only directory server functions like a *consumer replica* does in the Oracle Directory Server Enterprise Edition replication model.

▼ To Configure a Replica as Read-Only

This example assumes a replication configuration with replication servers on two hosts, host1 and host2. The example makes the directory server on host2 a read-only replica. The example uses the `dsconfig` command, which accesses the server configuration via the administration connector. For more information, see "Managing Administration Traffic to the Server" on page 62.

- **Use the `dsconfig` command to set the `writability-mode` of host2.**

```
$ dsconfig -h host2 -p 4444 -D "cn=Directory Manager" -w password -X -n \
  set-global-configuration-prop --set writability-mode:internal-only
```

A writability mode of *internal-only* means that replication operations are processed on the server, but the server is not writeable directly by LDAP client applications.

Detecting and Resolving Replication Inconsistencies

Directory server replication has been designed to ensure that replicated databases remain consistent, even in the case of hardware faults, directory server restarts, or network failures. Despite these efforts, however, it is possible that hardware failures (disk errors, memory errors) or software errors (causing memory corruption) might lead to inconsistent databases.

These topics explain how to detect replication inconsistencies, and how to resolve them when they are identified.

Types of Replication Inconsistencies

When inconsistencies occur, they might remain hidden for some time or they might trigger replication or application errors. Examples of inconsistencies include the following:

- An entry is present on all but one directory server in the replication topology.
- An entry has a DN on one directory server that is different to its DN on all other directory servers.
- An entry has different attributes on one directory server than on other directory servers in the replication topology.

Detecting Inconsistencies

Use the following methods to check for replication inconsistencies:

- **Check for information in the replication log file**. The replication log file is configured by default and lists inconsistencies that are detected by the replication mechanism. Imagine, for example, that a modify operation is performed on an entry that is missing from one directory server in the topology. When replication attempts to replay this operation to that server, it will detect the problem and produce an error in the `logs/replication` error log. This kind of error will not stop replication, but the operation will not be replayed and the administrator will need to repair the inconsistency.
- **Pay attention to errors reported by client applications or users**. Client applications or users might experience errors when accessing the directory server that might be due to replication inconsistencies.
- **Make regular checks for database consistency**. With the current directory server release, these checks must be performed manually, using searches or database exports.

Resolving Inconsistencies

If a replication inconsistency is found on a single directory server in the topology, it is not possible to fix this inconsistency using regular LDAP operations. This is because the LDAP operation itself would be replicated to the other directory servers in the topology and might cause damage on those servers. In addition, the fix might involve modifying attributes that are generated by the directory server, such as the `entryuuid` or `modifyTimestamp` attributes. Such attributes cannot be modified by regular LDAP operations.

Replication repair operations must therefore be done using LDAP operations that specify the Replication Repair Control (OID: `1.3.6.1.4.1.26027.1.5.2`).

Caution – Because the replication repair control allows you to skip several controls usually done by the directory server, it should be used with great care and only when consistency problems have been detected and asserted.

The repair control alters the regular processing of an operation as follows:

- The operation can modify attributes that might not normally be modified or added (`NO-USER-MODIFICATION`), such as `entryuuid` and `ds-sync-hist`.
- No replication change number is associated with the operation.
- The operation is not published to the replication server and is therefore a local-only operation.
- Replication does not try to resolve conflicts or to generate historical information for this operation.
- Most of the schema checks are not performed for this operation.

For example, the following `ldapmodify` operation repairs an entry on `host1` only, with the changes contained in the file `changes.ldif`:

```
$ ldapmodify -J 1.3.6.1.4.1.26027.1.5.2 -h localhost -p 1389 \
  -D "cn=Directory Manager" -w password -f changes.ldif
```

When you repair an entry, you must repair all of its regular attributes as well as the attributes generated by the directory server, such as `modifyTimestamp`, `modifiersName`, `createTimestamp`, `creatorsName`, and `ds-sync-hist`. The values of these attributes should be read from a directory server that contains the correct values, and recreated on the server with faulty values.

The `ds-sync-hist` attribute contains historical information that replication uses to solve modify conflicts. This attribute can only be viewed by an administrator.

Solving Naming Conflicts

Entries with identical DNs can be created on separate directory servers if they are created before the servers replicate the changes to each other. When the remote operation is replicated to the local server, a naming conflict occurs. The naming conflict results in the creation of a *conflict entry* on the local server.

Conflict entries have a specific DN, of the form `entryuuid=`*entryUid+oldRDN*. Every conflict entry includes a `ds-sync-conflict` attribute, whose value is the DN of the conflicting regular entry.

For example, imagine that the entry cn=bjensen,ou=People,dc=example,dc=com is created simultaneously on two directory servers. The entry on server 1 is given a unique ID of uid1 and the entry on server 2 is given a unique ID of uid2. Both directory servers will have the following two entries after replication:

```
cn=bjensen,dc=example,dc=com
...
entryuuid=uid2+cn=bjensen,dc=example,dc=com
  ds-sync-conflict:cn=bjensen,dc=example,dc=com
```

When you have identified the conflicting entry, you can rename it so that it has a unique DN.

If the naming attribute in a conflicting entry is multi-valued, you can rename the conflicting entry as follows:

1. Rename the entry while keeping the old RDN value, for example:

   ```
   $ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password
   dn: entryuuid=uid2+cn=bjensen,dc=example,dc=com
   changetype: modrdn
   newrdn: cn=bljensen
   deleteoldrdn: 0
   ^D
   ```

   You cannot delete the old RDN value in this step because it also contains the entryuuid operational attribute, which cannot be deleted.
2. Remove the old RDN value of the naming attribute and the conflict marker attribute, for example:

   ```
   $ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password
   dn: cn=bljensen,dc=example,dc=com
   changetype: modify
   delete: cn
   cn: bjensen
   delete: ds-sync-conflict
   ^D
   ```

If the naming attribute in a conflicting entry is single-valued, for example dc (domain component), you cannot simply rename the entry to another value of the same attribute. Instead, you must give the entry a temporary name, as follows:

1. Rename the entry by using a different naming attribute, and keep the old RDN, for example::

   ```
   $ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password
   dn: entryuuid=uid2+dc=HR,dc=example,dc=com
   changetype: modrdn
   newrdn: o=TempHR
   deleteoldrdn: 0
   ^D
   ```

   You cannot delete the old RDN value in this step because it also contains the entryuuid operational attribute, which cannot be deleted.

2. Change the desired naming attribute to a unique value and remove the conflict marker attribute, for example:

   ```
   $ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password
   dn: o=TempHR,dc=example,dc=com
   changetype: modify
   replace: dc
   dc: NewHR
   delete: ds-sync-conflict
   ^D
   ```
3. Rename the entry back to the intended naming attribute and delete the temporary RDN, for example:

   ```
   $ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password
   dn: dc=NewHR,dc=example,dc=com
   changetype: modrdn
   newrdn: dc=NewHR
   deleteoldrdn: 1
   ^D
   ```

Purging Historical Replication Data

Oracle Unified Directory maintains a history of all changes that have been made on the server as a result of replication operations. This historical replication data is stored in an attribute of each user entry, and can eventually take up a large amount of space on your disk. Historical information is therefore purged when an entry is modified, or when you specifically run a command to purge the data.

By default, information that is older than one day is purged. You can specify the age of data that should be purged by setting the value of the `conflicts-historical-purge-delay` property of the replication domain. The following example specifies that data older than five days should be purged. Note that the value of the property is expressed in minutes.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -X -n \
  set-replication-domain-prop --provider-name "Multimaster Synchronization" \
  --domain-name dc=example,dc=com --set conflicts-historical-purge-delay:7200m
```

You can also purge historical data immediately, or schedule a task to purge the data at a specific time. Imagine, for example, that you initialize a server with a large number of entries, then perform a significant number of changes on these entries. The resulting replication historical data will increase the size of the database quite substantially. If your server is then used mainly for read operations, the large database size remains, because no modifications are made to trigger a purge of the historical data. In this case, you can launch a once off purge task to remove the historical data that was generated by the initial modifications, and return the database to a more accurate size.

Because the purge process can take some time, you are required to specify the maximum duration of the purge (in seconds). To purge historical data immediately, run the following command:

```
$ dsreplication -h localhost -p 4444 --adminUID admin --adminPassword password \
  purge-historical --maximumDuration 3600 --baseDN dc=example,dc=com -X -n
```

For information about scheduling commands as tasks, see "Configuring Commands As Tasks" on page 64.

Using Isolated Replicas

An *isolated replica* is a directory server that can accept changes from other replicas for replay but cannot send changes to the replication server to which it is connected. An isolated replica cannot be the source of data updates to the topology. You can use isolated replicas to separate a directory server from the rest of the replication topology.

Every directory server in the topology has a `trusted` configuration property that is set to `true` by default. Isolated replicas are identified as such by configuring them as *untrusted* servers in the topology, that is, by setting the `trusted` configuration property to `false`. Data that comes from an untrusted directory server is discarded by a replication server. This ensures that an isolated replica cannot be the source of data updates in the replication topology.

Only *directory servers* are configured as trusted or untrusted. Replication servers do not have the trusted configuration flag.

To configure a directory server as untrusted, use the `dsreplication set-trust` command, as follows:

```
$ dsreplication --adminUID admin --adminPassword password -X \
  set-trust --trustedHost host1 --trustedPort 4444 \
  --modifiedHost host2 --modifiedPort 5444 --trustValue untrusted
```

The `dsreplication set-trust` command is supported in both interactive and non-interactive modes.

- You can only configure the trust flag of a directory server from another trusted server in the topology. You cannot configure the trust flag from that server itself. The `–trustedHost` and `--modifiedHost` options can therefore not refer to the same directory server.
- When you modify a directory server from `untrusted` to `trusted`, the host that is being modified must be running, otherwise the command will fail.
- When you modify a directory server from `untrusted` to `trusted`, the host that is being modified must not contain any *untrusted changes*. An untrusted change is a change that has been made on an untrusted directory server and has therefore not been propagated to the

rest of the topology. If the host that is being modified contains untrusted changes, the affected suffixes should be re-initialized with an appropriate data set from one of the trusted servers in the topology before the host is modified to trusted.

Use the `dsreplication status` command to determine whether a directory server is trusted or untrusted. For example:

```
$ dsreplication status --adminUID admin --adminPassword password -X \
 --hostname host1 --port 4444

dc=example,dc=com - Replication Enabled
=======================================
Server    :Entries:M.C.[1]:A.O.M.C.[2]:Port[3]:Encryption[4]:Trust [5]:U.C.[6]:Status[7]
----------:-------:-------:-----------:-------:-------------:---------:-------:---------
host1:4444:2002   :0      :N/A        :8989   :Disabled     :Trusted  :N/A    :Normal
host2:5444:2002   :0      :N/A        :8989   :Disabled     :Untrusted:0      :Normal

[1] The number of changes that are still missing on this server (and that have been
    applied to at least one other server).
[2] Age of oldest missing change: the date on which the oldest change that has not
    arrived on this server was generated.
[3] The port used to communicate between the servers whose contents are being
    replicated.
[4] Whether the replication communication through the replication port is encrypted
    or not.
[5] Whether this directory server is trusted or not. Updates coming from an untrusted
    server are discarded and not propagated.
[6] The number of untrusted changes. These are changes generated on this server while
    it is untrusted. Those changes are not propagated to the rest of the topology but
    are effective on the untrusted server.
[7] The status of the replication domain on this directory server.
```

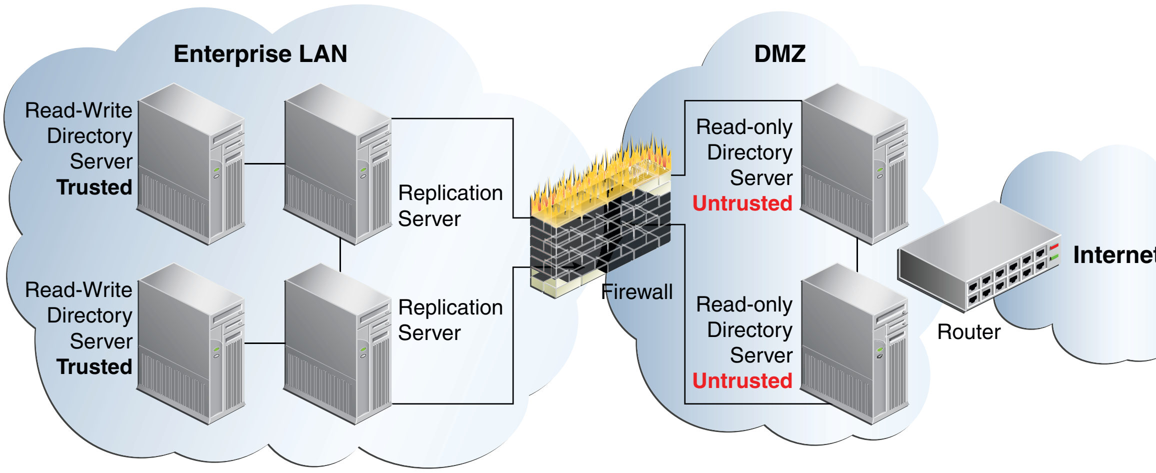
Deployment Scenarios for Isolated Replicas

There are two main scenarios for using isolated replicas in a replication topology:

- Providing additional security in a demilitarized zone (DMZ)
- Testing client applications in a staging area

Using Isolated Replicas in a DMZ

A demilitarized zone (DMZ) is the area in an enterprise network that is exposed to an untrusted network, such as the Internet. A DMZ provides a layer of protection because it stands between a trusted and untrusted network. Direct access from the outside is limited to the equipment located inside the DMZ. The following figure shows how isolated replicas can be used in a DMZ.


Enterprise LAN
DMZ
Read-Write Directory Server Trusted
Read-Write Directory Server Trusted
Replication Server
Replication Server
Firewall
Read-only Directory Server Untrusted
Read-only Directory Server Untrusted
Router
Internet

By placing read-only directory servers in the DMZ, you can prevent compromised data from being transmitted to the replication servers in the private area of your network. The servers in the DMZ must be configured to be untrusted to safeguard against malicious data being accepted from them. The servers inside the private area are configured to have read and write access. This configuration ensures that data changes are propagated throughout the replication topology, only by the directory servers in the private area. The read-only directory servers in the DMZ obtain data changes from the replication servers located inside the private network. If an outside attacker attempts to compromise data, the direct access point is a read-only server inside the DMZ. Malicious data cannot be transmitted because directory servers in the DMZ are untrusted. The integrity of the server data inside the private enterprise LAN is therefore protected.

This scenario has the following configuration requirements:

- Each directory server in the DMZ is configured as untrusted *and* as read-only.
- Each replication server in the topology is located inside the private enterprise LAN.
- Each directory server in the private enterprise LAN is configured as a trusted server with read-write access.

Each trusted directory server in this topology has the following access rights:

- Can send changes to the replication server to which it is connected. Those changes will be propagated to all other directory servers in the topology.
- Can replay changes sent by the replication server to which it is connected.
- Can be the source of an online full update operation to initialize other servers with its data.

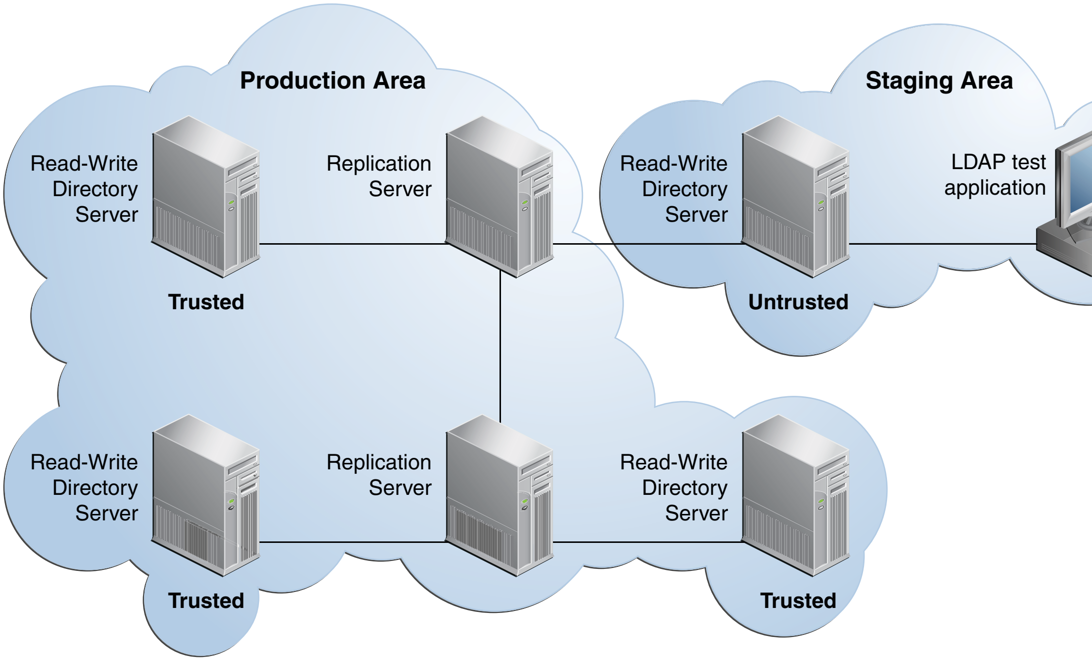
Each untrusted directory server in this topology has the following access limitations:

- Is not authorized to send changes to the replication server to which it is connected. If an untrusted directory server sends changes, the changes are evaluated as compromised data, and the replication server discards the changes.
- Can replay changes sent by the replication server to which it is connected.
- Cannot be the source of an online full update operation to initialize other servers with its data.

Using Isolated Replicas for Testing

Isolated replicas can be useful to test an application against live data in a staging area. This can be accomplished by configuring the isolated replicas to be untrusted, but with read and write access. The application's access point is the isolated replica and data is written only to the isolated replicas in the staging area.

The following figure shows how isolated replicas can be used in a staging area.



Replicating Between Oracle Directory Server Enterprise Edition and Oracle Unified Directory

Oracle Unified Directory 11g Release 1 (11.1.1) provides a mechanism to replicate data between Oracle Directory Server Enterprise Edition and Oracle Unified Directory. The main purpose of this replication gateway is to enable migration from Oracle Directory Server Enterprise Edition to Oracle Unified Directory.

For a comprehensive overview of the replication gateway and its use in a topology that includes both Oracle Directory Server Enterprise Edition and Oracle Unified Directory servers, see Chapter 4, "Overview of the Replication Gateway," in *Oracle Fusion Middleware Deployment Planning Guide for Oracle Unified Directory*.

Setting up replication between these two disparate topologies involves three steps:

- Migrating the Oracle Directory Server Enterprise Edition schema and configuration to the Oracle Unified Directory server.
- Initializing the Oracle Unified Directory server with the data from the Oracle Directory Server Enterprise Edition server.
- Configuring replication between the Oracle Directory Server Enterprise Edition server and the Oracle Unified Directory server.

The following procedures describe each step. These procedure assume that you have the following:

- An installed and running Oracle Directory Server Enterprise Edition server.

  The Oracle Unified Directory replication gateway supports the DS6–mode password policy only. If your Oracle Directory Server Enterprise Edition instance is using a DS5–mode password policy, you must upgrade it.
- An installed and running Oracle Unified Directory directory server.

  The Oracle Unified Directory server must be configured *without* any suffixes.

▼ To Migrate the Oracle Directory Server Enterprise Edition Schema and Configuration

Before You Begin This procedure describes various options of the `ds2oud` command. You can run the `ds2oud` command completely interactively by just typing `ds2oud` on the command line. In interactive mode, the command prompts you for the required responses. For more information about the `ds2oud` command, see "ds2oud" in *Oracle Fusion Middleware Command-Line Usage Guide for Oracle Unified Directory*.

1 **On the Oracle Unified Directory directory server, run the `ds2oud --diagnose` command, providing the connection details of the Oracle Directory Server Enterprise Edition server.**

This command assesses the Oracle Directory Server Enterprise Edition server instance and informs you whether any of the server configuration must be migrated to the Oracle Unified Directory server.

```
$ ds2oud --diagnose -D "cn=directory manager" -j pwdfile -h host1.example.com -p 1389
```

2 **Run the `ds2oud` command with one or more of the migration options to migrate the schema, the server configuration, or both.**

To migrate the schema and the configuration parameters:

```
$ ds2oud --migrateAll \
  -D "cn=directory manager" -j pwdfile -h host1.example.com -p 1389 \
  --oudBindDN "cn=directory manager" --oudBindPasswordFile pwdfile \
  --oudHostname localhost --oudAdminPort 4444 --oudPort 1389
```

You are prompted for additional information relating to the Oracle Unified Directory configuration. This command creates a compatible configuration on the Oracle Unified Directory directory server.

▼ To Initialize the Oracle Unified Directory with Oracle Directory Server Enterprise Edition Data

1 **On the Oracle Directory Server Enterprise Edition server, run the following command to export the data set:**

```
$ dsadm export -f opends-export dsee-instance-path baseDN exportedLDIFPath
```

where *exportedLDIFPath* is the path of the resulting LDIF file that contains the replicated data.

2 **On the Oracle Unified Directory server, prepare the server to be initialized. For example:**

```
$ dsreplication pre-external-initialization -h localhost -p 4444 --adminUID admin \
  --adminPassword password -baseDN dc=example,dc=com -X -n --noPropertiesFile
```

3 **Copy the LDIF file that was generated in step 1 to a directory that is accessible by the Oracle Unified Directory servers.**

4 **On the Oracle Unified Directory server, import the LDIF data, as follows:**

```
$ import-ldif -h localhost -p 4444 \
  -D "cn=admin,cn=Administrators,cn=admin data" -w password \
  --includeBranch dc=example,dc=com --ldifFile exportedLDIFPath \
  --clearBackend --trustAll --noPropertiesFile
```

5 **On the Oracle Unified Directory server, run the post–initialization script, for example:**

```
$ dsreplication post-external-initialization -h localhost -p 4444 --adminUID admin \
  --adminPassword password --baseDN dc=example,dc=com -X -n --noPropertiesFile
```

▼ To Configure Replication Between Oracle Directory Server Enterprise Edition and Oracle Unified Directory

1. **Install and configure the replication gateway, as described in Chapter 5, "Setting Up the Replication Gateway," in** *Oracle Fusion Middleware Installation Guide for Oracle Unified Directory***.**

2. **To test that replication is working correctly, modify at least one entry on each Oracle Directory Server Enterprise Edition server and check the modification on the Oracle Unified Directory server.**

◆ ◆ ◆ CHAPTER 9

Controlling Access To Data

Controlling access to directory contents is an integral part of creating a secure directory service. Access to data is managed with access control instructions (ACIs) that specify the access right to individual entries, all sub-entries below an entry, or all entries on a global basis.

Numerous or complicated ACIs require greater processing resources than a few simple ACIs. You can significantly reduce the performance of your directory by specifying a large number of ACIs or extremely complicated ACIs.

Oracle Unified Directory includes the ability to view the effective rights of a given user for a given entry. This feature simplifies the administration of the complex and powerful access control mechanism.

For an overview of the ACI model, see "Access Control Principles" in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

The following sections describe how to create ACIs to control access to data:

- "Managing Global ACIs With `dsconfig`" on page 357
- "Managing ACIs With `ldapmodify`" on page 360
- "Managing Access Control With Oracle Directory Services Manager" on page 362
- "Access Control Usage Examples" on page 365
- "Proxy Authorization ACIs" on page 370
- "Viewing Effective Rights" on page 371

Managing Global ACIs With `dsconfig`

Global ACIs control access to the root of the DIT instead of to a particular sub-tree. Global ACIs apply to all entries in the directory. You can set, reset, and delete global ACIs with the `dsconfig` command and with the `ldapmodify` command. `dsconfig` accesses the server configuration over SSL, using the administration connector. For more information about `dsconfig`, see "Managing the Server Configuration With `dsconfig`" on page 25.

You cannot use `dsconfig` to manage ACIs that are applied to entries in sub-trees. To manage non-global ACIs, see "Managing ACIs With `ldapmodify`" on page 360.

Default Global ACIs

When you install Oracle Unified Directory, eight default global ACIs are defined. The effect of all the default global ACIs is to allow the following:

- Anyone has read access to certain controls and extended operations.
- Anyone has access to search, compare, and read user attributes (except for the `userpassword` and `authPassword` attributes.)
- Authenticated users can modify a subset of the attributes in their own entries in the directory. Users are unable to delete their own entries.
- Anyone has access to key operational attributes including many in the root DSE and `cn=schema`, as well as other attributes that show up in entries throughout the server.

The proxy does not evaluate global ACIs. The proxy forwards LDAP requests to the remote LDAP server, and the remote LDAP server evaluates the ACIs.

▼ To Display the Global ACIs

The global ACIs are all values of the `global-aci` property of the access control handler. You can use `dsconfig` to display the global ACIs currently configured on the server by viewing the `global-aci` property.

● Run the `dsconfig` command as follows:

```
$ dsconfig -h localhost -p 4444 -D cn="Directory Manager" -w password -n \
  get-access-control-handler-prop \
  --property global-aci

Property   : Value(s)
-----------:-------------------------------------------------------------------
global-aci : (extop="1.3.6.1.4.1.26027.1.6.1 || 1.3.6.1.4.1.26027.1.6.3 ||
           : 1.3.6.1.4.1.4203.1.11.1 || 1.3.6.1.4.1.1466.20037 ||
           : 1.3.6.1.4.1.4203.1.11.3") (version 3.0; acl "Anonymous extended
           : operation access"; allow(read) userdn="ldap:///anyone";),
           : "(target="ldap:///")(targetscope="base")(targetattr="objectClass||
           : namingContexts||supportedAuthPasswordSchemes||supportedControl||su
           : pportedExtension||supportedFeatures||supportedLDAPVersion||support
           : edSASLMechanisms||vendorName||vendorVersion")(version 3.0; acl
           : "User-Visible Root DSE Operational Attributes"; allow
           : (read,search,compare) userdn="ldap:///anyone";)",
           : (target="ldap:///cn=changelog")(targetattr="*")(version 3.0; acl
           : "External changelog access"; deny (all) userdn="ldap:///anyone";),
           : "(target="ldap:///cn=schema")(targetscope="base")(targetattr="obje
           : ctClass||attributeTypes||dITContentRules||dITStructureRules||ldapS
           : yntaxes||matchingRules||matchingRuleUse||nameForms||objectClasses"
           : )(version 3.0; acl "User-Visible Schema Operational Attributes";
           : allow (read,search,compare) userdn="ldap:///anyone";)",
           : (target="ldap:///dc=replicationchanges")(targetattr="*")(version
           : 3.0; acl "Replication backend access"; deny (all)
           : userdn="ldap:///anyone";),
           : "(targetattr!="userPassword||authPassword")(version 3.0; acl
           : "Anonymous read access"; allow (read,search,compare)
           : userdn="ldap:///anyone";)",
           : (targetattr="audio||authPassword||description||displayName||givenN
           : ame||homePhone||homePostalAddress||initials||jpegPhoto||labeledURI
           : ||mobile||pager||postalAddress||postalCode||preferredLanguage||tel
           : ephoneNumber||userPassword")(version 3.0; acl "Self entry
           : modification"; allow (write) userdn="ldap:///self";),
           : "(targetattr="createTimestamp||creatorsName||modifiersName||modify
           : Timestamp||entryDN||entryUUID||subschemaSubentry")(version 3.0;
           : acl "User-Visible Operational Attributes"; allow
           : (read,search,compare) userdn="ldap:///anyone";)",
           : "(targetattr="userPassword||authPassword")(version 3.0; acl "Self
           : entry read"; allow (read,search,compare) userdn="ldap:///self";)",
           : (targetcontrol="1.3.6.1.1.12 || 1.3.6.1.1.13.1 || 1.3.6.1.1.13.2
           : || 1.2.840.113556.1.4.319 || 1.2.826.0.1.3344810.2.3 ||
           : 2.16.840.1.113730.3.4.18 || 2.16.840.1.113730.3.4.9 ||
           : 1.2.840.113556.1.4.473 || 1.3.6.1.4.1.42.2.27.9.5.9") (version
           : 3.0; acl "Authenticated users control access"; allow(read)
           : userdn="ldap:///all";), (targetcontrol="2.16.840.1.113730.3.4.2 ||
           : 2.16.840.1.113730.3.4.17 || 2.16.840.1.113730.3.4.19 ||
           : 1.3.6.1.4.1.4203.1.10.2 || 1.3.6.1.4.1.42.2.27.8.5.1 ||
           : 2.16.840.1.113730.3.4.16") (version 3.0; acl "Anonymous control
           : access"; allow(read) userdn="ldap:///anyone";)
```

▼ To Delete a Global ACI

The easiest way to delete a global ACI is to use dsconfig in interactive mode. Interactive mode walks you through the ACI configuration, and is therefore not documented here. If you delete global ACIs in non-interactive mode, make sure that you escape all special characters in the ACI specification as required by your command line shell.

This example deletes the global ACI that allows anonymous access by using dsconfig in non-interactive mode.

● **Run the dsconfig command as follows.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-access-control-handler-prop \
  --remove global-aci:\(targetattr!=\"userPassword\|\|authPassword\"\) \
  \(version\ 3.0\;\ acl\ \"Anonymous\ read\ access\"\;\ allow\ \(read,search,compare\)
  \ userdn=\"ldap:///anyone\"\;\)
```

▼ To Add a Global ACI

When you add a global ACI, make sure that you escape all special characters in the ACI specification as required by your command-line shell.

The following example adds the global ACI that was removed in the previous procedure, using `dsconfig` in non-interactive mode:

- **Run the `dsconfig` command as follows.**

```
$ dsconfig -h localhost -p 4444 -D cn="Directory Manager" -w password -n \
  set-access-control-handler-prop \
  --add global-aci:\(targetattr!=\"userPassword\|\|authPassword\"\) \
  \(version\ 3.0\;\ acl\ \"Anonymous\ read\ access\"\;\ allow\ \(read,search,compare\)
  \ userdn=\"ldap:///anyone\"\;\)
```

Managing ACIs With `ldapmodify`

You can create access control instructions (ACIs) manually using LDIF statements, and add them to your directory by using the `ldapmodify` command. Because ACI values can be very complex, it is useful to view existing values and copy them to help create new ones.

For additional sample ACIs to the ones illustrated here, see "Access Control Usage Examples" on page 365.

▼ To View ACI Attribute Values

ACIs are stored as one or more values of the `aci` attribute on an entry. The `aci` attribute is a multivalued operational attribute that can be read and modified by directory users, and should itself be protected by ACIs.

Administrative users are usually given full access to the `aci` attribute.

- **View the values of the `aci` attribute by running the following `ldapsearch` command:**

```
$ ldapsearch -h host -p port -D "cn=Directory Manager" -w password \
-b entryDN -s base "(objectclass=*)" aci
```

The result is LDIF text that you can copy into a new LDIF ACI definition for editing. Because the value of an ACI is a long string, the output from the `ldapsearch` operation is likely to be displayed over several lines, with the first space being a continuation marker. Take this into account when copying and pasting the LDIF output.

Next Steps To view the effect of an ACI value, in terms of the permissions that it grants or denies, see "Viewing Effective Rights" on page 371.

▼ To Add an ACI

You can add an ACI by specifying the ACI in an LDIF file and then applying the LDIF file with the `ldapmodify` command. The LDIF file must contain one or more `aci` attributes, each of which is composed of the aci: prefix followed by the ACI specification. For more information, see "ACI Syntax" in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

1 **Create the ACI in an LDIF file.**

The following sample LDIF file (aci.ldif) adds an ACI that grants a particular user (csmith) full access rights to the directory:

```
dn: ou=people,dc=example,dc=com
changetype: modify
add: aci
aci: (targetattr="*")(version 3.0; acl "give csmith full rights"; allow(all)
userdn =  "ldap:///uid=csmith,ou=People,dc=example,dc=com";)
```

2 **Use the ldapmodify command to apply the ACI to the directory.**

The following command applies the ACI contained in the aci.ldif file to the directory:

```
$ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  --filename aci.ldif
Processing MODIFY request for ou=people,dc=example,dc=com
MODIFY operation successful for DN ou=people,dc=example,dc=com
```

▼ To Remove an ACI

You can remove an ACI by specifying its value in an LDIF file, and then removing the value with the ldapmodify command.

1 **Remove the ACI in an LDIF file.**

The following sample LDIF file (remove-aci.ldif) removes the ACI that was added in the previous procedure:

```
dn: ou=people,dc=example,dc=com
changetype: modify
delete: aci
aci: (targetattr="*")(version 3.0; acl "give csmith full rights"; allow(all)
userdn =  "ldap:///uid=csmith,ou=People,dc=example,dc=com";)
```

2 **Use the ldapmodify command to apply the change to the directory.**

The following command applies the changes contained in the remove-aci.ldif file to the directory:

```
$ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password \
--filename remove-aci.ldif
Processing MODIFY request for ou=people,dc=example,dc=com
MODIFY operation successful for DN ou=people,dc=example,dc=com
```

Managing Access Control With Oracle Directory Services Manager

You can use ODSM to view the existing ACIs that are configured in the server, to create new access control points, and to create new ACIs in a user-friendly interface. The following topics described how to manage access control by using ODSM.

Display the Configured ACIs

Oracle Unified Directory supports several preconfigured ACIs, by default. You can display all ACIs that are configured in the server by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Security** tab.
3. Expand the **Directory ACLs** element.
4. All configured ACIs are listed under the access control point in which the ACI is defined. Expand the access control point to view the ACIs. For example, to display the list of ACIs that apply to the Root entry, expand the Root entry.
5. Select an ACI to view its properties in the right hand pane.

Create an Access Control Point

An access control point is the entry in which an ACI is defined (in other words, the entry that contains the corresponding `aci` attribute.

You can define a new access control point by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Security** tab.
3. Expand the **Directory ACLs** element.
4. Click the **Add** icon.
5. In the **Location** field, enter the DN of the entry that will be the new access control point, or click **Select** to select the entry from the directory.
6. To add one or more ACIs to the access control point, click **Create ACI**.
7. Enter the ACI details. For more information about these fields, see "Add an ACI" on page 364.
8. When you have added the required ACIs to the access control point, click **Create**.

Create an Access Control Point Based on an Existing Access Control Point

You can define a new access control point that is based on an existing access control point by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Security** tab.
3. Expand the **Directory ACLs** element.
4. Select the access control point on which you want to base the new access control point.
5. Click the **Add like** icon.
6. In the **Location** field, enter the DN of the entry that will be the new access control point, or click **Select** to select the entry from the directory.
7. The new access control point is automatically created with the same ACL as the access control point on which it was based.
8. To add, remove, or edit the existing ACIs on the new access control point, click **Create**, **Edit** or **Delete**.
9. To add or edit an ACI, enter the required details. For more information about these fields, see "Add an ACI" on page 364.
10. When you have modified the ACIs for the new access control point, click **Create**.

Delete an Access Control Point

You can delete an access control point by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Security** tab.
3. Expand the **Directory ACLs** element.
4. Select the access control point that you want to delete and click the **Delete** icon.
5. Click **OK** to confirm the deletion.

Add an ACI

You can add an ACI to an existing access control point, by using ODSM as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Security** tab.
3. Expand the **Directory ACLs** element.
4. Expand the access control point to which you want to add the new ACI.
5. Select one of the ACIs in the access control list.
6. Click the **Add** icon.
7. To build the ACI in a user friendly interface, select the **Detail View** tab.
8. Select the **Scope** of the ACI.

   Usually an ACI has subtree scope. You can restrict the scope of the ACI by selecting one of the following values:

   - **Base.** The ACI applies to the target resource only.
   - **One.** The ACI applies to the target resource's first-generation children.
   - **Subtree.** The ACI applies to the target resource and the subtree below it.
   - **Subordinate.** The ACI applies only to the subtree below the target resource.
9. In the **Targets** field, select each element of the ACI and click **Edit** to define its properties.

   For more information about defining ACI targets, see "Defining Targets" in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.
10. In the **Permissions** field, click the **Add** icon to define bind rules.

    For more information about defining ACI permissions, see "Defining Permissions" in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.
11. If you would rather define the ACI manually, click the **Text Editor View** tab and enter the details of the ACI.

    Click **Validate** to check that the ACI conforms to the ACI syntax.

    You can also use this view to copy and paste existing ACIs.
12. When you have completed the ACI definition, click *Create*.

Add an ACI Based on an Existing ACI

You can add an ACI that is based on an existing ACI, by using ODSM as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Security** tab.

3. Expand the **Directory ACLs** element.
4. Expand the access control point that contains the ACI that you want to copy.
5. Select the ACI that you want to copy.
6. Click the **Add like** icon.
7. Edit the elements of the ACI that you want to change, either in **Text Editor View** or in **Detail View**.
8. When you have completed the ACI definition, click **Create**.

Modify an ACI

You can modify an existing ACI, by using ODSM as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Security** tab.
3. Expand the **Directory ACLs** element.
4. Expand the access control point that contains the ACI that you want to change
5. Select the ACI that you want to change.
6. Edit the elements of the ACI, either in **Text Editor View** or in **Detail View**.
7. When you have completed your changes, click **Apply**.

Access Control Usage Examples

This section provides several sample ACIs that can be used to implement an access control policy.

Disabling Anonymous Access

The directory server allows anonymous access by default. There might be situations in which you want to disable anonymous access, particularly to sensitive data within your directory.

The following default ACI allows anonymous read access to all user attributes except for the `userpassword` and `authPassword` attributes:

```
aci: (targetattr!="userPassword||authPassword")(version 3.0; acl "
Anonymous read access"; allow (read,search,compare) userdn="ldap:///anyone";)
```

To disable anonymous access, remove this ACI from the default access control handler, as shown in the following example:

```
$ dsconfig -h localhost -p 4444 -D cn="Directory Manager" -w password -n \
  set-access-control-handler-prop \
  --remove global-aci:'(targetattr!="userPassword||authPassword") \
  (version 3.0; acl "Anonymous read access"; \
  allow (read,search,compare) userdn="ldap:///anyone";)’
```

Note – Depending on your shell, you might need to escape any quotations in the ACI itself.

Granting Write Access to Personal Entries

The default global ACIs allow write access to a limited subset of the attributes of a user's own entry. These attributes include the following:

- audio
- authPassword
- description
- displayName
- givenName
- homePhone
- homePostalAddress
- initials
- jpegPhoto
- labeledURI
- mobile
- pager
- postalAddress
- postalCode
- preferredLanguage
- telephoneNumber
- userPassword

Use this procedures in this section to grant users write access to additional attributes of their own entries.

Granting Write Access Based on DNS

The following example ACI enables users internal to `example.com` to change their own business category and room number.

Remember, by allowing write access, you also grant users the right to delete attribute values.

```
aci: (targetattr="businessCategory || roomNumber")
(version 3.0; acl "Write example.com"; allow (write)
userdn="ldap:///self" and dns="*.example.com";)
```

This example assumes that the ACI is added to the `ou=People,dc=example,dc=com` entry.

Granting Write Access Based on Authentication Method

The following example enables any user to update all of his own personal information in the example.com tree provided that he establish an SSL connection to the directory.

By setting this permission, you are also granting users the right to delete attribute values.

```
aci: (targetattr="*")
(version 3.0; acl "Write SSL"; allow (write)
userdn= "ldap://self" and authmethod="ssl";)
```

This example assumes that the aci is added to the ou=subscribers,dc=example,dc=com entry.

Granting a Group Full Access to a Suffix

Most directories have a group that is used to identify certain corporate functions. These groups can be given full access to all or part of the directory. By applying the access rights to the group, you can avoid setting the access rights for each member individually. Instead, you grant users these access rights by adding them to the group.

The following sample ACI allows a group named the HRgroup full access to the ou=People branch of the directory so that they can update employee information:

```
aci: (targetattr="*") (version 3.0; acl "HR"; allow (all)
groupdn= "ldap:///cn=HRgroup,ou=People,dc=example,dc=com";)
```

This example assumes that the ACI is added to the ou=People,dc=example,dc=com entry.

Granting Rights to Add and Delete Group Entries

Some organizations want to allow employees to create entries in the tree if it can increase their efficiency, or if it can contribute to the corporate dynamics. The following examples assume that example.com has a social committee that is organized into various clubs (tennis, swimming, skiing, and so on).

Creating a "Create Group" ACI

This sample ACI allows any example.com employee to create a group entry representing a new club, under the ou=social committee branch.

```
aci: (target="ldap:///ou=social committee,dc=example,dc=com")
(targetattr="*")(targattrfilters="add=objectClass:
(|(objectClass=groupOfNames)(objectClass=top))")
(version 3.0; acl "Create Group"; allow (read,search,add)
userdn= "ldap:///uid=*,ou=People,dc=example,dc=com")
and dns="*.example.com";)
```

This example assumes that the ACI is added to the `ou=social committee, dc=example,dc=com` entry.

Note – This ACI does not grant write permission, which means that the entry creator cannot modify the entry. Because the server adds the value `top` behind the scenes, you must specify `objectClass=top` in the `targattrfilters`.

Creating a `"Delete Group"` ACI

This sample ACI ensures that only the group owner can modify or delete a group entry under the ou=Social Committee branch.

```
aci: (target="ou=social committee,dc=example,dc=com")
(targetattr = "*")
(targattrfilters="del=objectClass:(objectClass=groupOfNames)")
(version 3.0; acl "Delete Group"; allow (write,delete)
userattr="owner#GROUPDN";)
```

This example assumes that the ACI is added to the `ou=social committee,dc=example,dc=com` entry.

Allowing Users to Add or Remove Themselves From a Group

Many directories set ACIs that allow users to add or remove themselves from groups. This is useful, for example, for allowing users to add and remove themselves from mailing lists. The following sample ACI enables all employees to add themselves to any group entry under the `ou=social committee` subtree:

```
aci: (targettattr="member")(version 3.0; acl "Group Members";
allow (selfwrite)
(userdn= "ldap:///uid=*,ou=People,dc=example,dc=com") ;)
```

This example assumes that the ACI is added to the `ou=social committee, dc=example,dc=com` entry.

Granting Conditional Access to a Group

In many cases, when you grant a group privileged access to the directory, you want to ensure that those privileges are protected from intruders trying to impersonate the privileged users. Therefore, in many cases, access control rules that grant critical access to a group or role are often associated with a number of conditions.

The following sample ACI grants the Directory Administrators group full access to the corporate clients branch of the directory tree, provided the following conditions are fulfilled:

- The connection is authenticated using a certificate over SSL
- Access is requested between 08:00 and 18:00, Monday through Thursday
- Access is requested from a specified IP address

```
aci: (target="ou=corporate-clients,dc=example,dc=com")
(targetattr = "*") (version 3.0; acl "corporate-clients"; allow (all)
(groupdn="ldap:///cn=DirectoryAdmin,ou=corporate-clients,dc=example,dc=com")
and (authmethod="ssl") and (dayofweek="Mon,Tues,Wed,Thu") and
(timeofday >= "0800" and timeofday <= "1800") and (ip="255.255.123.234"); )
```

This example assumes that the ACI is added to the `ou=corporate-clients,dc=example,dc=com` entry.

Denying Access

If your directory holds business-critical information, you might specifically want to deny access to it. The following sample ACIs allow users to read certain "billing information", such as connection time and account balance, under their own entries, but prohibits them from changing this information.

This ACI allows users to read the information. The example assumes that the relevant attributes have been created in the schema.

```
aci: (targetattr="connectionTime || accountBalance")
(version 3.0; acl "Billing Info Read"; allow (search,read)
userdn="ldap:///self";)
```

This ACI prevents users from changing the information. The example assumes that the relevant attributes have been created in the schema.

```
aci: (targetattr="connectionTime || accountBalance")
(version 3.0; acl "Billing Info Deny";
deny (write) userdn="ldap:///self";)
```

Defining Permissions for DNs That Contain a Comma

DNs that contain commas require special treatment within LDIF ACI statements. In the target and bind rule portions of the ACI statement, commas must be escaped by a single backslash (\). The following example illustrates this syntax:

```
dn: o=example.com Bolivia\, S.A.
objectClass: top
objectClass: organization
aci: (target="ldap:///o=example.com Bolivia\,S.A.")
```

```
(targetattr="*") (version 3.0; acl "aci 2"; allow (all)
groupdn = "ldap:///cn=Directory Administrators,
o=example.com Bolivia\, S.A.";)
```

Proxy Authorization ACIs

The proxy authorization method is a special form of authentication: a user that binds to the directory using his own identity is granted the rights of another user, through proxy authorization.

This example makes the following assumptions:

- The client application's bind DN is `uid=MoneyWizAcctSoftware,ou=Applications,dc=example,dc=com`.
- The targeted subtree to which the client application is requesting access is `ou=Accounting,dc=example,dc=com`.
- An Accounting Administrator with access permissions to the `ou=Accounting,dc=example,dc=com` subtree exists in the directory.

For the client application to gain access to the Accounting subtree (using the same access permissions as the Accounting Administrator), the application requires the following rights and controls:

- The Accounting Administrator must have access permissions to the `ou=Accounting,dc=example,dc=com` subtree. The following ACI grants all rights to the Accounting Administrator entry:

  ```
  aci: (target="ldap:///ou=Accounting,dc=example,dc=com")
  (targetattr="*") (version 3.0; acl "allow All-AcctAdmin"; allow
  (all) userdn="ldap:///uid=AcctAdministrator,ou=Administrators,
  dc=example,dc=com";)
  ```

- The client application must have proxy rights. The following ACI grants proxy rights to the client application:

  ```
  aci: (target="ldap:///ou=Accounting,dc=example,dc=com")
  (targetattr="*") (version 3.0; acl "allow proxy-
  accounting software"; allow (proxy) userdn=
  "ldap:///uid=MoneyWizAcctSoftware,ou=Applications,
  dc=example,dc=com";)
  ```

- The client application must be allowed to use the proxy authorization control. The following ACI allows the client application to use the proxy authorization control:

  ```
  aci: (targetcontrol = "2.16.840.1.113730.3.4.18")
  (version 3.0; acl "allow proxy auth - accounting software";
  allow (all) userdn="ldap:///uid=MoneyWizAcctSoftware,ou=Applications,
  dc=example,dc=com";)
  ```

With these ACIs in place, the `MoneyWizAcctSoftware` client application can bind to the directory and send an LDAP command such as `ldapsearch` or `ldapmodify` that requires the access rights of the proxy DN.

In the previous example, if the client wanted to perform an `ldapsearch` command, the command would include the following controls:

```
$ ldapsearch -D "uid=MoneyWizAcctSoftware,ou=Applications,dc=example,dc=com" \
  -w password -Y "dn:uid=AcctAdministrator,ou=Administrators,dc=example,dc=com" \
  -b "ou=Accounting,dc=example,dc=com"  "objectclass=*"\
...
```

The base of the search must match the target of the ACIs. 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.

For more information, see "To Search Using the Proxied Authorization Control" on page 260.

Viewing Effective Rights

When you maintain the access control policy on the entries of a directory, it is useful to know the effects on security of the ACIs that you define. The directory server enables you to evaluate existing ACIs and report the effective rights that they grant for a given user on a given entry.

The Get Effective Rights Control

The directory server responds to the Get Effective Rights control, which can be included in a search operation. The response to this control is to return the effective rights information about the entries and attributes in the search results. This extra information includes read and write permissions for each entry and for each attribute in each entry. The permissions may be requested for the bind DN used for the search or for an arbitrary DN, allowing administrators to test the permissions of directory users.

Effective rights functionality relies on an LDAP control. To view the effective rights when going through a proxy server, you must enable this control in the proxy chaining policy. You must also ensure that the proxy identity used to bind to the remote server is also allowed to access the effective rights attributes.

Using the Get Effective Rights Control

The behavior of the Get Effective Rights Control differs from the Internet draft Get Effective Rights Control in the following ways:

- There is no response control returned with the search results. Instead, the rights information is added to the result entries. Also, the format of the rights information is completely different from the draft and is described below.
- The request control only takes an `authzid`.

There are two ways to specify the Get Effective Rights control with the `ldapsearch` command:

1. Use the `-J "1.3.6.1.4.1.42.2.27.9.5.2"` option or simply `-J effectiverights`. If you specify a NULL value for the Get Effective Rights Control's `authzid` value, the bind user is used as the `authzid` and the rights for the attributes and entries being returned with the current `ldapsearch` operation are retrieved.
2. The simpler and preferred method is to use the `-g` option with or without the `-e` option:
3.
   a. `-g "dn:` *DN*`"`--The search results will show the effective rights of the user binding with the given *DN*. This option allows an administrator to check the effective rights of another user. The option `-g "dn:"` will show the effective rights for anonymous authentication.

   b. `-e` *attributeName1* `-e` *attributeName2* --The search results will also include the effective rights on the named attributes. This option can be used to specify attributes that would not appear in the search results for the entry. For example, this option can be used to determine if a user has permission to add an attribute that does not currently exist in an entry.

   Note – The `-e` option requires the `-g` option and should not be used with the `-J` option.

   If you use the `-g` option, do not use the `-J` option with the OID of the Get Effective Rights control.

Besides using one of these two ways to specify the Get Effective Rights Control, you must specify the type of information you want to view, either the simple rights or the more detailed logging information that explains how those rights are granted or denied. The type of information is determined by adding either `aclRights` or `aclRightsInfo`, respectively, as an attribute to return in the search results. You can request both attributes to receive all effective rights information, although the simple rights are redundant with the information in the detailed logging information.

Note – The `aclRights` and `aclRightsInfo` attributes have the behavior of virtual operational attributes. They are not stored in the directory, and they will not be returned unless explicitly requested. These attributes are generated by the directory server in response to the Get Effective Rights Control. For this reason, neither of these attributes can be used in filters or search operations of any kind.

The effective rights feature inherits other parameters that affect access control (such as time of day, authentication method, machine address, and machine name) from the user initiating the search operation.

The following example shows how a user, Carla Fuente, can view her rights in the directory. In the results, a `1` means that permission is granted, and a `0` means that permission is denied.

```
$ ldapsearch -J effectiverights -h rousseau.example.com -p 1389 \
  -D "uid=cfuente,ou=People,dc=example,dc=com" -w password \
  -b "dc=example,dc=com" "(objectclass=*)" aclRights
dn: dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0
dn: ou=Groups, dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0
dn: ou=People, dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0
dn: cn=Accounting Managers,ou=groups,dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0
dn: cn=HR Managers,ou=groups,dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0
dn: uid=bjensen,ou=People, dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0
dn: uid=cfuente, ou=People, dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:1,proxy:0
```

This result shows Carla Fuente the entries in the directory where she has at least read permission and that she can modify her own entry. The effective rights control does not bypass normal access permissions, so a user will never see the entries for which they do not have read permission. In the following example, the Directory Manager can see the entries to which Carla Fuente does not have read permission:

```
$ ldapsearch -h rousseau.example.com -p 1389 -D "cn=Directory Manager" -w password \
  -g "dn: uid=cfuente,ou=People,dc=example,dc=com" -b "dc=example,dc=com" \
  "(objectclass=*)" aclRights
dn: dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0
dn: ou=Groups, dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0
dn: cn=Directory Administrators, dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:0,write:0,proxy:0
dn: ou=Special Users,dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:0,write:0,proxy:0
dn: ou=People, dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0
dn: cn=Accounting Managers,ou=groups,dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0
dn: cn=HR Managers,ou=groups,dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0
dn: uid=bjensen,ou=People, dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0
dn: uid=cfuente, ou=People, dc=example,dc=com
aclRights;entryLevel: add:0,delete:0,read:1,write:1,proxy:0
```

In the output above, the directory manager can see that Carla Fuente cannot even view the Special Users nor the Directory Administrators branches of the directory tree. In the following example, the Directory Administrator can see that Carla Fuente cannot modify the `mail` and `manager` attributes in her own entry:

```
$ ldapsearch -h rousseau.example.com -p 1389 -D "cn=Directory Manager" -w password \
  -g "dn: uid=cfuente,ou=People,dc=example,dc=com" -b "dc=example,dc=com" \
  "(uid=cfuente)" aclRights "*"
version: 1
```

```
dn: uid=cfuente, ou=People, dc=example,dc=com
aclRights;attributeLevel;mail: search:1,read:1,compare:1,
write:0,selfwrite_add:0,selfwrite_delete:0,proxy:0
mail: cfuente@example.com
aclRights;attributeLevel;uid: search:1,read:1,compare:1,
write:1,selfwrite_add:1,selfwrite_delete:1,proxy:0
uid: cfuente
aclRights;attributeLevel;givenName: search:1,read:1,compare:1,
write:1,selfwrite_add:1,selfwrite_delete:1,proxy:0
givenName: Carla
aclRights;attributeLevel;sn: search:1,read:1,compare:1,
write:1,selfwrite_add:1,selfwrite_delete:1,proxy:0
sn: Fuente
aclRights;attributeLevel;cn: search:1,read:1,compare:1,
write:1,selfwrite_add:1,selfwrite_delete:1,proxy:0
cn: Carla Fuente
aclRights;attributeLevel;userPassword: search:0,read:0,
compare:0,write:1,selfwrite_add:1,selfwrite_delete:1,proxy:0
userPassword: {SSHA}wnbWHIq2HPiY/5ECwe6MWBGx2KMiZ8JmjF80Ow==
aclRights;attributeLevel;manager: search:1,read:1,compare:1,
write:0,selfwrite_add:0,selfwrite_delete:0,proxy:0
manager: uid=bjensen,ou=People,dc=example,dc=com
aclRights;attributeLevel;telephoneNumber: search:1,read:1,compare:1,
write:1,selfwrite_add:1,selfwrite_delete:1,proxy:0
telephoneNumber: (234) 555-7898
aclRights;attributeLevel;objectClass: search:1,read:1,compare:1,
write:1,selfwrite_add:1,selfwrite_delete:1,proxy:0
objectClass: top
objectClass: person
objectClass: organizationalPerson
objectClass: inetorgperson
aclRights;entryLevel: add:0,delete:0,read:1,write:0,proxy:0
```

Understanding Effective Rights Results

Depending on the options specified, an effective rights request returns the following information:

- "Rights Information" on page 374
- "write, selfwrite_add, and selfwrite_delete Permissions" on page 376
- "Logging Information" on page 378

Rights Information

The effective rights information is presented according to the following subtypes:

aclRights;entrylevel - Presents entry-level rights information

aclRights;attributelevel - Presents attribute-level rights information

aclRightsInfo;entrylevel - Presents entry-level logging information

aclRightsInfo;attributelevel - Presents attribute-level logging information

The format of the `aclRights` string is as follows:

`aclRights;entryLevel:` *permission*:*value*(*permission*:*value*)*

and

`aclRights;attributeLevel:` *permission*:*value*(*permission*:*value*)*

The possible entry-level permissions are `add`, `delete`, `read`, `write`, and `proxy`. The possible values for each permission are `0` (permission not granted) and `1` (permission granted).

Entry-level Permission	Explanation
`add` and `delete`	The ability of a user to add and delete the entire entry.
`read`	The ability of a user to read and search attributes in the entry.
`write`	The ability of a user to add, delete, and replace attribute values in the entry.
`proxy`	The ability of a user to access the directory with the rights of the entry.

Note – For information about assigning these permissions in an ACI, see “ACI Syntax” in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

The possible attribute-level permissions are `read`, `search`, `compare`, `write`, `selfwrite_add`, `selfwrite_delete`, and `proxy`. The possible values for each permission are `0` (permission not granted) and `1` (permission granted). For the case of the write permission, the value of "?" is also permitted.

Attribute-level Permission	Explanation
`read`	The ability of a user to read the attribute value in the entry.
`search`	The ability of a user to search the attribute value in the entry.
`compare`	The ability of a user to compare the attribute value in the entry with a value that is provided by the user.
`write`	The ability of a user to add, delete, and replace the attribute value in the entry. This applies to all attributes except the `authorization dn`.

Attribute-level Permission	Explanation
selfwrite_add	The ability of a user to add the attribute, authorization dn.
selfwrite_delete	The ability of a user to delete the attribute, authorization dn.
proxy	The ability of a user to access the directory with the rights of the attribute in the entry.

Note – The write, selfwrite_add, and selfwrite_delete permissions are particularly complex. If you see a "?", consult the logging information to establish why the permissions will or will not be granted. For more information, see Table 9–1.

The format of the aclRightsInfo string is as follows:

aclRightsInfo;logs;entryLevel;*permission*: acl_summary(main):*permission-string*

and

aclRightsInfo;logs;attributeLevel;*permission*;attribute:
acl_summary(main):*permission-string*

The entry-level and attribute-level permissions are described in the preceding section.

The *permission-string* contains detailed information about the effective rights at the entry-level and attribute-levels.

write, selfwrite_add, and selfwrite_delete Permissions

The attribute-level permission for write can be either 0, 1, or "?". Only write attribute-level permissions can have a value of "?", which usually results from a targattrfilters ACI component. For add and delete permissions, the entries that can be modified depend on the values of the attributes in the entry. Only the permission, 0 or 1, is returned on the entries as they are returned with the ldapsearch operation.

For all attribute values except the authorization dn, if the value for a write permission is 1, the permission is granted for both add and delete. Similarly, for all attribute values except the authorization dn, a value of 0 for a write permission means that the permission is not granted for either add or delete ldapmodify operations. The permission in force for the value of the authorization dn is returned explicitly in one of the selfwrite permissions, that is, either selfwrite_add or selfwrite_delete.

Although selfwrite_add and selfwrite_delete attribute-level permissions do not exist in the context of ACIs, a set of ACIs can grant a user selfwrite permission for just the add or just the delete part of a modify operation. For `selfwrite` permissions, the value of the attribute being modified is the `authorization dn`. The same distinction is not made for `write` permissions because the value of the attribute being modified for a write permission is undefined.

When the effective permission depends on a `targattrfilters` ACI, the "`?`" value indicates that the logging information should be consulted for more permission detail. The interdependencies between the `write`, `selfwrite_add`, and `selfwrite_delete` permissions are fairly complex and are outlined in the following table.

TABLE 9–1 Effective Rights Permission Interdependencies

write	selfwrite_add	selfwrite_delete	Effective Rights Explanation
`0`	`0`	`0`	Cannot add or delete any values of this attribute.
`0`	`0`	`1`	Can only delete the value of the `authorization dn`.
`0`	`1`	`0`	Can only add the value of the `authorization dn`.
`0`	`1`	`1`	Can only add or delete the value of the `authorization dn`.
`1`	`0`	`0`	Can add or delete all values except the `authorization dn`.
`1`	`0`	`1`	Can delete all values including the `authorization dn` and can add all values excluding the authorization dn.
`1`	`1`	`0`	Can add all values including the `authorization dn` and can delete all values excluding the `authorization dn`.
`1`	`1`	`1`	Can add or delete all values of this attribute.

TABLE 9–1 Effective Rights Permission Interdependencies *(Continued)*

write	selfwrite_add	selfwrite_delete	Effective Rights Explanation
?	0	0	Cannot add or delete the `authorization dn` value, but might be able to add or delete other values. Refer to logging information for further details regarding the `write` permission.
?	0	1	Can delete but cannot add the value of the `authorization dn`, and might be able to add or delete other values. Refer to logging information for further details regarding the `write` permission.
?	1	0	Can add but cannot delete the value of the `authorization dn` and might be able to add or delete other values. Refer to logging information for further details regarding the `write` permission.
1	?	1	Can add and delete the value of the `authorization dn` and might be able to modify add, modify, or delete other values. Refer to logging information for further details regarding the `write` permission.

Logging Information

The effective rights logging information enables you to understand and debug access control difficulties. The logging information contains an access control summary statement, called the `acl_summary`, that indicates why access control has been allowed or denied. The access control summary statement includes the following information:

- Whether access was allowed or denied
- The permissions granted
- The target entry of the permissions

- The name of the target attribute
- The subject of the rights being requested
- Whether or not the request was made by proxy, and if so, the proxy authentication DN
- The reason for allowing or denying access (important for debugging purposes as explained in the following table)

The following table lists the effective rights logging information reasons and their explanations.

TABLE 9–2 Effective Rights Logging Information Reasons and Their Explanations

Logging Information Reason	Explanation
`no reason available`	No reason available to explain why access was allowed or denied.
`no allow acis`	No `allow` ACIs exist, which results in denied access.
`result cached deny`	Cached information was used to determine the access denied decision.
`result cached allow`	Cached information was used to determine the access allowed decision.
`evaluated allow`	An ACI was evaluated to determine the access allowed decision. The name of the ACI is included in the log information.
`evaluated deny`	An ACI was evaluated to determine the access denied decision. The name of the ACI is included in the log information.
`no acis matched the resource`	No ACIs match the resource or target, which results in denied access.
`no acis matched the subject`	No ACIs match the subject requesting access control, which results in denied access.
`allow anyone aci matched anon user`	An ACI with a `userdn = "ldap:///anyone"` subject allowed access to the anonymous user.
`no matching anyone aci for anon user`	No ACI with a `userdn= "ldap:///anyone"` subject was found, so access for the anonymous user was denied.
`user root`	The user is root DN and is allowed access.

Note – Write permissions for virtual attributes are not provided, nor is any associated logging evaluation information, because virtual attributes cannot be updated.

Restricting Access to the Get Effective Rights Control

Viewing effective rights is itself a directory operation that should be protected and appropriately restricted.

The default ACI does not allow read access to the `aclRights` and `aclRightsInfo` operational attributes used to return effective rights. Create a new ACI for these attributes to enable access by directory users to this information.

For example, the following ACI allows members of the Directory Administrators group to get effective rights:

```
aci: (targetattr = "aclRights||aclRightsInfo")(version 3.0; acl "getEffectiveRights";
allow(all) groupdn = "ldap:///cn=Directory
Administrators,ou=Groups,dc=example,dc=com";)
```

In addition, access is needed to use the Get Effective Rights Control.

To enable access by directory users to the Get Effective Rights Control, create a new ACI target by using the OID (`1.3.6.1.4.1.42.2.27.9.5.2`) for this control. For additional ACI syntax information, see "Defining Targets" in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

For example, the following ACI allows members of the Directory Administrators group to use the Get Effective Rights control:

```
aci: (targetcontrol = "1.3.6.1.4.1.42.2.27.9.5.2")(version 3.0;
acl "getEffectiveRights control access";
allow(all) groupdn = "ldap:///cn=Directory
Administrators,ou=Groups,dc=example,dc=com";)
```

◆ ◆ ◆ CHAPTER 10

Managing Users and Groups With dsconfig

The directory server provides a comprehensive user management model that includes identity mapping, and account status notification. This section describes how to configure these elements by using the dsconfig command.

The section covers the following topics:

- "Managing Root User, Global Administrator, and Administrator Accounts" on page 381
- "Managing User Accounts" on page 389
- "Defining Groups" on page 393
- "Maintaining Referential Integrity" on page 405
- "Simulating ODSEE Roles in an Oracle Unified Directory Server" on page 407

For information about user passwords, see Chapter 11, "Managing Password Policies."

Managing Root User, Global Administrator, and Administrator Accounts

Oracle Unified Directory provides a flexible Privilege Subsystem that allows you to configure root users, Global Administrators, and administrators for your server. You can configure multiple root users and assign different root privileges to each administrator. For administrative domains, you can also configure multiple Global Administrators to manage administrative domains in your network or in a replicated environment.

The topics in this section describe the management of multiple root users and the privilege subsystem. The topics also provide instructions on how to configure and maintain the various user accounts required to administer your server securely.

Before you start with the procedures outlined here, determine the following guidelines for your server:

- Number of root users, their privileges, and resource limits, if any.
- Number of administrators, their privileges, and resource limits, if any.
- Guidelines for user accounts on your system.
- Password policies for the server and for specific groups of users.

Working With Multiple Root Users

Oracle Unified Directory provides one default root DN or root user, "`cn=Directory Manager`". The default root DN is a user entry assigned with specialized privileges with full read and write access to all data in the server. Comparable to a Unix root user or superuser, the root DN can bypass access controls to carry out tasks on the server. The root user is defined below the "`cn=Root DNs,cn=config`" branch of the server at `cn=Directory Manager,cn=Root DNs,cn=config`.

The server supports multiple root users who have their own entries and their own set of credentials on the server. This allows you to assign privileges to a user who might need root access for a particular task but might not need the full set of root user privileges. With each entry, you can assign strong authentication such as the GSSAPI SASL mechanism, password policies, or add resource limits (if your schema allows it) to one root user while having a completely different configuration for another root user.

Root users differ from regular user entries in the following ways:

- **Configuration**. Root users are the only user accounts that can exist in the server configuration (`cn=config`).
- **Privilege inheritance**. Root users automatically inherit the set of default root user privileges. Regular users do not automatically receive any privileges unless explicitly granted. You can grant privileges using real, virtual root-privilege-name attributes, or both in the entry.
- **Lockdown mode**. Root users are the *only* users who can cause the server to enter or leave lockdown mode and only over the loopback interface.

The Privilege Subsystem supports the configuration of multiple root users.

Root Users and the Privilege Subsystem

The Privilege Subsystem allows you to assign refined privileges to users who might require only a specific set of root user access privileges. Root users are automatically granted a set of privileges defined in the `default-root-privilege-name` attribute in the "`cn=Root DNs,cn=config`" subtree.

The Privilege Subsystem is independent from the Access Control Subsystem, but some operations might be subject to access controls.

The following set of privileges are automatically assigned to the root user.

Privilege	Description
`bypass-acl`	Allows the user to bypass access control evaluation.
`modify-acl`	Allows the user to make changes to access control instructions defined in the server.
`config-read`	Allows the user to have read access to the server configuration.
`config-write`	Allows the user to have write access to the server configuration.
`ldif-import`	Allows the user to request the LDIF import task.
`ldif-export`	Allows the user to request the LDIF export task.
`backend-backup`	Allows the user to request the back-end backup task.
`backend-restore`	Allows the user to request the back-end restore task.
`server-shutdown`	Allows the user to request the server shutdown task.
`server-restart`	Allows the user to request the server restart task.
`disconnect-client`	Allows the user to terminate arbitrary client connections.
`cancel-request`	Allows the user to cancel arbitrary client requests.
`unindexed-search`	Allows the user to request unindexed search operations.
`password-reset`	Allows the user to reset the user passwords.
`update-schema`	Allows the user to update the server schema.
`privilege-change`	Allows the user to change the set of privileges assigned to a user, or to change the set of default root privileges.

The following privileges can be assigned to the root user.

Privilege	Description
`data-sync`	Allows the user to participate in data synchronization environment.

Privilege	Description
`jmx-read`	Allows the user to read JMX attribute values.
`jmx-write`	Allows the user to update JMX attribute values.
`jmx-notify`	Allows the user to subscribe to JMX notifications.
`proxied-auth`	Allows the user to use the proxied authorization control or to request an alternate SASL authorization ID.

Managing Root Users With `dsconfig`

Use the `dsconfig` command to manage root users. For more information, see "Managing the Server Configuration With `dsconfig`" on page 25.

▼ To View the Default Root User Privileges

The default root user has a number of privileges, which are stored as values of the `default-root-privilege-name` property.

● **View the default root user privileges by running the following `dsconfig` command:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  get-root-dn-prop

Property                    : Value(s)
----------------------------:--------------------------------------------------
default-root-privilege-name : backend-backup, backend-restore, bypass-acl,
                                    : cancel-request, config-read, config-write,
                                    : disconnect-client, ldif-export, ldif-import,
                                    : modify-acl, password-reset, privilege-change,
                                    : server-restart, server-shutdown,
                                    : unindexed-search, update-schema
```

▼ To Edit the Default Root User Privileges

The easiest way to manage root user privileges is to use `dsconfig` in interactive mode. Interactive mode walks you through the root user configuration, and is therefore not documented here.

To add or remove privileges for the default root user, add or remove the values of the `default-root-privilege-name` property. This property can hold the following values:

- `backend-backup`
- `backend-restore`
- `bypass-acl`
- `cancel-request`
- `config-read`

- `config-write`
- `data-sync`
- `disconnect-client`
- `jmx-notify`
- `jmx-read`
- `jmx-write`
- `ldif-export`
- `ldif-import`
- `modify-acl`
- `password-reset`
- `privilege-change`
- `proxied-auth`
- `server-restart`
- `server-shutdown`
- `unindexed-search`
- `update-schema`

This example adds the `data-sync` privilege to the default root user, by using `dsconfig` in non-interactive mode.

● **Run the `dsconfig` command as follows:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-root-dn-prop --add default-root-privilege-name:data-sync
```

▼ To Create a Root User

Root users are stored below the entry `cn=Root DNs,cn=config`. To create a new root user, create the entry in LDIF and add it by using the `ldapmodify` command. Note that the `cn=config` suffix is available only through the administration connector, and must therefore be accessed over SSL, via the administration port.

Root users automatically inherit the set of default root user privileges on the server. For information about adding or removing privileges for a specific root user, see "To Change a Root User's Privileges" on page 386.

1 **Create a root user entry below the `cn=Root DNs,cn=config` entry.**

The following LDIF file represents a new root user named "Administration Manager". The entry is saved in a file named `add-root-user.ldif`.

```
dn: cn=MyRootUser,cn=Root DNs,cn=config
objectClass: inetOrgPerson
objectClass: person
objectClass: top
objectClass: ds-cfg-root-dn-user
objectClass: organizationalPerson
userPassword: password
cn: MyRootUser
sn: MyRootUser
```

```
ds-cfg-alternate-bind-dn: cn=MyRootUser
givenName: Directory
```

2 **Use the `ldapmodify` command to add the entry.**

```
$ ldapmodify -h localhost -p 4444 -D "cn=Directory Manager" -w password \
  --useSSL --defaultAdd --filename "add-root-user.ldif"
Processing ADD request for cn=MyRootUser,cn=Root DNs,cn=config
ADD operation successful for DN cn=MyRootUser,cn=Root DNs,cn=config
```

3 **(Optional) Use the `ldapsearch` command to display all the root users defined in the server.**

```
$ ldapsearch -p 4444 -b "cn=root DNs,cn=config" -D "cn=directory manager" -w password \
  --useSSL "objectclass=*" dn
dn: cn=Root DNs,cn=config

dn: cn=MyRootUser,cn=Root DNs,cn=config

dn: cn=Directory Manager,cn=Root DNs,cn=config
```

▼ To Change a Root User's Password

1 **Create a password in a secure file.**

2 **Use `ldappasswordmodify` to change the password.**

```
$ ldappasswordmodify -h localhost -p 4444 -D "cn=MyRootUser" -w password \
  --useSSL --newPasswordFile rootuser_pwd.txt
The LDAP password modify operation was successful
```

▼ To Change a Root User's Privileges

If you want to have a different set of privileges for a specific root user, add the `ds-privilege-name` attribute to that root user's entry.

The following example gives the root user "`cn=MyRootUser,cn=Root DNs,cn=config`" the ability to use proxied authorization. The example removes the ability to change user privileges or access the configuration. The minus sign before the privilege indicates that the privilege is being removed rather than granted.

● **Apply the following LDIF statement to the root user's entry:**

```
dn: cn=MyRootUser,cn=Root DNs,cn=config
changetype: modify
add: ds-privilege-name
ds-privilege-name: proxied-auth
ds-privilege-name: -config-read
ds-privilege-name: -config-write
```

In this example, the root user "`cn=MyRootUser,cn=Root DNs,cn=config`" would inherit all privileges automatically granted to root users with the exception of the `config-read` and `config-write` privileges. The user would also be given the `proxied-auth` privilege.

Setting Root User Resource Limits

You can set resource limits on the server for search operations by using the operational attributes on the client application that is binding to the server. The following resource limits are available:

- **Look-through limit**. Specify the maximum number of entries that can be examined during a single search operation. Use the `ds-rlim-lookthrough-limit` operational attribute.
- **Size limit**. Specify the maximum number of entries that can be returned in a single search operation. Use the `ds-rlim-size-limit` operational attribute.
- **Time limit**. Specify the maximum length of time in seconds that the server can spend processing a search operation. Use the `ds-rlim-time-limit` operational attribute.

The following LDIF update statement sets resource limits for the new root user created in the previous section. This statement should be applied to the root user's entry.

```
dn: cn=MyRootUser,cn=Root DNs,cn=config
changetype: modify
add: ds-rlim-lookthrough-limit
ds-rlim-lookthrough-limit: 1000
-
add: ds-rlim-size-limit
ds-rlim-size-limit: 500
-
add: ds-rlim-time-limit
ds-rlim-time-limit: 300
```

To set a particular resource limit to *unlimited*, set the value of the corresponding attribute to `0` (zero).

Managing Global Administrators

When you set up replication servers using the graphical installer or the `dsreplication` command, you are prompted to set a user name and password for the Global Administrator. The Global Administrator is responsible for managing and maintaining administrative server domains in replicated environments.

The Global Administrator exists in the `cn=Administrators,cn=admin data` subtree. To view the Global Administrator entry, run the following `ldapsearch` command:

```
$ ldapsearch -h localhost -p 4444 -D "cn=Directory Manager" -w password \
  --useSSL -b "cn=Administrators,cn=admin data" -s sub "(objectclass=*)"
dn: cn=Administrators,cn=admin data
objectClass: top
objectClass: groupofurls
description: Group of identities which have full access.
cn: Administrators
memberURL: ldap:///cn=Administrators,cn=admin data??one?(objectclass=*)
```

```
dn: cn=admin,cn=Administrators,cn=admin data
objectClass: person
objectClass: top
userPassword: {SSHA}+ed1wbhcWjxtv2zJ6OHEA2TuE9n1qIJGnuR94w==
description: The Administrator that can manage all the OUD instances.
cn: admin
sn: admin
```

Managing Administrators

An administrator generally has broader rights and permissions than most users. You can create a number of administrators, with different access controls and resource limits.

▼ To Create a New Administrator

1 Import the administrator data using `import-ldif`.

For this example, the administrator being added has `uid=Admin.Lab`.

- **Alternatively, you can use an existing user.**

2 (Optional) Create a group of administrators with `cn=Administrators`.

Since the group of administrators should have only a few users, you can create a static group. For more information, see “Defining Static Groups” on page 394.

```
dn: cn=Administrators,ou=People,dc=example,dc=com
objectClass: top
objectClass: groupOfNames
member: uid=Admin.Lab,ou=People,dc=example,dc=com
cn: Administrator
```

3 Set the privileges of the administrator by using the `ldapmodify` command.

For example, the following command would give the administrator the rights to perform backup and restore on the back end.

```
ldapmodify -h localhost -p 1389 -w password -D "cn=directory manager"
dn: uid=Admin.Lab,ou=People,dc=example,dc=com
changetype: modify
add: ds-privilege-name
ds-privilege-name: backend-backup
ds-privilege-name: backend-restore
```

4 Set resource limits, if required.

The procedure is similar to setting the resource limits for a root user. See “Setting Root User Resource Limits” on page 387.

▼ To Create an Administrator with Root User Privileges

You can assign root user privileges to an administration or user.

1. **Create an administrator, or use an existing user.**

   See "To Create a New Administrator" on page 388.

2. **Modify the privileges using the `ldapmodify` command.**

   For example, the command below changes the privileges for the administrator named `Admin.Lab` to have the same default privileges as a root user.

```
ldapmodify -h localhost -p 1389 -w password -D "cn=directory manager"
dn: uid=Admin.Lab,cn=Administrators,ou=People,dc=example,dc=com
changetype: modify
add: ds-privilege-name
ds-privilege-name: bypass-acl
ds-privilege-name: modify-acl
ds-privilege-name: config-read
ds-privilege-name: config-write
ds-privilege-name: ldif-import
ds-privilege-name: ldif-export
ds-privilege-name: backend-backup
ds-privilege-name: backend-restore
ds-privilege-name: server-shutdown
ds-privilege-name: server-restart
ds-privilege-name: disconnect-client
ds-privilege-name: cancel-request
ds-privilege-name: password-reset
ds-privilege-name: update-schema
ds-privilege-name: privilege-change
ds-privilege-name: unindexed-search
```

Note – The privileges on the access controls `bypass-acl` and `modify-acl` should only be assigned to a restricted number of people. Assigning the rights to bypass or modify access controls to inexperienced users can be risky.

Managing User Accounts

User accounts are essentially user entries that you create, modify, or remove in your directory. The directory server provides easy-to-use utilities to manage user accounts and passwords.

Before you begin to manage user accounts, ensure that you have the appropriate password policies set up on the directory server. For more information, see Chapter 11, "Managing Password Policies."

Changing Passwords

Directory administrators are often asked to create, reset, or remove passwords for other users. The `ldappasswordmodify` utility enables you to change or reset a user's password with the LDAP password modify extended operation. You can specify authorization IDs with the `--authzid` option by prefixing `dn:`, `u:`, or by specifying the full DN.

▼ To Change the Directory Manager's Password

- **Use the `ldappasswordmodify` command, as shown in the following example:**

```
$ ldappasswordmodify -h localhost -p 1389 \
  --authzID "dn:cn=Directory Manager" \
  --currentPassword mypassword --newPassword mynewpassword

The LDAP password modify operation was successful
```

▼ To Reset and Generate a New Password for a User

This example assumes that the user does not remember the existing password.

- **Use the `ldappasswordmodify` command, as shown in the following example:**

```
$ ldappasswordmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  --authzID u:jvedder

The LDAP password modify operation was successful
Generated Password:  evx07npv
```

▼ To Change a User's Password

This example assumes that the user remembers the existing password. The new password is passed to the server in a specified file.

- **Use the `ldappasswordmodify` command, as shown in the following example:**

```
$ ldappasswordmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  --authzID uid=jvedder,ou=People,dc=example,dc=com \
  --currentPassword password --newPasswordFile pwdFile

The LDAP password modify operation was successful
```

Managing a User's Account Information

You can use the `manage-account` command to display information about the user's account and any password policy that is applied to the user. You can also use this command to enable and disable a user's account. The `manage-account` command accesses the server over SSL via the administration port. For more information, see "Managing Administration Traffic to the Server" on page 62.

▼ To View a User's Account Information

The `manage-account` command returns the DN of the password policy in effect on a user account, as well as the account status, and password and login related information

1 **To display all available information on a user account, use the `manage-account` command with the `get-all` subcommand, as shown in the following example:**

```
$ manage-account -D "cn=directory manager" -w password get-all \
  --targetDN uid=kvaughan,ou=People,dc=example,dc=com
Password Policy DN:  cn=Default Password Policy,cn=Password Policies,cn=config
Account Is Disabled:  false
Account Expiration Time:
Seconds Until Account Expiration:
Password Changed Time:  19700101000000.000Z
Password Expiration Warned Time:
Seconds Until Password Expiration:  432000
Seconds Until Password Expiration Warning:  0
Authentication Failure Times:
Seconds Until Authentication Failure Unlock:
Remaining Authentication Failure Count:
Last Login Time:
Seconds Until Idle Account Lockout:
Password Is Reset:  false
Seconds Until Password Reset Lockout:
Grace Login Use Times:
Remaining Grace Login Count:  4
Password Changed by Required Time:
Seconds Until Required Change Time:
Password History:
```

2 **To display just a single property of the account, substitute the `get-all` subcommand with the subcommand corresponding to the property you want to view.**

For example, to view just the password history, run the following command:

```
$ manage-account -D "cn=directory manager" -w password get-password-history \
  --targetDN "uid=kvaughan,ou=People,dc=example,dc=com"
```

For a complete list of subcommands, run the following command:

```
$ manage-account --help
```

▼ To View Account Status Information

You can use the `manage-account` command to assess whether an account is enabled or disabled.

● **Use the `manage-account` command with the `get-account-is-disabled` subcommand, as shown in the following example:**

```
$ manage-account -D "cn=directory manager" -w password get-account-is-disabled \
  --targetDN "uid=kvaughan,ou=People,dc=example,dc=com"
Account Is Disabled:  false
```

▼ To Disable an Account

- **Use the `manage-account` command with the `set-account-is-disabled` subcommand, as shown in the following example:**

```
$ manage-account -h localhost -p 4444 -D "cn=directory manager" -w password -X \
set-account-is-disabled --operationValue true \
--targetDN "uid=kvaughan,ou=People,dc=example,dc=com"
Account Is Disabled:  true
```

▼ To Enable an Account

- **Use the `manage-account` command with the `clear-account-is-disabled` subcommand, as shown in the following example:**

```
$ manage-account -D "cn=directory manager" -w password clear-account-is-disabled \
  --targetDN "uid=kvaughan,ou=People,dc=example,dc=com"
Account Is Disabled:  false
```

Setting Resource Limits on a User Account

You can control search operations on the server for each client account by assigning resource limits to the entry. Resource limits are assigned by adding specific operational attributes to the user entry. The directory server then enforces the limits based on the account that the client uses to bind to the directory.

The resource limits that you set on specific user accounts take precedence over the resource limits set in the server-wide configuration. The following limits can be set:

- **Look-through limit**. Specifies the maximum number of entries examined for a search operation. Use the `ds-rlim-lookthrough-limit` operational attribute.
- **Size limit**. Specifies the maximum number of entries returned in response to a search operation. use the `ds-rlim-size-limit` operational attribute.
- **Time limit**. Specifies the maximum time spent processing a search operation. Use the `ds-rlim-time-limit` operational attribute.

Note – The Directory Manager can use unlimited resources by default.

▼ To Set Resource Limits on an Account

1 **Modify the entry in an LDIF file, adding the operational attributes, as shown here:**

```
dn: uid=kvaughan,ou=people,dc=example,dc=com
changetype: modify
add: ds-rlim-lookthrough-limit
ds-rlim-lookthrough-limit: 1000
```

```
-
add: ds-rlim-size-limit
ds-rlim-size-limit: 500
-
add: ds-rlim-time-limit
ds-rlim-time-limit: 300
```

2 **Use the `ldapmodify` command to apply the changes, as shown here:**

```
$ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  --filename add_resource.ldif
Processing MODIFY request for uid=kvaughan,ou=people,dc=example,dc=com
MODIFY operation successful for DN uid=kvaughan,ou=people,dc=example,dc=com
```

Defining Groups

The directory server supports *groups*, which are collections of entries that are manageable as a single object. Typically, directory administrators configure groups of printers, groups of software applications, groups of employees, and so forth. Groups are especially useful when assigning special access privileges to a set of users. For example, you can assign access managers the privileges to employee data while restricting those same privileges to others in the company.

The directory server supports the following group types:

- **Static groups**. A static group defines its membership by providing explicit sets of distinguished names (DNs) using the `groupOfNames`, `groupOfUniqueNames`, or `groupOfEntries` object class. Statics groups are well supported by external clients and provide good performance.

  A disadvantage of static groups is that as the group membership increases, the ability to easily manage the data becomes more difficult. For every entry that changes, all groups containing the changed entry must also be changed. This task becomes more difficult as the number of members of a group grows large. As a result, static groups are best used for relatively small groups that change infrequently.

  For more info, see "Defining Static Groups" on page 394.

- **Dynamic groups**. A dynamic group defines its membership using a set of search criteria in the form of an LDAP URL, using the `groupOfUrls` object class. Compared to static groups, dynamic groups handle large numbers of members well (millions of entries). As entries are updated, all parent groups are updated automatically.

  A disadvantage of dynamic groups is that not all clients support them. Performance also is adversely affected if you need to query the whole list of entries. Thus, dynamic groups are best suited for groups with a very large number of entries or for clients that need to determine specific group membership for an entry.

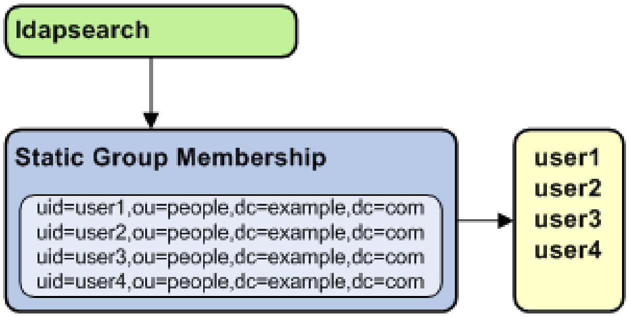
  For more info, see "Defining Dynamic Groups" on page 399.

- **Virtual static groups**. A virtual static group appears and behaves like a static group to external clients, except that each member is represented by a virtual attribute that defines its membership on the fly from another dynamic group. Virtual static groups provide an efficient way to manage large numbers of entries and avoid the scalability issues for clients that only support static groups.
- For more info, see "Defining Virtual Static Groups" on page 401.

Defining Static Groups

A static group is one whose entry contains a membership list of explicit DNs. Many clients support static groups, but static groups are difficult to manage as the number of members in a group increases in size. For example, if you have a member entry that requires a DN change, then you must change the user's DN for each group she belongs to.

Because a static group contains a list of explicit member DNs, its database footprint increases as the membership list grows. For this reason, a static group is best suited for small groups (less than 10,000) whose entries do not change frequently. Using large static groups can have a detrimental impact on performance. If you know that group membership will exceed 10,000, consider using dynamic groups instead.


ldapsearch
Static Group Membership
uid=user1,ou=people,dc=example,dc=com
uid=user2,ou=people,dc=example,dc=com
uid=user3,ou=people,dc=example,dc=com
uid=user4,ou=people,dc=example,dc=com
user1
user2
user3
user4

The directory server supports the following three types of static groups, divided according to the object class they use:

- `groupOfNames` You can define a static group by using the `groupOfNames` object class and by explicitly specifying the member DNs using the `member` attribute.

Note – RFC 4519 requires that the member attribute be mandatory within the groupOfNames object class. This membership requirement has traditionally caused data management problems when an administrator attempted to delete the last member in the group. The directory server solves this problem by allowing the member attribute to be optional. The optional membership requirement allows you to have an empty object class when you delete the last member of the group.

```
dn: cn=Example Static Group 1,ou=Groups,dc=example,dc=com
objectClass: top
objectClass: groupOfNames
member: uid=user1,ou=People,dc=example,dc=com
member: uid=user2,ou=People,dc=example,dc=com
cn: Example Static Group 1
```

- groupOfUniqueNames You can define a static group by using the groupOfUniqueNames object class and by explicitly specifying the member DNs using the uniqueMember attribute. The groupOfUniqueNames object class differs from the groupOfNames object class in that you can enumerate the group's members by specifying a unique DN plus an optional identifier. The identifier ensures that the unique objects can be identified when adding, deleting, or renaming any object.

  For example, you could delete or move an employee (cn=Tom Smith) and add a new employee who has the same name (cn=Tom Smith) to the directory. To distinguish the two, you must add a separate identifier by using a bit string. The following example shows two users with the same name, but the second uniqueMember has an optional identifier.

```
uniqueMember: uid=tsmith,ou=People,dc=example,dc=com
uniqueMember: uid=tsmith,ou=People,dc=example,dc=com#’0111101’B
```

Note – Few LDAP applications actually use the optional UID identifier.

RFC 4519 requires that the uniqueMember attribute be mandatory within the groupOfUniqueNames object class. This membership requirement has historically caused data management problems when an administrator tried to delete the last member in the group. The directory server solves this problem by allowing the uniqueMember attribute to be optional. The optional membership requirement allows you to have an empty object class when you delete the last member of the group.

```
dn: cn=Example Static Group 2,ou=Groups,dc=example,dc=com
objectClass: top
objectClass: groupOfUniqueNames
uniqueMember: uid=user1,ou=People,dc=example,dc=com
uniqueMember: uid=user2,ou=People,dc=example,dc=com
cn: Example Static Group 2
```

- groupOfEntries You can define a static group using the groupOfEntries object class. Based on the original specifications (RFC 4519 and draft-findlay-ldap-grouofentries-00.txt, which expired in March, 2008), the groupOfEntries object class differs from the groupOfNames and groupOfUniqueNames object classes in that attributes are optional. This allows you to specify an empty object class without any members.

Note – The directory server supports the groupOfEntries draft but also allows empty groupOfNames and groupOfUniqueNames object classes. As a result, you can create empty groups of any type (groupOfEntries, groupOfNames, and groupOfUniqueNames).

```
dn: cn=Example Static Group 3,ou=Groups,dc=example,dc=com
objectClass: top
objectClass: groupOfEntries
cn: Example Static Group 3
```

▼ To Create a Static Group With groupOfNames

1 **Create the group entry in LDIF, including the group name (cn) and the groupOfNames object class.**

This example shows an LDIF file, named static-group1.ldif, that defines the new group.

```
dn: cn=Directory Administrators,ou=Groups,dc=example,dc=com
cn: Directory Administrators
objectclass: top
objectclass: groupOfNames
ou: Groups
member: uid=ttully,ou=People,dc=example,dc=com
member: uid=charvey,ou=People,dc=example,dc=com
member: uid=rfisher,ou=People,dc=example,dc=com
```

2 **Add the group by using ldapmodify to apply the LDIF file.**

```
$ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  --defaultAdd --filename static-group1.ldif
Processing ADD request for cn=Directory Administrators,ou=Groups,dc=example,dc=com
ADD operation successful for DN cn=Directory
Administrators,ou=Groups,dc=example,dc=com
```

▼ To Create a Static Group With groupOfUniqueNames

1 **Create the group entry in LDIF, including the group name (cn) and the groupOfUniqueNames object class.**

This example shows an LDIF file, named static-group2.ldif, that defines the new group.

```
dn: cn=Directory Administrators2,ou=Groups,dc=example,dc=com
cn: Directory Administrators2
objectclass: top
objectclass: groupOfUniqueNames
ou: Groups
uniquemember: uid=alangdon,ou=People,dc=example,dc=com
uniquemember: uid=drose,ou=People,dc=example,dc=com
uniquemember: uid=polfield,ou=People,dc=example,dc=com
```

2 **Add the group by using ldapmodify to apply the LDIF file.**

```
$ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  --defaultAdd --filename static-group2.ldif
```

3 **Verify the change by using `ldapsearch` and the `isMemberOf` attribute.**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  --baseDN dc=example,dc=com "(uid=rdaugherty)" isMemberOf
dn: uid=alangdon,ou=People,dc=example,dc=com
isMemberOf: cn=Directory Administrators2,ou=Groups,dc=example,dc=com
```

▼ To Create a Static Group With `groupOfEntries`

1 **Create the group entry in LDIF, including the group name (`cn`) and the `groupOfEntries` object class.**

This example shows an LDIF file, named `static-group3.ldif`, that defines the new group.

```
dn: cn=Directory Administrators3,ou=Groups,dc=example,dc=com
cn: Directory Administrators3
objectclass: top
objectclass: groupOfEntries
ou: Groups
member: uid=bfrancis,ou=People,dc=example,dc=com
member: uid=tjames,ou=People,dc=example,dc=com
member: uid=bparker,ou=People,dc=example,dc=com
```

2 **Add the group by using `ldapmodify` to apply the LDIF file.**

```
$ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  --defaultAdd --filename static-group3.ldif
```

3 **Verify the change by using `ldapsearch` and the `isMemberOf` attribute.**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  --baseDN dc=example,dc=com "(uid=bparker)" isMemberOf
dn: uid=bparker,ou=People,dc=example,dc=com
isMemberOf: cn=Directory Administrators3,ou=Groups,dc=example,dc=com
```

▼ To List All Members of a Static Group

You can use the `isMemberOf` virtual attribute to search for a group. The attribute is added to the user entry at the start of the search and then removed after the search has finished. This functionality provides easy management of groups with fast read access.

● **Use the `ldapsearch` command with the virtual attribute `isMemberOf`.**

This example searches for all users who are members of the group "Accounting Managers".

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  -b dc=example,dc=com \
  "(isMemberOf=cn=Accounting Managers,ou=Groups,dc=example,dc=com)"
dn: uid=scarter,ou=People,dc=example,dc=com
objectClass: person
objectClass: inetOrgPerson
objectClass: top
objectClass: organizationalPerson
ou: Accounting
ou: People
sn: Carter
```

```
facsimiletelephonenumber: +1 408 555 9751
roomnumber: 4612
userpassword: {SSHA}3KiJ51sx2Ug7DxZoq0vA9ZY6uaomevbJUBm7OA==
l: Sunnyvale
cn: Sam Carter
telephonenumber: +1 408 555 4798
givenname: Sam
uid: scarter
mail: scarter@example.com
dn: uid=tmorris,ou=People,dc=example,dc=com
objectClass: person
objectClass: inetOrgPerson
objectClass: top
objectClass: organizationalPerson
ou: Accounting
ou: People
sn: Morris
facsimiletelephonenumber: +1 408 555 8473
roomnumber: 4117
userpassword: {SSHA}bjFFHv6k1kbI6fZoCEfqmTj9XOZxWR06gxpKpQ==
l: Santa Clara
cn: Ted Morris
telephonenumber: +1 408 555 9187
givenname: Ted
uid: tmorris
mail: tmorris@example.com
```

▼ To List All Static Groups of Which a User Is a Member

- **Search using `ldapsearch` and the virtual attribute `isMemberOf`, as shown in the following example:**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  -b dc=example,dc=com "(uid=scarter)" isMemberOf
dn: uid=scarter,ou=People,dc=example,dc=com
isMemberOf: cn=Accounting Managers,ou=groups,dc=example,dc=com
```

▼ To Determine Whether a User is a Member of a Group

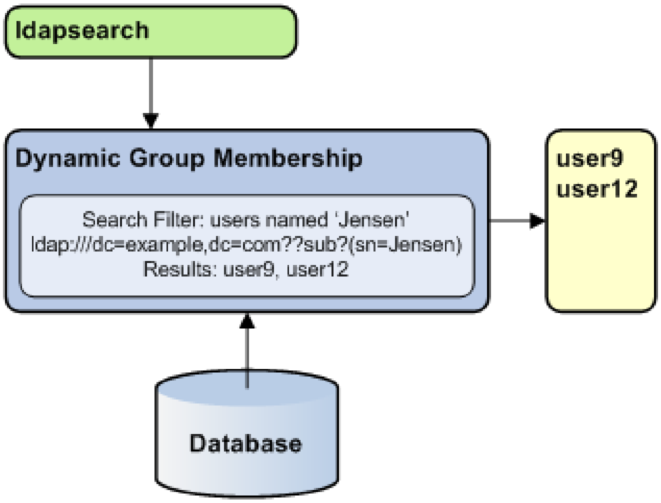
- **Search using `ldapsearch`, as shown in the following example:**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  -b "cn=Account Managers,ou=Groups,dc=example,dc=com" \
  "(&(objectclass=groupOfUniqueNames) \
  (uniquemember=uid=scarter,ou=People,dc=example,dc=com))"
dn: cn=Accounting Managers,ou=groups,dc=example,dc=com
objectClass: groupOfUniqueNames
objectClass: top
ou: groups
description: People who can manage accounting entries
cn: Accounting Managers
uniquemember: uid=scarter, ou=People, dc=example,dc=com
uniquemember: uid=tmorris, ou=People, dc=example,dc=com
```

Defining Dynamic Groups

A *dynamic group* is one whose membership, rather than being maintained explicitly in a list, is determined by search criteria using an LDAP URL. For example, suppose that you want to send an email to all managers in the `dc=example,dc=com` naming context. To do this, you create a dynamic group in which you specify `cn=Managers,ou=Groups,dc=example,dc=com`. You further specify that you want only email addresses returned. When the email application queries the directory for that particular group, the directory server computes the membership dynamically and returns the corresponding list of email addresses.

Dynamic groups use the `groupOfURLs` object class and the `memberURL` attribute to define LDAP URLs with the criteria (search base, scope, and filter) to be used for determining members of the group. The mechanism for determining whether a user is a member of a dynamic group is a constant-time operation, so it is just as efficient for groups with millions of members as it is for a group with only a few members. However, care must be taken when specifying the search criteria as it can adversely affect performance if searching over a large set of data.


ldapsearch
Dynamic Group Membership
Search Filter: users named 'Jensen'
ldap:///dc=example,dc=com??sub?(sn=Jensen)
Results: user9, user12
user9
user12
Database

To Create a Dynamic Group

1 **Create an LDIF file that specifies the group.**

This example specifies the dynamic group for employees located at Cupertino.

```
dn: cn=cupertinoEmployees,ou=Groups,dc=example,dc=com
cn: CupertinoEmployees
objectclass: top
objectclass: groupOfURLs
ou: Groups
memberURL: ldap:///ou=People,dc=example,dc=com??sub?(l=Cupertino)
```

2 **Add the group by using `ldapmodify` to process the LDIF file.**

```
$ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  --defaultAdd --filename dynamic_group.ldif
Processing ADD request for cn=cupertionEmployees,ou=Groups,dc=example,dc=com
ADD operation successful for DN cn=cupertionEmployees,ou=Groups,dc=example,dc=com
```

▼ To List All Members of a Dynamic Group

This procedure illustrates the use of the virtual attribute `isMemberOf`. Do not use this procedure for very large groups, because it adversely affects the directory server's performance.

● **Search using `ldapsearch` and the virtual attribute `isMemberOf`.**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  -b "dc=example,dc=com" \
"(isMemberOf=cn=cupertinoEmployees,ou=Groups,dc=example,dc=com)"
dn: uid=abergin,ou=People,dc=example,dc=com
objectClass: person
objectClass: inetOrgPerson
objectClass: top
objectClass: organizationalPerson
ou: Product Testing
ou: People
sn: Bergin
facsimiletelephonenumber: +1 408 555 7472
roomnumber: 3472
userpassword: {SSHA}YcDl0pHLxkd/ouW2jslAk1XaT5SiY4ium5qh8w==
l: Cupertino
cn: Andy Bergin
telephonenumber: +1 408 555 8585
givenname: Andy
uid: abergin
mail: abergin@example.com
...(more entries)...
```

▼ To List All Dynamic Groups of Which a User Is a Member

● **Search using `ldapsearch` and the virtual attribute `isMemberOf`.**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  -b dc=example,dc=com "(uid=abergin)" isMemberOf
dn: uid=abergin,ou=People,dc=example,dc=com
isMemberOf: cn=QA Managers,ou=groups,dc=example,dc=com
isMemberOf: cn=cupertinoEmployees,ou=Groups,dc=example,dc=com
```

▼ To Determine Whether a User Is a Member of a Dynamic Group

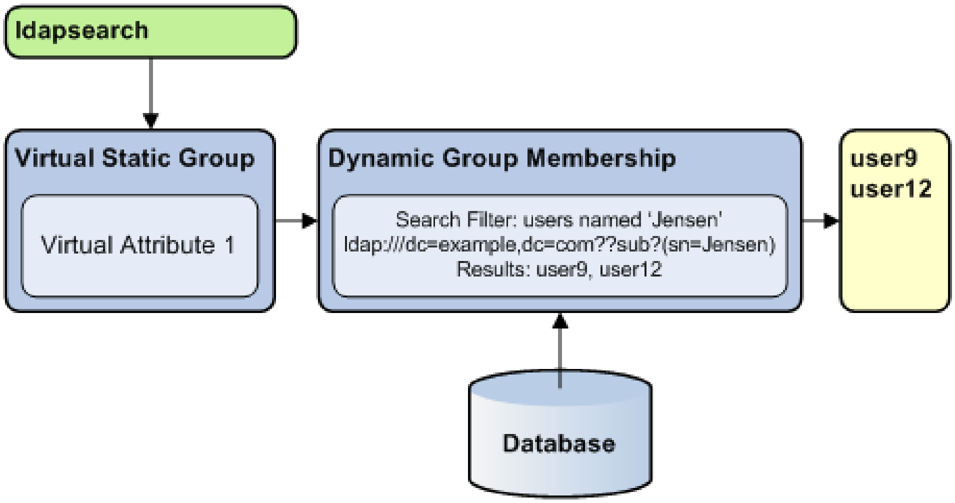
● **Search using `ldapsearch` and the virtual attribute `isMemberOf`.**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  -b dc=example,dc=com \
"(&(uid=abergin)(isMemberOf=cn=cupertinoEmployees,ou=Groups,dc=example,dc=com))"
dn: uid=abergin,ou=People,dc=example,dc=com
objectClass: person
```

```
objectClass: inetOrgPerson
objectClass: top
objectClass: organizationalPerson
ou: Product Testing
ou: People
sn: Bergin
facsimiletelephonenumber: +1 408 555 7472
roomnumber: 3472
userpassword: {SSHA}YcDl0pHLxkd/ouW2jslAk1XaT5SiY4ium5qh8w==
l: Cupertino
cn: Andy Bergin
telephonenumber: +1 408 555 8585
givenname: Andy
uid: abergin
mail: abergin@example.com
```

Defining Virtual Static Groups

A *virtual static group*, efficiently manages scalability for clients that can only support static groups. In a virtual static group, each entry behaves like a static group entry by using virtual attributes. The virtual attributes are dynamically determined when invoked, and the operations that determine group membership are passed to another group, such as a dynamic group, as shown in the following diagram.



Virtual static groups should include either the `groupOfNames` or `groupOfUniqueNames` object class but should not include the `member` or `uniqueMember` attribute. Virtual static groups should also contain the `ds-virtual-static-group` auxiliary object class and the `ds-target-group-dn` attribute. The `ds-target-group-dn` attribute is used to reference the actual group to mirror as a virtual static group and is used in place of the `member` or `uniquemember` attribute. For example:

```
dn: cn=Example Virtual Static Group,ou=Groups,dc=example,dc=com
objectClass: top
objectClass: groupOfUniqueNames
objectClass: ds-virtual-static-group
cn: Example Virtual Static Group
ds-target-group-dn: cn=Example Real Group,ou=Groups,dc=example,dc=com
```

Virtual static groups are most efficient when the application issues a search targeted at the membership attribute but does not actually retrieve the entire set of members. It is common for applications to use a filter such as the following to attempt to determine whether a user is a member of a given group:

```
(&(objectClass=groupOfUniqueNames)(uniqueMember=uid=john.doe,\
  ou=People,dc=example,dc=com))
```

For applications that retrieve the set of members, virtual static groups might not be ideal because the process of constructing the entire member list can be expensive.

▼ To Create a Virtual Static Group

1. **Create an LDIF file that specifies the group.**

   This sample file, `virtual-static.ldif`, specifies a virtual static group named `cupertinoEmployees`.

   ```
   dn: cn=virtualStatic,ou=Groups,dc=example,dc=com
   cn: Virtual Static
   objectclass: top
   objectclass: groupOfUniqueNames
   objectclass: ds-virtual-static-group
   ou: Groups
   ds-target-group-dn: cn=cupertinoEmployees,ou=Groups,dc=example,dc=com
   ```

2. **Add the group by using `ldapmodify` to process the LDIF file.**

   ```
   $ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password \
     --defaultAdd --filename virtual-static.ldif
   Processing ADD request for cn=virtualStatic,ou=Groups,dc=example,dc=com
   ADD operation successful for DN cn=virtualStatic,ou=Groups,dc=example,dc=com
   ```

▼ To List All Members of a Virtual Static Group

Virtual static groups are best used in cases where the search is targeted at the membership attribute. This procedure is therefore not recommended but is included to show how to access the list.

This example procedure uses the dynamic group, `cupertinoEmployees`, created in the previous example.

- **Search using `ldapsearch` and the virtual attribute `isMemberOf`.**

  ```
  $ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
    -b dc=example,dc=com "(isMemberOf=cn=virtualStatic,ou=Groups,dc=example,dc=com)"
  dn: uid=abergin,ou=People,dc=example,dc=com
  ```

```
objectClass: person
objectClass: inetOrgPerson
objectClass: top
objectClass: organizationalPerson
ou: Product Testing
ou: People
sn: Bergin
facsimiletelephonenumber: +1 408 555 7472
roomnumber: 3472
userpassword: {SSHA}YcDl0pHLxkd/ouW2jslAk1XaT5SiY4ium5qh8w==
l: Cupertino
cn: Andy Bergin
telephonenumber: +1 408 555 8585
givenname: Andy
uid: abergin
mail: abergin@example.com
...(more entries)...
```

▼ To List All Virtual-Static Groups of Which a User Is a Member

- **Search using `ldapsearch` and the virtual attribute `isMemberOf`.**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  -b dc=example,dc=com "(uid=abergin)" isMemberOf
dn: uid=abergin,ou=People,dc=example,dc=com
isMemberOf: cn=QA Managers,ou=groups,dc=example,dc=com
isMemberOf: cn=cupertinoEmployees,ou=Groups,dc=example,dc=com
isMemberOf: cn=virtualStatic,ou=Groups,dc=example,dc=com
```

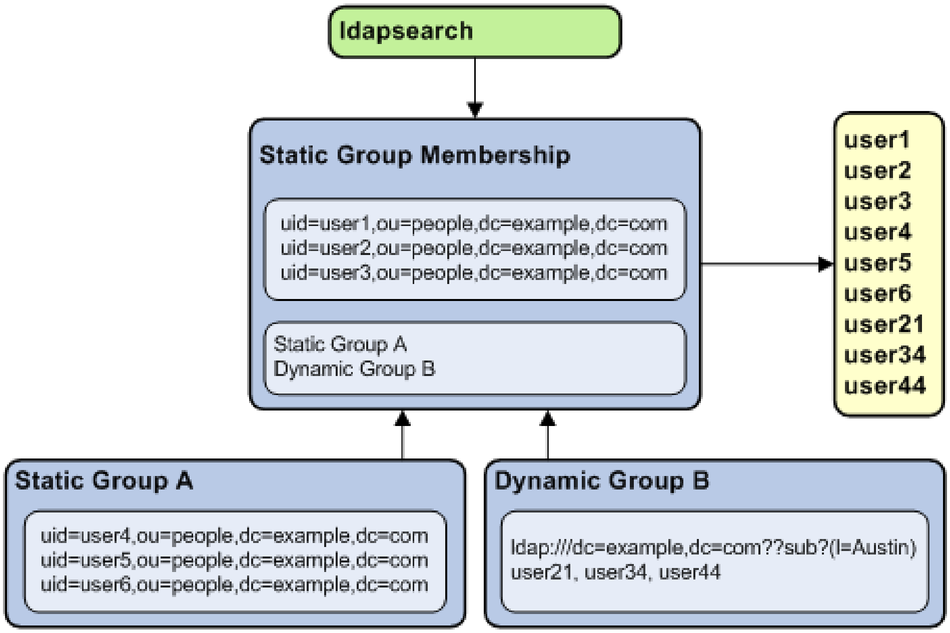
▼ To Determine Whether a User is a Member of a Virtual Static Group

- **Search using `ldapsearch` and the `uniqueMember` attribute.**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  -b "cn=virtualStatic,ou=Groups,dc=example,dc=com" \
  "(&(objectclass=groupOfUniqueNames) \
  (uniquemember=uid=abergin,ou=People,dc=example,dc=com))"
dn: cn=virtualStatic,ou=Groups,dc=example,dc=com
objectClass: groupOfUniqueNames
objectClass: top
objectClass: ds-virtual-static-group
ou: Groups
ds-target-group-dn: cn=cupertinoEmployees,ou=Groups,dc=example,dc=com
cn: Virtual Static
cn: virtualStatic
```

Defining Nested Groups

Groups can be nested, where one group is defined as a child group entry whose DN is listed within another group, its parent. The nesting of groups allows you to set up inherited group memberships when performance is not a priority. You can add zero or more member attributes with their values set to the DNs of nested child groups, including both static and dynamic groups.


ldapsearch
Static Group Membership
uid=user1,ou=people,dc=example,dc=com
uid=user2,ou=people,dc=example,dc=com
uid=user3,ou=people,dc=example,dc=com
Static Group A
Dynamic Group B
user1
user2
user3
user4
user5
user6
user21
user34
user44
Static Group A
uid=user4,ou=people,dc=example,dc=com
uid=user5,ou=people,dc=example,dc=com
uid=user6,ou=people,dc=example,dc=com
Dynamic Group B
ldap:///dc=example,dc=com??sub?(l=Austin)
user21, user34, user44

▼ To Create a Nested Group

This example procedure creates a nested group using one static group and one dynamic group.

1 **Create an LDIF file that specifies a static group.**

This example file, `static-group.ldif`, specifies a virtual static group named `Dev Contractors`.

```
dn: cn=Contractors,ou=Groups,dc=example,dc=com
cn: Dev Contractors
objectclass: top
objectclass: groupOfUniqueNames
ou: Dev Contractors Static Group
uniquemember: uid=wsmith,ou=Contractors,dc=example,dc=com
uniquemember: uid=jstearn,ou=Contractors,dc=example,dc=com
uniquemember: uid=pbrook,ou=Contractors,dc=example,dc=com
uniquemember: uid=njohnson,ou=Contractors,dc=example,dc=com
uniquemember: uid=sjones,ou=Contractors,dc=example,dc=com
```

2 **Add the group by using `ldapmodify` to process the LDIF file.**

```
$ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  --defaultAdd --filename static-group.ldif
```

3 **Create an LDIF file that specifies a dynamic group.**

This example file, dynamic-group.ldif, specifies a dynamic group named Developers.

```
dn: cn=Developers,ou=Groups,dc=example,dc=com
cn: Developers
objectclass: top
objectclass: groupOfURLs
ou: Groups
memberURL: ldap:///ou=People,dc=example,dc=com??sub?(ou=Product Development)
```

4 **Add the group by using ldapmodify to process the LDIF file.**

```
$ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  --defaultAdd --filename dynamic-group.ldif
```

5 **Create an LDIF file that specifies a nested static group.**

This example file, nested-group.ldif, specifies a nested group named Developers Group.

```
dn: cn=DevelopersGroup,ou=Groups,dc=example,dc=com
cn: Developers Group
objectclass: top
objectclass: groupOfUniqueNames
ou: Nested Static Group
uniquemember: cn=Contractors,ou=Groups,dc=example,dc=com
uniquemember: cn=Developers,ou=Groups,dc=example,dc=com
```

6 **Add the group by using ldapmodify to process the LDIF file,**

```
$ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  --defaultAdd --filename nested-group.ldif
```

Maintaining Referential Integrity

Referential integrity is a database mechanism for ensuring that all references are properly maintained after delete, rename, or move operations. For example, if an entry is removed from the directory, the directory server also removes the entry from any groups of which the entry is listed as a member.

The referential integrity mechanism is configured as a plug-in in the directory server and can be enabled using the dsconfig command. For more information, see "Managing the Server Configuration With dsconfig" on page 25.

Overview of the Referential Integrity Plug-In

By default, the referential integrity plug-in is disabled. When you enable the plug-in by using dsconfig, it performs integrity updates on the member and uniquemember attributes immediately after a delete, rename, or move operation. Whenever you delete, rename, or move a user or group entry in the directory, the operation is logged to the referential integrity log file, *instance-dir*/OUD/logs/referint.

After a specified time, known as the *update interval*, the server performs a search on the specified attributes and matches the results with the DNs of the deleted or modified entries recorded in the log. If the log file shows that an entry was deleted, the corresponding attribute is deleted. If the log file shows that an entry was changed, the corresponding attribute value is modified accordingly.

You can configure the properties of the referential integrity plug-in to suit your requirements. The following properties can be configured:

- **Enabled**. Turn on the referential integrity plug-in.
- **plugin type**. By default, the delete, rename, and move operations are set. You can change a plug-in type to only delete, for example.
- **Attribute type**. By default, the attribute types are set to `member,uniquemember` but can be changed to some other attribute. If you use or define attributes containing DN values, you can use the referential integrity plug-in to monitor these attributes.
- **Base-DN**. By default, the scope is to use all public naming contexts but this can be changed to a specific context.
- **Log file**. By default, `logs/referint` is the log file. You can record the referential integrity updates in a different file. For example, if you want to record changes in a replicated environment, you can write to the *changelog* file on a replication server, so that it can be replicated to a consumer server.
- **Update interval**. By default, the update interval is set to 0 seconds, which will run referential integrity immediately after a delete, rename, or move operation. To minimize the impact of the updates on system performance, increase the amount of time between updates. Typical update intervals are as follows:
  - 0 seconds, update immediately
  - 90 seconds (updates every 90 seconds)
  - 3600 seconds (updates every hour)
  - 10,800 seconds (updates every 3 hours)
  - 28,800 seconds (updates every 8 hours)
  - 86,400 seconds (updates once a day)
  - 604,800 seconds (updates once a week)

▼ To Enable the Referential Integrity Plug-In

● **Set the `enabled` property of the plug-in to true.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-plugin-prop \
  --plugin-name "Referential Integrity" --set enabled:true
```

Simulating ODSEE Roles in an Oracle Unified Directory Server

Oracle Directory Server Enterprise Edition (ODSEE) includes a roles subsystem that is used to provide a specialized type of grouping mechanism. This capability is not included directly in Oracle Unified Directory, because it is based on non-standard functionality, uses Netscape-proprietary schema elements, and is not widely used in LDAP-enabled applications.

However, Oracle Unified Directory does provide all of the functionality offered by ODSEE roles, and this functionality is available for use with standard grouping mechanisms. If you have an application that was specifically written to rely on the roles functionality available in ODSEE and cannot work with standard grouping mechanisms, you can configure Oracle Unified Directory to simulate ODSEE roles to satisfy such applications.

Note – If your application needs to create and destroy role entries (for example, an entry containing one of the subordinates of the `nsRoleDefinition` object class), that functionality is currently not available in Oracle Unified Directory.

▼ To Determine Whether a User is a Member of a Role

If the application needs only to determine whether a user is a member of a given role, it should only need to look at the `nsRole` attribute in the target user's entry to determine whether the DN of the appropriate role is present. In this case, you can simulate role functionality by following these steps.

After these steps are completed, the `nsRole` virtual attribute appears as an operational attribute in user entries, and should include the DNs of all groups in which that user is a member. Note that `nsRole` is an operational attribute, and must be explicitly requested for it to be returned in search results. You must also ensure that the authenticated user has permission to see that attribute.

1. **Update the directory server to include the necessary schema for the ODSEE roles implementation.**

   This schema is provided in the LDIF file named `03-dsee-roles.ldif`.

   - **Either copy the file into the `config/schema` directory of the directory server implementation and restart the server, or**

   - **Use the `add schema file` task to cause the server to load the schema file into a running server instance.**

2. **Create a static or dynamic group to define role membership.**

   Make sure that the group has an appropriate set of members.

3 **Create a new instance of the `isMemberOf` virtual attribute to provide the `nsRole` virtual attribute.**

The `nsRole` attribute will include a list of the DNs of all groups in which the target user is a member. Use the `dsconfig` command to create the virtual attribute, as follows:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  create-virtual-attribute \
  --type is-member-of --name nsRole --set attribute-type:nsRole --set enabled:true
```

▼ To Alter Membership by Using the `nsRoleDN` Attribute

Follow this procedure if the application you are using expects to be able to alter membership by placing the name of the corresponding role in the `nsRoleDN` virtual attribute in a user's entry.

After these steps are completed, any user entry that contains an `nsRoleDN` value of "`cn=Test Role,ou=Roles,dc=example,dc=com`" also has that DN present in the `nsRole` operational attribute.

1 **Create a dynamic group entry with the DN of the desired role.**

2 **Configure the group to include members that contain an `nsRoleDN` attribute with a value equal to the DN of the target role.**

For example, if the application is going to add an `nsRoleDN` value of "`cn=Test Role,ou=Roles,dc=example,dc=com`", add the following entry:

```
dn: cn=Test Role,ou=Roles,dc=example,dc=com
objectClass: top
objectClass: groupOfURLs
cn: Test Role
memberURL: ldap:///dc=example,dc=com??sub?(nsRoleDN=\
  cn=Test Role,ou=Roles,dc=example,dc=com)
```

CHAPTER 11

Managing Password Policies

A *password policy* is a set of rules governing the use of passwords in the system and is an integral component of any security strategy employed for your directory.

Oracle Unified Directory includes a default password policy for general users and a default root users password policy. These default password policies reside in the directory server's configuration and can be modified. Oracle Unified Directory supports multiple password policies, so you can create and configure specialized password policies for a specific set of users in addition to using the default password policies.

This chapter outlines the components of password policies and provides procedures to configure and manage password policies. The chapter covers the following topics:

Password Policy Components

All password policies involve the following configurable components:

- **Password complexity requirements**. Specifies the composition of the password and its required number of characters. Typically, you would specify the minimum number of characters used in a password, the type of characters allowed, and the required number of numeric characters. For example, many institutions require a minimum of seven or eight characters, one numeral, one special character, as well as a mix of uppercase and lowercase letters.
- **Password history**. Determines the number of unique passwords a user must use before an old password can be reused.

- **Maximum password age**. Determines how long a password can be used before the user is allowed or required to change it.
- **Minimum password age**. Determines how long a new password must be kept before the user can change it.
- **First Login**. Determines if the user will be required to change his password upon first logging in to the system.
- **Authorized password change**. Refers to the conditions under which a user can change his password. For example, before a user can change his password, the server can be configured to require the user to enter his current password to authenticate his identity before entering a new password.
- **Account lockout**. Determines the conditions under which an account is disabled for access by the user. For example, if a user fails to properly authenticate after three attempts, then the server can be configured to lock the account on the fourth attempt. The administrator will be required to manually unlock the account for user.
- **Password storage scheme**. Determines how the password is to be encrypted and stored on the server. You can configure storage schemes for certain accounts on the server. For example, root user passwords require strong encryption due to the importance of the account and its privileges. Thus, you can configure the use the SSHA-512 storage scheme to store root user passwords.

The Default Password Policy

The Default Password Policy includes a number of configurable properties. These are listed in the following table.

Property	Description
`account-status-notification-handler`	The account status notification handler is used to send messages when events occur during the course of password policy processing. This property specifies the DNs of the account status notification handlers that should be used for this password policy.
`allow-expired-password-changes`	Not Recommended. Indicates whether users are allowed to change their passwords after the passwords have expired. The user needs to issue the request anonymously and include the current password in the request. If this property is enabled, this feature uses the Password Modify Extended Operation, which is enabled by default at initial configuration.
`allow-user-password-changes`	Indicates whether users are allowed to change their own passwords if they have access control rights to do so.

Property	Description
`default-password-storage-scheme`	Specifies the DNs for the password storage schemes that are used to encode clear-text passwords for this password policy.
`deprecated-password-storage-scheme`	Specifies the DNs for password storage schemes that are considered deprecated for this password policy. If a user with this password policy authenticates to the server and his password is encoded with any deprecated schemes, those values are removed and replaced with values encoded using the default password storage scheme.
`expire-password-without-warning`	Indicates whether user passwords are allowed to expire even if the user has not yet seen a password expiration warning. If this is set to `false`, the user is always guaranteed to see at least one warning message even if the password expiration time has passed. The expiration time will be reset to the current time plus the warning interval (`ds-cfg-password-expiration-warning-interval`).
`force-change-on-add`	Indicates whether users are required to change their passwords the first time they use their accounts and before they are allowed to perform any other operation.
`force-change-on-reset`	Indicates whether users are required to change their passwords after an administrative password reset and before they are allowed to perform any other operation.
`grace-login-count`	Specifies the maximum number of grace logins that a user should be given. A grace login makes it possible for a user to authenticate to the server even after the password has expired, but the user is not allowed to do anything else until he has changed his password.
`idle-lockout-interval`	Specifies the maximum length of time that a user account can remain idle (that is, that the user may go without authenticating to the directory) before the server locks the account. This action is enforced if `last login time` tracking is enabled and if the `idle lockout interval` is set to a nonzero value.

Property	Description
`last-login-time-attribute`	Specifies the name of the attribute in the user's entry that is used to hold the last login time for the user. If this is provided, the specified attribute must either be defined as an operational attribute in the server schema, or it must be allowed by at least one of the object classes in the user's entry. The `ds-pwp-last-login` operational attribute has been defined for this purpose. Last login time tracking is only enabled if the `ds-cfg-last-login-time-attribute` and `ds-cfg-last-login-time-format` attributes have been configured for the password policy.
`last-login-time-format`	Specifies the format string that should be used to generate the last login time values. This can be any valid format string that can be used in conjunction with the `java.text.SimpleDateFormat` class. Note that for performance reasons, it might be desirable to configure this attribute so that it only stores the date (format: yyyyMMdd) and not the time of the last login. Then, it only needs to be updated once per day, rather than each time the user may authenticate. Last login time tracking is only enabled if the `ds-cfg-last-login-time-attribute` and `ds-cfg-last-login-time-format` attributes have been configured for the password policy.
`lockout-duration`	Specifies the length of time that a user account should remain locked due to failed authentication attempts before it is automatically unlocked. A value of "`0 seconds`" indicates that any locked accounts are not automatically unlocked and must be reset by an administrator.
`lockout-failure-count`	Specifies the number of authentication failures required to lock a user account, either temporarily or permanently. A value of zero indicates that automatic lockout is not enabled.
`lockout-failure-expiration-interval`	Specifies the maximum length of time that a previously failed authentication attempt should be counted toward a lockout failure. Note that the record of all previous failed attempts is always cleared upon a successful authentication. A value of "`0 seconds`" indicates that failed attempts are never automatically expired.

Property	Description
`max-password-age`	Specifies the maximum length of time that a user is allowed to keep the same password before choosing a new one. This is often known as the *password expiration interval*. A value of "`0 seconds`" indicates that passwords never expire. If the `ds-cfg-expire-passwords-without-warning` attribute is set to `false`, the effective password expiration time is recalculated to be the time at which the first warning is received, plus the warning interval (`ds-cfg-password-expiration-warning-interval`). This behavior ensures that a user always has the full configured warning interval to change his password.
`max-password-reset-age`	Specifies the maximum length of time that users are allowed to change their passwords after they have been administratively reset and before they are locked out. This is only applicable if the `ds-cfg-force-change-on-reset` attribute is set to `true`. A value of "`0 seconds`" indicates that there are no limits on the length of time that users have to change their passwords after administrative resets.
`min-password-age`	Specifies the minimum length of time that a user is required to have a password value before it can be changed again. Providing a nonzero value ensures that users are not allowed to repeatedly change their passwords in order to flush their previous password from the history so it can be reused.
`password-attribute`	Specifies the attribute in the user's entry that holds the encoded passwords for the user. The specified attribute must be defined in the server schema, and it must have either the user password syntax or the authentication password syntax. Typically, you enter "userPassword" for the User Password syntax (OID: `1.3.6.1.4.1.26027.1.3.1`). You can also specify, if your server supports it, the value `authPassword` for the authenticated password syntax (OID: `1.3.6.1.4.1.4203.1.1.2`).

Property	Description
`password-change-requires-current-password`	Indicates whether users are required to provide their current password when setting a new password. If this is set to `true`, then users are required to provide their current password when changing their existing password. This may be done using the password modify extended operation, or using a standard LDAP modify operation by deleting the existing password value and adding the new password value in the same modify operation.
`password-expiration-warning-interval`	Specifies the length of time before the password expires that the users should start to receive notification that it is about to expire. This must be given a nonzero value if the `ds-cfg-expire-passwords-without-warning` attribute is set to `false`.
`password-generator`	Specifies the DN for the password generator that should be used in conjunction with this password policy. The password generator is used in conjunction with the password modify extended operation to provide a new password for cases in which the client did not include one in the request. If no password generator DN is specified, then the password modify extended operation does not automatically generate passwords for users.

Property	Description
`password-history-count`	Specifies the maximum number of password values that should be maintained in the password history. Whenever a user's password is changed, the server checks the proposed new password against the current password and all passwords stored in the history. If a match is found, then the user is not allowed to use that new password. A value of zero indicates either that the server should not maintain a password history (that is, the password history duration has a value of "`0 seconds`") or that the password history list should be based entirely on duration and no maximum count should be enforced (that is, the password history duration has a value other than "`0 seconds`"). Note that if an administrator reduces the configured password history count to a smaller (but still nonzero) value, each user entry containing password history state information is not impacted until a password change is processed for that user. At that time, any excess history state values is purged from the entry. If the history count is reduced to zero and the password history duration is also set to "0 seconds," any state information in the user's entry is retained in case the feature is re-enabled.
`password-history-duration`	Specifies the maximum length of time that a formerly used password should remain in effect in the user's password history. Whenever a user's password is changed, the server checks the proposed new password against the current password and all passwords stored in the history. If a match is found, the user is not allowed to use that new password. A value of "`0 seconds`" indicates either that the server should not maintain a password history (that is, the password history count has a value of "`0`") or that the password history list should be based entirely on count and no maximum duration should be enforced (that is, the password history count has a value other than "`0`").
`password-validator`	Specifies the DNs for password validators that should be used in conjunction with this password policy. The password validators are invoked whenever a user attempts to provide a new password in order to determine whether that new password is acceptable.

Property	Description
`previous-last-login-time-format`	Specifies the format string that was used in the past for older last login time values. This value is not necessary unless the last login time feature is enabled and the format in which the values are stored has been changed.
`require-change-by-time`	Specifies a time by which all users with this password policy are required to change their passwords. This option works independently of password expiration (that is, force all users to change their passwords at some point even if password expiration is disabled).
`require-secure-authentication`	Indicates whether users with this password policy are required to authenticate in a secure manner using a secure communication mechanism like SSL, or a secure SASL mechanism like DIGEST-MD5, EXTERNAL, or GSSAPI that does not expose the password in the clear.
`require-secure-password-changes`	Indicates whether users with this password policy are required to make password changes in a secure manner, such as over a secure communication channel like SSL.

To View the Properties of the Default Password Policy

You can view the properties of the default password policy by using the `dsconfig` command, or by using ODSM.

- Run the following `dsconfig` command to view the properties of the default password policy:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  get-password-policy-prop \
  --policy-name "Default Password Policy"

Property                                   : Value(s)
-------------------------------------------:-------------------------
account-status-notification-handler       : -
allow-expired-password-changes             : false
allow-user-password-changes                : true
default-password-storage-scheme            : Salted SHA-1
deprecated-password-storage-scheme         : -
expire-passwords-without-warning           : false
force-change-on-add                        : false
force-change-on-reset                      : false
grace-login-count                          : 0
idle-lockout-interval                      : 0 s
last-login-time-attribute                  : -
last-login-time-format                     : -
lockout-duration                           : 0 s
lockout-failure-count                      : 0
```

```
lockout-failure-expiration-interval       : 0 s
max-password-age                          : 0 s
max-password-reset-age                    : 0 s
min-password-age                          : 0 s
password-attribute                        : userpassword
password-change-requires-current-password : false
password-expiration-warning-interval      : 5 d
password-generator                        : Random Password Generator
password-history-count                    : 0
password-history-duration                 : 0 s
password-validator                        : -
previous-last-login-time-format           : -
require-change-by-time                    : -
require-secure-authentication             : false
require-secure-password-changes           : false
```

- To view the properties of the default password policy by using ODSM, do the following:
  - Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
  - Select the **Security** tab.
  - Expand the **Password Policy** element.
  - Select **Default Password Policy**.

    The password policy properties, and their values, are displayed in the right-hand pane.

Password Policies in a Replicated Environment

All password policies reside in the directory server configuration (under `cn=config`). Configuration information is not replicated and is specific to each directory server instance. If you modify the default password policy, you must make the same changes on each directory server instance in a replicated topology. Similarly, specialized password policies are not replicated to other directory servers.

Additional considerations for using password policies in replicated environments include the following:

- The directory server replicates all password information (current password, password history, password expiration) that is stored in the user entry.
- If a user changes his password, the new password might take a while to be updated on all replicas.
- A user might receive multiple password expiration warnings, one from each replicated server.

Configuring Password Policies by Using the Command Line

The easiest way to configure a password policy is to by using the `dsconfig` command to manage the existing password policies and to modify the password policy properties. The following examples use `dsconfig` to modify various properties of the password policy.

EXAMPLE 11–1 Configuring Account Lockout

The following account lockout features can be configured:

- **Lockout failure count.** Specifies the number of authentication failures required to lock a user account.
- **Lockout duration.** Determines the length of time that the account is in a locked state after failed authentication attempts. After the duration time, the account is automatically unlocked. A value of zero indicates that the account is not be automatically unlocked.
- **Lockout failure expiration interval.** Determines the maximum length of time that a previously failed authentication attempt should be counted toward a lockout failure. A value of zero indicates that failed attempts never automatically expire.
- **Idle lockout interval.** Specifies the maximum length of time that a user account can go without authenticating to the directory before the server locks the account. This property is enforced if the `last-login-time` is enabled and `idle-lockout-interval` is set to a nonzero value.

The following command sets the account lockout properties for the default password policy.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-password-policy-prop \
  --policy-name "Default Password Policy" --set "lockout-failure-count:3" \
  --set "lockout-duration:15 minutes" --set "idle-lockout-interval:90 days" \
  --set "lockout-failure-expiration-interval:10 minutes"
```

EXAMPLE 11–2 Configuring Last Login

Last login is a basic security feature that helps the user to keep track of the login history. The directory server provides an operational attribute, `ds-pwp-last-login`, that holds the user's last login time. If you specify another attribute, the operational attribute must be defined in the server schema, or it must be allowed by at least one of the object classes in the user's entry.

The `last-login-time-format` property determines the time format. If the time format has changed and last login is enabled, the `previous-last-login-time-format` property is used.

The following command sets the last login properties for the default password policy.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-password-policy-prop \
  --policy-name "Default Password Policy" \
  --set "last-login-time-attribute:ds-pwp-last-login-time" \
  --set "last-login-time-format:yyyyMMdd" \
```

EXAMPLE 11–2 Configuring Last Login *(Continued)*

```
  --set "previous-last-login-time-format:yyyyMMdd"
```

EXAMPLE 11–3 Configuring Password History Count and Duration

The `password-history-count` property specifies the number of past passwords that should be maintained in the history. A value of zero indicates that the server does not maintain a password history.

The `password-history-duration` property specifies the maximum length of time that a previously used password should remain in the user's password history. A value of `0 seconds` indicates that the server should not maintain a password history.

The following command configures password history count and duration for the default password policy.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-password-policy-prop \
  --policy-name "Default Password Policy" --set "password-history-count:3" \
  --set "password-history-duration:5 seconds"
```

▼ To Create a New Password Policy

You can configure and store multiple password policies with different configuration options. When you set up a directory server instance, the instance uses the default password policy and applies it to all user entries, except root users (for example, the `cn=Directory Manager` account).

You can change the default password policy or you can create new password policies for specific groups in your directory. If a specific property is not present in a password policy, the server reads that property from the default password policy, in other words, all password policies inherit their default values from the default password policy.

The following command creates a new password policy and sets the `default-password-storage-scheme`, `lockout-duration`, `lockout-failure-count`, and `password-change-requires-current-password` properties. The remaining properties are inherited from the default Password Policy.

- **Use the `dsconfig` command to create a new password policy, as follows:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  create-password-policy \
  --policy-name "Temp Password Policy" --set password-attribute:userPassword \
  --set default-password-storage-scheme:"Salted SHA-1" \
  --set lockout-duration:300s --set lockout-failure-count:3 \
  --set password-change-requires-current-password:true
```

▼ To Create a First Login Password Policy

The First Login Password Policy is a specialized password policy that requires a user to change his password when first logging in to the system. Typically, an administrator sets up a new temporary password for newly created accounts, and the user is required to create his password after first logging in with the temporary password.

- **Use the `dsconfig` command to create a first login password policy.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  create-password-policy \
  --policy-name "First Login Password Policy" --set password-attribute:userpassword \
  --set default-password-storage-scheme:"Salted SHA-1" \
  --set allow-user-password-changes:true --set force-change-on-add:true \
  --set force-change-on-reset:true --set expire-password-without-expiration:false \
  --set password-expiration-warning-interval:86400 \
  --set min-password-age:0 --set max-password-age:259200 --set lockout-duration:3600 \
  --set lockout-failure-count:3 --set password-change-requires-current-password:true
```

▼ To Assign a Password Policy to an Individual Account

You can assign a password policy to an individual by adding the `ds-pwp-password-policy-dn` attribute to the user's entry. The server then uses the configured password policy for that user.

1. **Use `ldapmodify` to add the `ds-pwp-password-policy-dn` attribute.**

```
$ ldapmodify --h localhost -p 1389 -D "cn=Directory Manager" -w password \
dn: uid=mgarcia,ou=Contractors,dc=example,dc=com
changetype: modify
add: ds-pwp-password-policy-dn
ds-pwp-password-policy-dn: cn=Temp Password Policy,cn=Password Policies,cn=config
```

2. **Verify the entry by using `ldapsearch`.**

```
$ ldapsearch -h localhost -p 1389 -D "cn=Directory Manager" -w password \
  -b "dc=example,dc=com" -s sub "(uid=mgarcia)" ds-pwp-password-policy-dn
```

▼ To Prevent Password Policy Modifications

To prevent users from modifying their password policy, you must add an ACI to the root entry.

- **Use the `ldapmodify` command with the specific ACI.**

```
$ ldapmodify -h localhost -p 1389 -D "cn=Directory Manager" -w password \
dn: dc=example,dc=com
changetype: modify
add: aci
aci: (targetattr != "passwordPolicySubentry")(version 3.0; acl "Allow self
modification except for passwordPolicySubentry";
allow (write) (userdn = "ldap:///self");)
```

▼ To Assign a Password Policy to a Group of Users

You can assign a password policy to a group of users by adding a virtual attribute that automatically assigns the `ds-pwp-password-policy-dn` attribute to all user entries that match the criteria associated with that virtual attribute. The criteria can be based entirely or in part on the group membership for a user.

- **Use `dsconfig` to create a virtual attribute that adds a password policy to a group of users.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  create-virtual-attribute \
  --name "Add PWPolicy to Admins" --type user-defined --set enabled:true \
  --set attribute-type:ds-pwp-password-policy-dn \
  --set group-dn:cn=Admins,ou=Groups,dc=example,dc=com \
  --set conflict-behavior:real-overrides-virtual \
  --set value:"cn=Admins PWPolicy,cn=Password Policies,cn=config"
```

▼ To Delete a Password Policy

You can delete any password policy, except the Default Password Policy and the Default Root User Policy, from the directory when it is no longer needed.

In practice, first check the users who have the password policy you plan to delete, move them to a new password policy, and then remove the old password policy. If a password policy is deleted, any users who have a deleted password policy continue to have the `ds-pwd-password-policy-dn` pointing to the old password policy. The server returns an error when any requests to access the entry occur.

- **Use `dsconfig` to delete a password policy.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  delete-password-policy --policy-name "Temp Password Policy"
```

Configuring Password Policies by Using Oracle Directory Services Manager

You can use ODSM to manage password policies, as described in the following sections.

List the Configured Password Policy Subentries

You can display all password policy subentries that are configured in the server by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Security** tab.
3. Expand the **Password Policy Subentry** element.

   The DNs of all password policy subentries are listed.
4. To display the details of a password policy subentry, select its DN.

   The password policy subentry properties are displayed in the right hand pane.
5. To modify any aspect of the password policy subentry, change the required value and click **Apply**.

For a description of all possible properties, and their values, see the *Oracle Unified Directory Configuration Reference*.

Create a Password Policy Subentry

You can create a new password policy subentry by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Security** tab.
3. Expand the **Password Policy Subentry** element.
4. Click the **Add** icon.

   The password policy subentry properties are displayed in the right hand pane.
5. On the **Create new password policy subentry** screen, complete the required fields.

   For a description of all possible properties, and their values, see the *Oracle Unified Directory Configuration Reference*.
6. When you have completed configuring the password policy subentry, click **Create**.

Create a Password Policy Subentry Based on an Existing Password Policy Subentry

You can create a new password policy subentry that is based on an existing password policy subentry by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Security** tab.
3. Expand the **Password Policy Subentry** element.
4. Select the password policy subentry on which you want to base the new subentry.
5. Click the **Add like** icon.

   The properties of the original password policy subentry are displayed in the right hand pane.
6. Modify the required values.

   For a description of all possible properties, and their values, see the *Oracle Unified Directory Configuration Reference*.
7. When you have completed configuring the new password policy subentry, click **Create**.

Delete a Password Policy Subentry

You can delete a password policy subentry by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Security** tab.
3. Expand the **Password Policy Subentry** element.
4. Select the password policy subentry that you want to deleted.
5. Click the **Delete** icon.

   You are prompted to confirm the deletion. Click **OK**.

Display the Configured Password Policies

You can display the list of password policies by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Security** tab.
3. Expand the **Password Policy** element.

The list of configured password policies is displayed.

4. Select a password policy to display its properties in the right hand pane.

For a description of all possible properties, and their values, see the *Oracle Unified Directory Configuration Reference*.

Modify a Password Policy

You can modify a configured password policy by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Security** tab.
3. Expand the **Password Policy** element.

   The list of configured password policies is displayed.
4. Select the password policy whose properties you want to modify.

For a description of all possible properties, and their values, see the *Oracle Unified Directory Configuration Reference*.

Create a Password Policy

You can create a new password policy by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Security** tab.
3. Expand the **Password Policy** element.
4. Click the **Add** icon.
5. On the **Create New Password Policy** screen, configure the required properties.

   For a description of all possible properties, and their values, see the *Oracle Unified Directory Configuration Reference*.
6. When you have configured the new password policy, click **Create**.

Create a Password Policy Based on an Existing Password Policy

You can create a new password policy that is based on an existing password policy by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Security** tab.
3. Expand the **Password Policy** element.
4. Select the password policy on which you want to base the new policy.
5. Click the **Add like** icon.
6. On the **Create New Password Policy** screen, modify the properties to create the new policy.

   For a description of all possible properties, and their values, see the *Oracle Unified Directory Configuration Reference*.
7. When you have configured the new password policy, click **Create**.

Delete a Password Policy

You can delete a password policy by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Security** tab.
3. Expand the **Password Policy** element.
4. Select the password policy that you want to delete.
5. Click the **Delete** icon.
6. Click **OK** to confirm the deletion.

Display the Supported Password Validators

A password validator is a component of the password policy that determines whether a proposed password is acceptable for use. Oracle Unified Directory provides the following password validators:

- **Similarity-Based Password Validator.** Used to reject a password if it is too similar to the user's current password.
- **Dictionary.** Used to reject a password if it is a word that can be found in a dictionary.
- **Character Set.** Used to reject a password if the value does not contain characters from an acceptable range of character sets.

- **Attribute Value.** Used to reject a password if the value exists in any of the attributes contained in the user's entry.
- **Unique Characters.** Use to reject a password if it does not contain enough unique characters.
- **Repeated Characters.** Used to reject a password if it contains a string of too many repeated characters.
- **Length-Based Password Validator.** Used to reject a password if it is too long or too short.

You can use ODSM to display the list of password validators, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Security** tab.
3. Expand the **Password Validators** element.
4. The list of password validators is displayed.

Enable or Disable a Password Validator

You can use ODSM to enable or disable a password validator, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Security** tab.
3. Expand the **Password Validators** element.
4. Select the password validator that you want to enable or disable.
5. In the right hand pane, check or uncheck the **Enabled** box, as required.
6. Click **Apply** to save your changes.

Display the Supported Password Storage Schemes

A password storage scheme provides a mechanism for encoding user passwords for storage in the server. In most cases, the password is encoded in a manner that prevents users from determining what the clear-text password is, while still allowing the server to determine whether the user-supplied password is correct. Oracle Unified Directory supports a number of password storage schemes. For more information, see "password storage scheme" in *Oracle Fusion Middleware Glossary for Oracle Unified Directory*.

You can use ODSM to display the list of password storage schemes, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Security** tab.
3. Expand the **Password Storage** element.

4. The list of password storage schemes is displayed.

Enable or Disable a Password Storage Scheme

You can use ODSM to enable or disable a password storage scheme, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Security** tab.
3. Expand the **Password Storage** element.
4. Select the password storage scheme that you want to enable or disable.
5. In the right hand pane, check or uncheck the **Enabled** box, as required.
6. Click **Apply** to save your changes.

CHAPTER 12

Managing Directory Schema

The *schema* defines and governs the types of information objects that can be stored in a directory. A schema defines the types of entries in the directory information tree, maintains element uniqueness, and prevents unchecked schema growth that can arise when new elements are added to the directory. This section provides instructions on viewing and extending the schema provided with the directory server.

This chapter covers the following topics:

Directory Schema Overview

The directory server reads the schema once at startup and then uses the schema information to match a search filter request or assertion to an entry's attributes to determine if any add or modify operations are permitted by the client.

In most cases, the default schema should be sufficient for most applications. However, you can take advantage of the flexibility of the directory server to extend the schema to suit your applications. The general procedure is not to relinquish the standard schema to a new custom schema, but to use the standard attributes or object classes wherever possible. If you require custom attributes or object classes that are not handled with the standard schema, you can create or extend the standard schema with auxiliary attributes and object classes required for your application.

The schema is stored in the directory under the suffix (`cn=schema`). The directory server also has a subschema subentry that defines the schema elements plus the set of operational attributes in the directory.

You can extend the schema in one of two ways:

- Extend the schema over LDAP.
- Create a custom schema definition file.

Designing and Extending the Schema

Before you consider extending the default schema, or designing your own schema, ensure that you have a solid understanding of schema syntax and design.

The basic steps to design or extend a schema are as follows:

1. Map the data to the default schema. Where possible, use the existing schema elements that are defined in the directory server. Standard schema elements help to ensure compatibility with directory-enabled applications. Because the schema is based on the LDAP standard, it has been reviewed and agreed upon by a large number of directory users.
2. Identify unmatched data. The default schema was designed to accommodate a large variety of information objects. However, if the schema does not handle your specific data type, then make note of it and any other data types needed for your directory.
3. Extend the default schema to define new elements. For optimal performance, reuse existing schema elements wherever possible. Also, minimize the number of mandatory attributes that you define for each object class. Keep the schema as simple as possible. Do not define more than one object class or attribute for the same purpose.
4. Use schema checking. Schema checking ensures that attributes and object classes conform to the schema rules.
5. Select and apply a consistent data format. The LDAP schema allows you to place any data on any attribute value. However, you should store data consistently by selecting a format appropriate for your LDAP client application and directory users.

Default Schema Files

The default schema provided with the directory server is a collection of LDIF files stored under *install-dir*`/config/schema`. The directory server loads the schema files in alphanumeric order (numerals first) at directory server startup.

Caution – Never modify the standard schema definitions and internal operational attributes in these files.

The following table describes the default schema files and their contents.

TABLE 12–1 Default Schema Files

Schema File	Description
`00-core.ldif`	Contains the schema definitions for the LDAPv3 standard user and organization.
`01-pwpolicy.ldif`	Contains the schema definitions for password policies based on the `draftldappolicy` draft.
`02-config.ldif`	Contains the schema definitions for the attribute and object class definitions in the directory configuration file.
`03-changelog.ldif`	Contains the schema definitions for storing changes to directory data based on the `draftldap-changelog`.
`03-rfc2713.ldif`	Contains the schema definitions for representing Java objects in an LDAP directory based on RFC 2713.
`03-rfc2714.ldif`	Contains the schema definitions for representing CORBA object references in an LDAP directory based on RFC 2714. The Common Object Request Broker Architecture (CORBA) integrates machines in a multivendor, multiplatform environments using CORBA objects. A directory server can be a repository for CORBA object references, which allow for a centrally administered service for CORBA-compliant applications.
`03-rfc2739.ldif`	Contains the schema definitions for representing calendar attributes for a vCard directory based on RFC 2739. Calendar applications require a calendar user agent to locate a URI, located in a directory, for an individual's calendar. Note that the definition in RFC 2739 contains a number of errors. This schema file has been altered from the standard definition in order to fix a number of those problems.

TABLE 12–1 Default Schema Files *(Continued)*

Schema File	Description
03-rfc2926.ldif	Contains the schema definitions for mapping Service Location Protocol (SLP) advertisements based on RFC 2926. This specification allows directory servers to serve SLP directory agent back ends that create mappings between SLP templates and the LDAP directory schema.
03-rfc3112.ldif	Contains the schema definitions for the authentication password syntax based on RFC 3112.
03-rfc3712.ldif	Contains the schema definitions for storing printer information in the directory based on RFC 3712.
03-uddiv3.ldif	Contains the schema definitions for storing UDDI v3 information in the directory based on RFC 4403. Universal Description, Discovery and Integration (UDDI) is a platform-independent, XML-based registry for companies on the Internet. UDDI enables companies to publish service listings and defines which software applications interact together over the Internet.
04-rfc2307bis.ldif	Contains the schema definitions for storing naming service information in the directory based on `draftrfc2307bis`.

Configuring Schema Checking

The directory server provides a schema-checking mechanism that verifies whether newly-written or added entries conform to the directory server's schema. This mechanism ensures that data imported using `import-ldif`, or added using `ldapmodify`, meets the syntax rules of the schema.

The schema checking configuration is part of the advanced global configuration, and can be displayed with the following command:

```
$ dsconfig -D "cn=directory manager" -w password -n --advanced \
  get-global-configuration-prop
Property                               : Value(s)
---------------------------------------:-------------------------------------
...
check-schema                           : true
...
invalid-attribute-syntax-behavior      : reject
...
single-structural-objectclass-behavior : reject
...
```

The following configuration properties control schema-checking:

- check-schema. Possible values: true (default), false. This property controls whether the directory server should do schema-checking on newly imported or added entries. By default, the property is set to true. If you need to tune the server for maximum performance and you are certain that your clients will never make a change that causes a schema violation, you can set the property to false. The small performance benefits are minimal compared to the potential risks to your directory.
- invalid-attribute-syntax-behavior. Possible values are: reject (default), accept, and warn. This property controls how the server should behave if an attempt is made to use an attribute value that violates the associated syntax. By default, the server rejects any requests to use attributes that violate the schema. If this property is set to accept, the server silently accepts attribute violations. If this attribute is set to warn, the server accepts violations, but writes a message to the error log. If the check-schema property is set to false, invalid attribute syntax checking is not enforced.
- single-structural-objectclass-behavior. Possible values are: reject (default), accept, and warn. This property controls how the server should behave if an attempt is made to create or alter an entry that does not have exactly one structural object class. This means that object classes with no structural object classes or more than one are rejected by default. If this property is set to accept, entries with no structural object classes are allowed. If this property is set to warn, entries with no structural object classes (or more than one) are allowed, but a message is written to the error log. If the check-schema property is set to false, single structural object class checking is not enforced.

Caution – Changing the value of these properties from the default puts the integrity of the schema at risk, so in general do *not* alter these values.

Working With Object Identifiers (OIDs)

An object identifier (OID) is a numeric string used to uniquely identify an object in a directory. OIDs are used in directory schema, controls, and extended operations that require unique identification of elements.

LDAP object classes and attributes require a base object identifier (OID) that must be unique within your organization to avoid naming conflicts in the directory. If you plan to use your directory internally within your organization, use the OIDs provided in the directory server. If you plan to export your schema or publicly expose your schema in any way, you should consider entering a request for a unique OID for your organization. For more information, see “Obtaining a Base OID” on page 435.

After you have obtained a base OID, you can add branches to it for your organization's object classes and attributes. For example, the directory server uses an assigned base OID of 1.3.6.1.4.1.26027. For each component type, the directory server provides unique branch numbers to the base OID for each schema component.

Note – The directory server provides a comprehensive set of OIDs that should be sufficient for most applications. You can also request OIDs for addition to the directory server repository.

The following table shows the base OIDs used for each schema component:

TABLE 12–2 Base OIDs Used for Each Schema Component

OID Value	Type
`1.3.6.1.4.1.26027.1.1`	Attribute
`1.3.6.1.4.1.26027.1.2`	Object classes
`1.3.6.1.4.1.26027.1.3`	Attribute syntaxes
`1.3.6.1.4.1.26027.1.4`	Matching rules
`1.3.6.1.4.1.26027.1.5`	Controls
`1.3.6.1.4.1.26027.1.6`	Extended operations
`1.3.6.1.4.1.26027.1.9`	General use
`1.3.6.1.4.1.26027.1.999`	Experimental use

For each schema type, a unique branch number is added to the base OID. For example, attribute types use a branch number of `1` to form the OID of `1.3.5.1.4.1.26027.1.*1*`. For each specific attribute type, the directory server assigns another set of branch numbers, one for each attribute type.

The following table displays a (partial) list of assigned OID values for attribute types.

TABLE 12–3 Assigned OID Values for Attribute Types

OID Value	Attribute Type
`1.3.6.1.4.1.26027.1.1.1`	`ds-cfg-java-class`
`1.3.6.1.4.1.26027.1.1.2`	`ds-cfg-enabled`
`1.3.6.1.4.1.26027.1.1.3`	`ds-cfg-allow-attribute-name-exceptions`
`1.3.6.1.4.1.26027.1.1.4`	`ds-cfg-allowed-client`
`1.3.6.1.4.1.26027.1.1.5`	`ds-cfg-allow-ldap-v2`

Note – The directory server allows the use of non-numeric OIDs as long as a corresponding numeric OID is defined within the schema. For example, you can use a non-numeric OID, `mytestattribute-oid` for the named attribute, `myTestAttribute`. The non-numeric OID must be all lowercase with the `-oid` appended to the named attribute. The use of non-numeric OIDs is an LDAP-specification violation but is permissible for ease of use.

Obtaining a Base OID

If you plan to make your directory server publicly available, or if you plan to redistribute your schema definitions for custom applications, you can obtain a base OID for your organization. You can use your own OIDs in a custom schema file if you plan to create custom extensions to the directory server. Alternatively, you can modify the schema configuration files by adding your base OID with its respective branch number.

Note – Do not modify the default OIDs unless you are sure of what you are doing. Modifying the OIDs can potentially damage your directory server.

To obtain and create base OIDs for your organization, perform the following steps:

1. Point your browser to the Internet Assigned Numbers Authority (IANA) web site at (`http://www.iana.org`) or a national organization in your country that handles such tasks. In some countries, corporations already have OIDs assigned to them. If your organization does not already have an OID, you can fill out a request at the IANA web site.
2. Determine the unique object classes, attributes, names, and other schema elements. Ensure that the names are descriptive to make it easier to manage the schema. One trick is to add a custom prefix to your custom object classes and attributes. For example, if your organization is Example.com, you can add the prefix `Example` before each custom schema element, such as adding `Example` to a `Person` object class as in `ExamplePerson`.
3. Create an OID registry to keep track of OID assignments. The registry is nothing more than a list that you maintain to ensure that OIDs and their descriptions are unique within your directory. The registry should be sufficiently protected so that only a privileged administrator can modify the registry.
4. Create branches in the OID tree to accommodate the schema elements.
5. Shut down the directory servers in your topology.
6. Manually edit the schema configuration files on each directory server in your topology. Replace each OID with your company's OID. This avoids problems with schema replication seeing differences in the schema and attempting to synchronize the information.
7. Manually edit any custom schema extensions. Ideally, you should define any custom extensions in a separate file.

Extending the Schema

The directory server supports multiple methods to extend the schema. The schema files are a set of LDIF files located in the *install-dir*/config/schema directory. Do not modify these files directly, because doing so can result in unpredictable server behavior.

You can extend the schema as follows:

- **Extend the schema over LDAP.** Define your schema extensions, write the definitions to an LDIF file, and then add the custom schema extensions by using the `ldapmodify` command. When you use this method, the directory server automatically writes the new schema definitions to a file, `99user.ldif`. If you want to specify a different schema file, include the `X-SCHEMA-FILE` element with the name of your schema file. For example, as part of your attribute type definition, include the element `X-SCHEMA-FILE '98myschema.ldif'`.
- **Create a custom schema file.** Create a custom schema file with your definitions, save it as `98myschema.ldif`, and then move the file to the *install-dir*/config/schema directory.
- **Modify an existing schema file.** You can add a custom schema extension to an existing custom schema file, such as `99user.ldif`.
- When adding new schema elements, all attributes must be defined before they can be used in an object class.
- If you are creating several object classes that inherit from other object classes, you must create the parent object class first.
- Each custom attribute or object class that you create should be defined in only one schema file.
- When defining new schema definitions manually, the best practice is to add these definitions to the `99user.ldif` file or to your designated schema file.
- The directory loads schema files in alphanumeric order with numbers loaded first, so you should name custom schema files as follows: `[00-99]filename.ldif`.

Managing Attribute Types

You can add new attribute types to the schema by using the `ldapmodify` command. The attribute types syntax requires that you provide at least a valid OID to define a new element. In typical applications, you can optionally include the following identifiers for the attribute type. To see the full set of attribute type elements, see "Understanding Attribute Types" in *Oracle Fusion Middleware Architecture Reference for Oracle Unified Directory*.

`OID`

Required. Specifies the OID that uniquely identifies the attribute type in the directory server. The LDAP v3 specification requires the OID to be a numeric number, but the directory server supports the use of non-numeric OIDs for easy identification as long as the schema is used internally within the organization. The format is *attributename*`-oid`, for example, `telephoneNumber-oid`. Each non-numeric OID must have its corresponding numeric OID defined in the schema.

`NAME`

Optional. Specifies the set of human-readable names that are used to refer to the attribute type. If there is a single name, enclose it in single quotes, for example, `'blogURL'`. If there are multiple names, enclose each name in single quotes separated by spaces, and then enclose the entire set of names within parentheses, for example, `( 'blog' 'blogURL' )`. Ensure that there is a space between the left parenthesis and the name, and a space before the closing parenthesis.

`SUP`

Optional. Specifies the superior attribute type when you want one attribute type to inherit elements from another attribute type. The matching rule and attribute syntax specifications from the superior attribute type can be inherited by the subordinate type if it does not override the superior attribute type definition. The OID, any of the human-readable names associated with the superior attribute type or both can be used to collectively reference all of the subordinate attribute types.

`DESC`

Optional. Specifies a human-readable description of the attribute type.

`SYNTAX`

Optional. Specifies the attribute syntax for use with the attribute type. If provided, it should be given as a numeric OID. The core syntaxes are defined in section 3.3. of RFC 4517 and in Appendix A of the same document.

`SINGLE-VALUE`

Optional. Specifies whether the attributes of that type are allowed to have only a single value in any entry in which they appear. If `SINGLE-VALUE` is not present, the attributes are allowed to have multiple distinct values in the same entry.

`NO-USER-MODIFICATION`

Optional. Indicates that the values of the attributes of the given type cannot be modified by external clients (that is, the values can be modified only by internal processing within the directory server).

`USAGE`

Optional. Indicates how the attribute is to be used. Possible values are as follows: `userApplications`. Used to store user data. `directoryOperation`. Used to store data required for internal processing within the directory server. `distributeOperation`. Used to store operational data that must be synchronized across directory servers in the topology. `dSAOperation`. Used to store operational data that is specific to a particular directory server and should not be synchronized across the topology.

`extensions` — Optional. Specifies the extensions available to the attribute type. Oracle Unified Directory provides the following extensions:

- `X-ORIGIN`. Provides information on where the attribute type is defined. The element is a non-standard tool that you can use to locate the schema element, for example, the RFC number (`RFC4517`).
- `X-SCHEMA-FILE`. Indicates which schema file contains the attribute type definition. Used for internal purposes only and is not exposed to clients. You can use this extension to specify where the directory server should store your custom schema definitions.
- `X-APPROX`. Indicates which approximate matching rule should be used for the attribute type. If specified, the value should be the name of the OID of a registered approximate matching rule.

For example, you can specify the addition of a new attribute type, `blogURL`, in an LDIF file that will be added to the schema.

```
$ cat blogURL.ldif
dn: cn=schema
changetype: modify
add: attributeTypes
attributeTypes: ( 1.3.6.1.4.1.32473.1.1.590
  NAME ( ’blog’ ’blogURL’ )
  DESC ’URL to a personal weblog’
  SYNTAX 1.3.6.1.4.1.1466.115.121.1.15
  SINGLE-VALUE
  X-ORIGIN ’Oracle Unified Directory Server’
  USAGE userApplications )
```

Note – Pay special attention to the spaces in an attribute type declaration. The LDAP specification requires that a space exist between the opening parenthesis and the OID, and the value of the `USAGE` element and the closing parenthesis. Further, the LDIF specification states that LDIF parsers should ignore exactly one space at the beginning of each line. Therefore, it is a good practice to add two (2) spaces at the beginning of the line that starts with an element keyword. For example, add two spaces before `NAME`, `DESC`, `SYNTAX`, `SINGLE-VALUE`, `X-ORIGIN`, and `USAGE` in the previous example.

The OIDs used in this example are for illustration purposes only and should not be implemented in your directory.

To View Attribute Types

The cn=schema entry has a multivalued attribute, attributeTypes, that contains definitions of each attribute type in the directory schema. You can view the schema definitions by using the ldapsearch command.

Manipulation of the cn=schema suffix is regarded as an administrative action and, as such, it is recommended that you use the administration connector when accessing this suffix. See "Managing Administration Traffic to the Server" on page 62 for more information.

1 **Use the ldapsearch command as follows:**

```
$ ldapsearch -h localhost -p 4444 -D "cn=Directory Manager" -w password -X --useSSL \
  --baseDN cn=schema --searchScope base \
"(objectclass=*)" attributeTypes
dn: cn=schema
attributeTypes: ( 2.5.4.41 NAME 'name' EQUALITY caseIgnoreMatch SUBSTR caseIgnore
eSubstringsMatch SYNTAX 1.3.6.1.4.1.1466.115.121.1.15{32768} X-ORIGIN 'RFC 4519
' )
attributeTypes: ( 2.5.4.49 NAME 'distinguishedName' EQUALITY distinguishedNameMa
tch SYNTAX 1.3.6.1.4.1.1466.115.121.1.12 X-ORIGIN 'RFC 4519' )
attributeTypes: ( 2.5.4.0 NAME 'objectClass' EQUALITY objectIdentifierMatch SYNT
AX 1.3.6.1.4.1.1466.115.121.1.38 X-ORIGIN 'RFC 4512' )
...(more output)...
```

2 **(Optional) To view a specific attribute type, use the -dontWrap option and then use the grep command to search for the required attribute.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=Directory Manager" -w password -X --useSSL \
  -b cn=schema -s base --dontWrap "(objectclass=*)" attributeTypes | grep "telexNumber"
attributeTypes: ( 2.5.4.21 NAME 'telexNumber'
SYNTAX 1.3.6.1.4.1.1466.115.121.1.52 X-ORIGIN 'RFC 4519' )
```

To Create an Attribute Type

The cn=schema entry has a multivalued attribute, attributeTypes, that contains definitions of each attribute type in the directory schema. You add custom schema definitions by using the ldapmodify command. This example adds an attribute named blog.

Manipulation of the cn=schema suffix is regarded as an administrative action and, as such, it is recommended that you use the administration connector when accessing this suffix. See "Managing Administration Traffic to the Server" on page 62 for more information.

1 **Using a text editor, create an LDIF file with your schema extensions.**

```
dn: cn=schema
changetype: modify
add: attributeTypes
attributeTypes: ( 1.3.6.1.4.1.32473.1.1.590
  NAME ( 'blog' 'blogURL' )
  DESC 'URL to a personal weblog'
  SYNTAX 1.3.6.1.4.1.1466.115.121.1.15
  SINGLE-VALUE
  X-ORIGIN 'Oracle Unified Directory Server'
  USAGE userApplications )
```

2 Use `ldapmodify` to add the file.

```
$ ldapmodify -h localhost -p 4444 -D "cn=Directory Manager" -w password -X --useSSL \
  -a -f blogURL.ldif
Processing MODIFY request for cn=schema
MODIFY operation successful for DN cn=schema
```

3 Verify the addition by displaying it using `ldapsearch`.

```
$ ldapsearch -h localhost -p 4444 -D "cn=Directory Manager" -w password -X --useSSL \
  -b cn=schema -s base --dontWrap "(objectclass=*)" attributeTypes | grep 'blog'
attributeTypes: ( 1.3.6.1.4.1.32473.1.1.590 NAME ( 'blog' 'blogURL' )
DESC 'URL to a personal weblog' SYNTAX 1.3.6.1.4.1.1466.115.121.1.15
SINGLE-VALUE X-ORIGIN 'Oracle Unified Directory Server' USAGE userApplications )
```

Note – The directory server automatically adds new attribute definitions to the `99user.ldif` file.

▼ To Delete an Attribute Type

The `cn=schema` entry has a multivalued attribute, `attributeTypes`, that contains definitions of each attribute type in the directory schema. You can delete definitions with `X-ORIGIN 'user defined'` by using the `ldapmodify` command. The directory server does not allow deletions to other definitions.

Caution – Be careful when deleting attribute types, because doing so can harm your directory. Do not delete an attribute type unless absolutely necessary.

Manipulation of the `cn=schema` suffix is regarded as an administrative action and, as such, it is recommended that you use the administration connector when accessing this suffix. For more information, see "Managing Administration Traffic to the Server" on page 62.

1 Create the delete request in an LDIF file.

```
dn: cn=schema
changetype: modify
delete: attributeTypes
attributeTypes: ( 1.3.6.1.4.1.32473.1.1.590
  NAME ( 'blog' 'blogURL' )
  DESC 'URL to a personal weblog'
  SYNTAX 1.3.6.1.4.1.1466.115.121.1.15
  SINGLE-VALUE
  X-ORIGIN 'Oracle Unified Directory Server'
  USAGE userApplications )
```

2 **Use the `ldapmodify` command to process the delete request.**

```
$ ldapmodify -h localhost -p 4444 -D "cn=Directory Manager" -w password -X --useSSL \
  --defaultAdd --fileName "remove_blogURL.ldif"
Processing MODIFY request for cn=schema
MODIFY operation successful for DN cn=schema
```

Managing Object Classes

Object classes are named sets of attribute definitions that are used to control the types of data stored in entries. You can add new object classes to the schema by using the `ldapmodify` command. The object class syntax requires that you provide at least a valid OID to define your new element. In typical applications, you will also include the following optional identifiers for the object class type. For more information about the object class definition, see "Directory Schema Overview" on page 429.

`OID` Required. Specifies the OID that uniquely identifies the object class in the directory server. The LDAP v3 specification requires the OID to be a numeric number, but Oracle Unified Directory supports the use of non-numeric OIDs for easy identification because the schema is used internally within the organization. For example, the format is *objectClassName*`-oid`, such as `person-oid`.

`NAME` Optional. Specifies the set of human-readable names that are used to refer to the object class. If there is a single name, enclose it in single quotes, for example, `'blogURL'`. If there are multiple names, enclose each name in single quotes separated by spaces, and then enclose the entire set of names within parentheses, for example, `( 'blog' 'blogURL' )`. Ensure that there is a space between the left parenthesis and the name, and a space before the closing parenthesis.

`DESC` Optional. Specifies a human-readable description of the object class. If specified, the description should be enclosed in single quotation marks.

`SUP` Optional. Specifies the superior object class when you want it to inherit elements from another object class. The directory server allows only one superior object class, although the LDAP v3 specification allows for multiple superior object classes.

`OBSOLETE` Optional. Indicates whether the object class is active or not. If an object class is marked as `OBSOLETE`, then it should not be referenced by any new elements created in the directory server.

`SUP` *oids* Optional. The `SUP` keyword should be followed by the OID of the superior class.

`KIND` Optional. Indicates the type of object class that is being defined. Allowed values are `ABSTRACT`, `AUXILIARY` and `STRUCTURAL`.

`MUST` *oids* Optional. Specifies the set of attribute types that are required to be present (that is, have at least one value) in entries with that object class. If there is only a single required attribute, then the `MUST` keyword should be followed by the name or the OID of that attribute type. If there are multiple required attribute types, then separate them with dollar signs ($) and enclose the entire set of attribute types in parentheses. For example, `MUST ( sn $ cn )`.

`MAY` *oids* — Optional. Specifies the set of attribute types that are allowed but not required to be present in entries with that object class. If there is only a single required attribute, then the `MAY` keyword should be followed by the name or the OID of that attribute type. If multiple required attribute types are specified, then separate them by dollar signs ($) and enclose the entire set of attribute types in parentheses. For example, `MAY ( userPassword $ telephoneNumber $ seeAlso $ description )`.

extensions — Optional. Specifies the extensions available to the object class. The directory server provides the following extensions: `X-ORIGIN`. Provides information on where the object class is defined. The element is a non-standard tool that the user can use to conveniently locate the schema element. `X-SCHEMA-FILE`. Indicates which schema file contains the object class definition. Used for internal purposes only and is not exposed to clients. You can use this extension to specify where the directory server is to store your custom schema definitions.

For example, you can specify the addition of a new object class, `blogger`, in an LDIF file to be added to the schema.

```
$ cat blogger.ldif
dn: cn=schema
changetype: modify
add: objectClasses
objectClasses: ( 1.3.6.1.4.1.32473.1.1.10
  NAME ( ’blogger’ )
  DESC ’Someone who has a blog’
  SUP inetOrgPerson
  STRUCTURAL
  MAY blog
  X-ORIGIN ’Oracle Unified Directory Server’ )
```

Note – Pay special attention to the spaces in your object class declaration. The LDAP specification requires that a space exist between the opening parenthesis and the OID, and the value of the `X-ORIGIN` element and the closing parenthesis. Further, the LDIF specification states that LDIF parsers should ignore exactly one space at the beginning of each line. Therefore, it is a good practice to add two spaces before the line that begins with an element keyword, such as, `NAME`, `DESC`, `SUP`, `STRUCTURAL`, `MAY`, and `X-ORIGIN` in the previous example.

The OIDs used in this example are for illustration purposes only and should not be implemented in your directory.

To View Object Classes

The cn=schema entry has a multivalued attribute, objectClass, that contains definitions of each object class in the directory schema. You can view the schema definitions by using the ldapsearch command.

Manipulation of the cn=schema suffix is regarded as an administrative action and, as such, it is recommended that you use the administration connector when accessing this suffix. See "Managing Administration Traffic to the Server" on page 62 for more information.

1 **Use the ldapsearch command.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=Directory Manager" -w password -X --useSSL \
  -b cn=schema -s base "(objectclass=*)" objectClasses
dn: cn=schema
objectClasses: ( 2.5.6.0 NAME 'top' ABSTRACT MUST objectClass X-ORIGIN 'RFC 4512
' )
objectClasses: ( 2.5.6.1 NAME 'alias' SUP top STRUCTURAL MUST aliasedObjectName
X-ORIGIN 'RFC 4512' )
objectClasses: ( 2.5.6.2 NAME 'country' SUP top STRUCTURAL MUST c MAY ( searchGu
ide $ description ) X-ORIGIN 'RFC 4519' )
objectClasses: ( 2.5.6.3 NAME 'locality' SUP top STRUCTURAL MAY ( street $ seeAl
so $ searchGuide $ st $ l $ description ) X-ORIGIN 'RFC 4519' )
objectClasses: ( 2.5.6.4 NAME 'organization' SUP top STRUCTURAL MUST o MAY ( use
rPassword $ searchGuide $ seeAlso $ businessCategory $ x121Address $ registered
Address $ destinationIndicator $ preferredDeliveryMethod $ telexNumber $ telete
xTerminalIdentifier $ telephoneNumber $ internationaliSDNNumber $ facsimileTele
phoneNumber $ street $ postOfficeBox $ postalCode $ postalAddress $ physicalDel
iveryOfficeName $ st $ l $ description ) X-ORIGIN 'RFC 4519' )
...(more output)...
```

2 **(Optional) Use the --dontWrap option and the grep command to search for a specific object class.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=Directory Manager" -w password -X \
  --useSSL -b cn=schema -s base --dontWrap "(objectclass=*)" \
  objectClasses | grep "inetOrgPerson"
objectClasses: ( 2.16.840.1.113730.3.2.2 NAME 'inetOrgPerson' SUP organizationalPerson
STRUCTURAL MAY ( audio $ businessCategory $ carLicense $ departmentNumber $ displayName
$ employeeNumber $ employeeType $ givenName $ homePhone $ homePostalAddress $ initials
$ jpegPhoto $ labeledURI $ mail $ manager $ mobile $ o $ pager $ photo $ roomNumber
$ secretary $ uid $ userCertificate $ x500UniqueIdentifier $ preferredLanguage
$ userSMIMECertificate $ userPKCS12 ) X-ORIGIN 'RFC 2798' )
```

To Create an Object Class

The cn=schema entry has a multivalued attribute, objectClasses, that contains definitions of each object class in the directory schema. You add custom schema by using the ldapmodify command. This example adds an object class blogger based on the attribute created in the previous example.

Manipulation of the cn=schema suffix is regarded as an administrative action and, as such, it is recommended that you use the administration connector when accessing this suffix. See "Managing Administration Traffic to the Server" on page 62 for more information.

1 **Using a text editor, create an LDIF file with your schema extensions.**

```
dn: cn=schema
changetype: modify
add: objectClasses
objectClasses: ( 1.3.6.1.4.1.32473.1.1.10
  NAME ( 'blogger' )
  DESC 'Someone who has a blog'
  SUP inetOrgPerson
  STRUCTURAL
  MAY blog
  X-ORIGIN 'Oracle Unified Directory Server' )
```

2 **Use the `ldapmodify` command to add the file.**

```
$ ldapmodify -h localhost -p 4444 -D "cn=Directory Manager" -w password -X --useSSL \
  -a -f blogger.ldif
Processing MODIFY request for cn=schema
MODIFY operation successful for DN cn=schema
```

3 **Verify the addition by displaying it with `ldapsearch`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=Directory Manager" -w password -X --useSSL \
  -b cn=schema -s base --dontWrap "(objectclass=*)" objectClasses | grep 'blogger'
```

Note – The directory server automatically adds new object class definitions to the 99user.ldif file.

▼ To Delete an Object Class

The cn=schema entry has a multivalued attribute, objectClasses, that contains definitions for each object class in the directory schema. You can delete these definitions by using the ldapmodify command.

Caution – Be careful when deleting object classes, because doing so can harm your directory. Do not delete an object class unless absolutely necessary.

Manipulation of the cn=schema suffix is regarded as an administrative action and, as such, it is recommended that you use the administration connector when accessing this suffix. See "Managing Administration Traffic to the Server" on page 62 for more information.

1 **Create the delete request in LDIF format.**

```
dn: cn=schema
changetype: modify
```

```
delete: objectClasses
objectClasses: ( 1.3.6.1.4.1.32473.1.1.10
  NAME ( 'blogger' )
  DESC 'Someone who has a blog'
  SUP inetOrgPerson
  STRUCTURAL
  MAY blog
  X-ORIGIN 'Oracle Unified Directory Server' )
```

2 **Remove the object class by using `ldapmodify` to apply the LDIF file.**

```
$ ldapmodify -h localhost -p 4444 -D "cn=Directory Manager" -w password -X --useSSL \
  --fileName "remove_objectclass_schema.ldif"
```

Extending the Schema With a Custom Schema File

You can extend the schema by using a schema file that contains customized definitions. In general, the best practice is to modify the existing `99user.ldif` file in the *install-dir*`/config/schema` directory to add new definitions. When you update schema elements using LDAP, the new definitions are written to the `99user.ldif` file.

Alternatively, you can create a custom schema file and save it to the *install-dir*`/config/schema` directory. The directory server loads schema files in alphanumeric order with numbers loaded first. As such, you should name custom schema files as follows: `00-99`*filename*`.ldif`. The number should be higher than any standard schema file that has already been defined. If you name custom schema files with a number that is lower than the standard schema files, the server might encounter errors when loading the schema.

Replicating the Schema

In a replicated topology, schema definitions are automatically replicated to ensure that all servers use a single schema. Schema modifications on any server are replicated to all other servers in the topology.

When you configure replication, the schema of the first server is used to initialize the schema of the second server by default. You can, however, specify that the schema of the second server be used to initialize the schema of the first server. You can also specify that schema replication be disable altogether. For more information, see "Configuring Schema Replication" on page 343.

Managing the Schema With Oracle Directory Services Manager

You can manage most elements of the directory schema with ODSM. The following topics indicate the steps to manage the most common aspects of viewing and extending the schema.

Add a New Attribute Type

You can add a new attribute type to the schema by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.
3. The **Attributes** panel is expanded by default. If it is not expanded, click the arrow to expand it.
4. Click the **Add** icon.
5. Complete the following information on the **Create new attribute** window:
   - **Name.** Enter a unique name for the new attribute type.
   - **Object ID.** Specify the OID that uniquely identifies the attribute type in the directory server. Oracle Unified Directory supports the use of non-numeric OIDs for easy identification as long as the schema is used internally within the organization. However, for this release ODSM supports numeric OIDs only.
   - **Description.** Enter a human-readable description of the attribute type.
   - **Syntax.** Enter the attribute syntax for use with the attribute type. If provided, the syntax should be specified as a numeric OID. The core syntaxes are defined in section 3.3. of RFC 4517 and in Appendix A of the same document.
   - **Size.** Enter a maximum size for the value of the attribute, in bytes. In the case of multi-valued attributes, this refers to the maximum size of a single value, not of the combined values.
   - **Usage.** Specify how the attribute will be used. Possible values are as follows:
     - **userApplications.** The attribute will be used to store user data.
     - **directoryOperation.** The attribute will be used to store data that is required for internal processing within the directory server.
     - **distributedOperation.** The attribute will be used to store operational data that must be synchronized across directory servers in the topology.
     - **dSAOperation.** The attribute will be used to store operational data that is specific to a particular directory server and should not be synchronized across the topology.

- **Ordering.** Select the ordering index details for this attribute type. For more information see "Indexing Directory Data" on page 283.
- **Equality.** Select the equality index details for this attribute type. For more information see "Indexing Directory Data" on page 283.
- **Substring.** Select the substring index details for this attribute type. For more information see "Indexing Directory Data" on page 283.
- **Obsolete.** Select this box if the attribute type is no longer in use but is retained for compatibility.
- **Single Value.** Indicate whether attributes of this type may have only a single value in any entry in which they appear. If this checkbox is not selected, the attributes may have multiple distinct values in the same entry.
- **Collective.** Indicate whether the attribute is a collective attribute. For more information, see "Using Collective Attributes" on page 294.
- **Super.** If this new attribute extends an existing attribute, enter or select the name of the existing super type.
- **Origin.** Enter the source of this new attribute type, for example, RFC 4512.

  To view the source of all the schema elements in the directory, select **Show All** from the **View** menu.
- **Schema File Extension.** If the attribute type's definition is contained in a file, enter the path to the file.

6. Click **Create** to create the new attribute.

Add an Attribute Based on an Existing Attribute

You can add an attribute type that is based on an existing attribute type by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.
3. The **Attributes** panel is expanded by default. If it is not expanded, click the arrow to expand it.
4. Select the attribute on which you want to base the new attribute type.
5. Click the **Create like** icon.
6. Certain fields are completed by default, based on the attribute that you selected.

   Complete the remaining fields for the new attribute type.

For information about the fields and their values, see "Add a New Attribute Type" on page 446.

7. Click **Create** to create the new attribute.

Modify an Attribute

You can modify an existing attribute type by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.
3. The **Attributes** panel is expanded by default. If it is not expanded, click the arrow to expand it.
4. Select the attribute type that you want to modify.
5. Modify the required fields, on the right hand pane.

   For information about the fields, see "Add a New Attribute Type" on page 446.
6. Click **Apply** to save your changes.

Delete an Attribute

You can delete an existing attribute type by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.
3. The **Attributes** panel is expanded by default. If it is not expanded, click the arrow to expand it.
4. Select the attribute type that you want to delete.
5. Click the **Delete** icon and click **OK** to confirm the deletion.
6. Click **Apply** to save your changes.
7. Click the **Refresh** icon to refresh the list of attributes on the left hand pane and confirm that the attribute has been deleted from the schema.

Note – The server will return an error if you attempt to delete an attribute type that is already referenced by one or more entries in the server.

View All Directory Attributes

You can view all existing attribute types by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.
3. The **Attributes** panel is expanded by default. If it is not expanded, click the arrow to expand it.
4. All the attributes that are defined in the schema are listed in the left hand pane.
5. Select an attribute to display its properties in the right hand pane.

Search for Attributes

You can search for a specific attribute types by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.
3. The **Attributes** panel is expanded by default. If it is not expanded, click the arrow to expand it.
4. All the attributes that are defined in the schema are listed in the left hand pane.
5. Enter part or all of the attribute name in the **Search** field and click the **Go** icon.

   The search field supports pattern matching. For example, enter `*uid` to find all attributes that end with the string `uid`.
6. Select an attribute to display its properties in the right hand pane.

View the Indexing Details of an Attribute

Indexes are configured per server and index configuration is not replicated. A local database index is used to find entries that match search criteria. A VLV index is used to process searches efficiently with VLV controls. Unindexed searches are denied by default, unless the user has the unindexed-search privilege.

A local database index can be one of the following types:

- **approximate** - Improves the efficiency of searches using approximate search filters.
- **equality** - Improves the efficiency of searches using equality search filters.

- **ordering** - Improves the efficiency of searches using "greater than or equal to" or "less than or equal to" search filters.
- **presence** - Improves the efficiency of searches using presence search filters.
- **substring** - Improves the efficiency of searches using substring search filters.

You can view the indexes that are defined for an attribute by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.
3. The **Attributes** panel is expanded by default. If it is not expanded, click the arrow to expand it.
4. Select an attribute to display its properties in the right hand pane.
5. Scroll down to the **Indexed** property to view the indexing details for that attribute.

Add a New Object Class

You can add a new attribute type to the schema by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.
3. Click the **Object classes** panel to expand it.

   All existing object classes are displayed on the left pane.
4. Click the **Add** icon.
5. Complete the following information on the **Create new object class** window:
   - **Name.** Enter a unique name for the new object class.
   - **Object ID.** Specify the OID that uniquely identifies the object class in the directory server. Oracle Unified Directory supports the use of non-numeric OIDs for easy identification as long as the schema is used internally within the organization. However, for this release ODSM supports numeric OIDs only.
   - **Description.** Enter a human-readable description of the object class.
   - **Type.** Specify the type of object class. Possible values are as follows:
     - **Structural.** A structural object class defines the core type for any entry that contains it. An entry must have exactly one structural class (although that structural class can inherit from other structural or abstract classes).

  - **Auxiliary.** An auxiliary object class does not define the core type of an entry, but defines additional characteristics of that entry. An entry can contain zero or more auxiliary object classes. The set of auxiliary classes that are allowed for use in an entry can be controlled by a DIT content rule that is associated with that entry's structural object class.
  - **Abstract.** An abstract object class cannot be used directly in an entry but must be subclassed by either a structural object class or an auxiliary object class. The subclasses will inherit any required and/or optional attribute type defined by the abstract class.
- **Superclass.** Click the **Add** icon to specify one or more superior object classes. The new object class will inherit elements from its superior object classes.
- **Mandatory Attributes.** Click the **Add** icon to specify the set of attribute types that are required to be present (that is, have at least one value) in entries with that object class.
- **Optional Attributes.** Click the **Add** icon to specify the set of attribute types that are allowed but not required to be present in entries with that object class.
- **Inherited Attributes.** After the object class has been created, this field indicates the attributes that are inherited from the superior object classes of this object class.
- **Origin.** Enter the source of this new object class, for example, RFC 4512.

  To view the source of all the schema elements in the directory, select **Show All** from the **View** menu.
- **Schema File Extension.** If the definition of the new object class is contained in a file, enter the path to the file.

6. Click **Create** to create the new object class.

Add an Object Class Based on an Existing Object Class

You can add an object class that is based on an existing object class by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.
3. Expand the **Object classes** panel.
4. Select the object class on which you want to base the new object class.
5. Click the **Create like** icon.
6. Certain fields are completed by default, based on the object class that you selected. The existing object class is used as the superior object class for the new object class

   Complete the remaining fields for the new object class.

   For information about the fields and their values, see "Add a New Object Class" on page 450.

7. Click **Create** to create the new object class.

View the Properties of an Object Class

You can view the properties of an existing object class by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.
3. Expand the **Object Classes** panel.
4. All the object classes that are defined in the schema are listed in the left hand pane.
5. Select an object class to display its properties in the right hand pane.

Modify an Object Class

You can modify an existing object class by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.
3. Expand the **Object Classes** panel.
4. Select the object class that you want to modify.
5. Modify the required fields, on the right hand pane.

   For information about the fields, see "Add a New Object Class" on page 450.
6. Click **Apply** to save your changes.

Delete an Object Class

You can delete an existing object class by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.
3. Expand the **Object Classes** panel.
4. Select the object class that you want to delete.
5. Click the **Delete** icon and click **OK** to confirm the deletion.
6. Click **Apply** to save your changes.

7. Click the **Refresh** icon to refresh the list of attributes on the left hand pane and confirm that the object class has been deleted from the schema.

Note – The server will return an error if you attempt to delete an object class that is already referenced by one or more entries in the server.

Search for Object Classes

You can search for a specific object class by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.
3. Expand the **Object Classes** panel.
4. All the object classes that are defined in the schema are listed in the left hand pane.
5. Enter part or all of the object class name in the **Search** field and click the **Go** icon.

   The search field supports pattern matching. For example, enter `*person` to find all object classes that end with the string `person`.
6. Select an object class to display its properties in the right hand pane.

Display a List of LDAP Syntaxes

LDAP syntaxes are essentially data type definitions. The syntax for an attribute type indicates the type of data that should be held by the corresponding values. Syntaxes can be used to determine whether a particular value is acceptable for a given attribute, and to provide information about how the directory server should interact with existing values.

Oracle Unified Directory supports the ability to reject values that violate the associated attribute syntax, and this is the default behavior for the purposes of standards compliance. It is possible to disable attribute syntax checking completely if necessary. It is also possible to accept values that violate the associated syntax but log a warning message to the directory server's error log when this occurs. For information about disabling schema checking, see "Configuring Schema Checking" on page 432.

You cannot modify the LDAP syntaxes but you can view all existing LDAP syntaxes by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.

3. Expand the **Syntaxes** panel.
4. All the supported LDAP syntaxes are listed in the left hand pane.
5. Select a syntax to display its properties in the right hand pane.

   The information that is displayed includes all of the attributes and matching rules that currently refer to that syntax.

Search for a Syntax

You can search for a specific LDAP syntax by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.
3. Expand the **Syntaxes** panel.
4. All the supported LDAP syntaxes are listed in the left hand pane.
5. Enter part or all of the syntax name in the **Search** field and click the **Go** icon.

   The search field supports pattern matching. For example, enter `*time` to find all syntaxes that end with the string `time`.
6. Select a syntax to display its properties in the right hand pane.

Display a List of LDAP Matching Rules

Matching rules are used by the directory server to compare two values for the same attribute, that is, to perform matching operations on them. There are several different types of matching rules, including the following:

- **Equality matching rules.** These matching rules are used to determine whether two values are logically equal to each other. Different implementations of equality matching rules can use different criteria for making this determination (for example, whether to ignore differences in capitalization or deciding which spaces are significant).
- **Ordering matching rules.** These matching rules are used to determine the relative order for two values, for example, when evaluating greater-or-equal or less-or-equal searches, or when the results need to be sorted.
- **Substring matching rules.** These matching rules are used to determine whether a given substring assertion matches a particular value.

- **Approximate matching rules.** These matching rules are used to determine whether two values are approximately equal to each other. This is frequently based on "sounds like" or some other kind of fuzzy algorithm. Approximate matching rules are not part of the official LDAP specification, but they are included in Oracle Unified Directory for added flexibility.

You cannot modify the matching rules but you can view all existing matching rules by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.
3. Expand the **Matching Rules** panel.
4. All the configured matching rules are listed in the left hand pane.
5. Select a matching rule to display its properties in the right hand pane.

   The information that is displayed includes all of the attributes and matching rules that currently refer to that matching rule.

Search for a Matching Rule

You can search for a specific matching rule by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.
3. Expand the **Matching Rules** panel.
4. All the configured matching rules are listed in the left hand pane.
5. Enter part or all of the matching rule name in the **Search** field and click the **Go** icon.

   The search field supports pattern matching. For example, enter `*match` to find all matching rules that end with the string `match`.
6. Select a matching rule to display its properties in the right hand pane.

Display a List of Content Rules

DIT content rules provide a mechanism for defining the content that can appear in an entry. At most one content rule may be associated with an entry, based on its structural object class. If such a rule exists for an entry, it will work in conjunction with the object classes contained in that entry to define which attribute types must, may, and must not be present in the entry, as well as which auxiliary classes the entry may include.

You can view all the content rules that are configure in the server by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.
3. Expand the **Content Rules** panel.
4. All the configured content rules are listed in the left hand pane.
5. Select a content rule to display its properties in the right hand pane.

Search for a Content Rule

You can search for a specific content rule by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.
3. Expand the **Content Rules** panel.
4. All the configured content rules are listed in the left hand pane.
5. Enter part or all of the content rule name in the **Search** field and click the **Go** icon.
6. Select a content rule to display its properties in the right hand pane.

Create a New Content Rule

You can add a new content rules to the schema by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.
3. Expand the **Content Rules** panel.
4. Click the **Add** icon.
5. Complete the following information on the **Create new content rule** window:
   - **Name.** Enter a unique name for the new content rule.
   - **Structural Object Class.** Specify the name of the structural object class with which this content rule is associated.
   - **Description.** Enter a human-readable description of the content rule.

- **Auxiliary Object Classes.** Click the **Add** icon to specify the list of auxiliary object classes that may be present in entries with the associated structural class. If no values are provided, such entries will not be allowed to have any auxiliary object classes. You can specify the allowed auxiliary object classes by using their names or OIDs.
- **Mandatory Attributes.** Click the **Add** icon to specify the list of attribute types that are required to be present in entries with the associated structural class. This list is in addition to the attribute types that are required by the object classes included in the entry. These additional attribute types do not need to be allowed by any of those object classes. You can specify the mandatory attributes by using their names or OIDs.
- **Optional Attributes.** Click the **Add** icon to specify the list of attribute types that are allowed, but not required, to be present in entries with the associated structural class. This list is in addition to the attribute types that are allowed by the object classes included in the entry. You can specify the optional attributes by using their names or OIDs.
- **Disallowed Attributes.** Click the **Add** icon to specify the list of attribute types that are prohibited from being present in entries with the associated structural class. This list may not include any attribute types that are required by the structural class or any of the allowed auxiliary classes. The list can be used to prevent the inclusion of attribute types which would otherwise be allowed by one of those object classes. You can specify the disallowed attributes by using their names or OIDs.
- **Origin.** Enter the source of this new content rule, for example, RFC 4517.

  To view the source of all the schema elements in the directory, select **Show All** from the **View** menu.
- **Schema File Extension.** If the content rule's definition is contained in a file, enter the path to the file.

6. Click **Create** to create the new content rule.

Create a Content Rule Based on an Existing Content Rule

You can add a content rule that is based on an existing content rule by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in “Connecting to the Server From Oracle Directory Services Manager” on page 188.
2. Select the **Schema** tab.
3. Expand the **Content Rules** panel.
4. Select the content rule on which you want to base the new content rule.
5. Click the **Create like** icon.

6. Certain fields are completed by default, based on the content rule that you selected.

   Complete the remaining fields for the new content rule.

   For information about the fields and their values, see "Create a New Content Rule" on page 456.
7. Click **Create** to create the new content rule.

Modify a Content Rule

You can modify an existing content rule by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.
3. Expand the **Content Rules** panel.
4. Select the content rule that you want to modify.
5. Modify the required fields, on the right hand pane.

   For information about the fields, see "Create a New Content Rule" on page 456.
6. Click **Apply** to save your changes.

Delete a Content Rule

You can delete an existing content rule by using ODSM, as follows:

1. Connect to the directory server from ODSM, as described in "Connecting to the Server From Oracle Directory Services Manager" on page 188.
2. Select the **Schema** tab.
3. Expand the **Content Rules** panel.
4. Select the content rule that you want to delete.
5. Click the **Delete** icon and click **OK** to confirm the deletion.
6. Click **Apply** to save your changes.
7. Click the **Refresh** icon to refresh the list of content rules on the left hand pane and confirm that the content rule has been deleted from the schema.

CHAPTER 13

Monitoring Oracle Unified Directory

Oracle Unified Directory provides an extensible monitoring framework. The following sections provide an overview of the monitoring functionality, and describe how to configure monitoring:

- "Monitoring Overview" on page 459
- "Configuring Monitor Providers" on page 460
- "Configuring Logs With the Log Publisher" on page 461
- "Configuring Alerts and Account Status Notification Handlers" on page 466

When you have configured monitoring, you can view statistics on your server, or replicated topology, as described in the following sections:

- "Monitoring the Server With LDAP" on page 474
- "Monitoring the Server With SNMP" on page 500
- "Monitoring a Replicated Topology" on page 505
- "General Purpose Enterprise Monitoring Solutions" on page 515

Monitoring Overview

Monitoring information and performance data can be found in:

- logs

  For information about configuring logs, see "Configuring Logs With the Log Publisher" on page 461.
- alerts

  For information about configuring alerts, see "Configuring Alerts and Account Status Notification Handlers" on page 466.
- `cn=monitor`

  For information about `cn=monitor`, see "Monitoring the Server With LDAP" on page 474.
- DIRECTORY_SERVER_MIB, defined by RFC 2605

For information about monitoring the server with SNMP, see "Monitoring the Server With SNMP" on page 500.

To access the monitoring information, ensure that you have the required protocol:

- For logs you need a file system.
- For alerts you need JMX:RMI or SMTP.
- For `cn=monitor` you need LDAP or JMX:RMI (for example jconsole).
- For DIRECTORY_SERVER_MIB you need SNMP.

Configuring Monitor Providers

Monitor providers are enabled by default and provide information about the server that can be useful for monitoring or troubleshooting purposes. The `cn=monitor` entry contains the monitoring information that is published by the monitor providers. When the monitor provider is disabled, the provided information is no longer available under `cn=monitor`.

Monitor providers can be configured by using the `dsconfig` command. For more information, see "Managing the Server Configuration With `dsconfig`" on page 25.

▼ To View Monitor Providers

- **Run the `dsconfig` command with the `list-monitor-providers` subcommand, as follows:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
 list-monitor-providers

Monitor Provider   : Type              : enabled
-------------------:-------------------:--------
Client Connections : client-connection : true
Entry Caches       : entry-cache       : true
JVM Memory Usage   : memory-usage      : true
JVM Stack Trace    : stack-trace       : true
System Info        : system-info       : true
Version            : version           : true
```

▼ To Disable a Monitor Provider

- **Run the `dsconfig` command with `set-monitor-provider-prop` as follows:**

For example, to set the JVM Stack Trace monitor provider to false, use the following command:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
set-monitor-provider-prop --provider-name "JVM Stack Trace" --set enabled:false
```

Running the dsconfig command with the list-monitor-providers subcommand now shows the JVM Stack Trace monitor provider as false:

```
Monitor Provider   : Type              : enabled
-------------------:-------------------:--------
Client Connections : client-connection : true
Entry Caches       : entry-cache       : true
JVM Memory Usage   : memory-usage      : true
JVM Stack Trace    : stack-trace       : false
System Info        : system-info       : true
Version            : version           : true
```

Configuring Logs With the Log Publisher

Oracle Unified Directory provides several types of logs: access logs, audit logs, error logs, debug logs, and a replication repair log. The replication repair log is read-only and its use is restricted to enabling replication conflict resolution. This section describes how to use dsconfig to configure access, audit, error, and debug logs.

Log Configuration Overview

The easiest way to configure logging is to use the dsconfig command in interactive mode, which walks you through the configuration. This section provides the required commands in non-interactive mode. For more information about dsconfig, see "Managing the Server Configuration With dsconfig" on page 25.

Log configuration includes the definition of three configuration objects:

- **Log publisher.** A log publisher is defined for each logger. The log publisher type corresponds to the type of log. For more information about log publishers, see "Configuring Log Publishers" on page 461.
- **Log retention policy.** The retention policy determines how long archived log files are stored. For more information about log retention policies, see "Configuring Log Retention Policies" on page 463.
- **Log rotation policy.** The rotation policy determines how often log files are rotated. For more information on log rotation policies, see "Configuring Log Rotation Policies" on page 464.

Configuring Log Publishers

Oracle Unified Directory provides several log publishers by default.

Any number of log publishers of any type can be defined and active at any time. This means that you can log to different locations or different types of repositories and that you can specify various sets of criteria for what to include in the logs.

For more information about the configuration properties associated with log publishers, see the Oracle Unified Directory Configuration Reference..

Oracle Unified Directory can also write diagnostic log files in the Oracle Diagnostic Logging (ODL) format. ODL is disabled by default. To enable ODL, set the `enabled` property of the ODL Access Log publisher or the ODL Error Log publisher to `true`, as follows:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  set-log-publisher-prop --publisher-name "Oracle Access Logger" --set enabled:true
```

▼ To List Existing Log Publishers

1 **To view the existing log publishers run the following `dsconfig` command:**

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  list-log-publishers
```

The default output will be similar to the following:

```
Log Publisher             : Type              : enabled
--------------------------:-------------------:--------
File-Based Access Logger  : file-based-access : true
File-Based Audit Logger   : file-based-access : false
File-Based Debug Logger   : file-based-debug  : false
File-Based Error Logger   : file-based-error  : true
Oracle Access Logger      : file-based-access : false
Oracle Error Logger       : file-based-error  : false
Replication Repair Logger : file-based-error  : true
```

2 **(Optional) To display the properties of a log publisher run the following `dsconfig` command:**

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  get-log-publisher-prop --publisher-name "File-Based Error Logger"
```

Logging Internal Operations

By default, the `suppress-internal-logging` property for log publishers is set to `true`. If you need to log internal operations (such as operations performed by the LDIF connection handler and certain plug-ins), set `suppress-internal-logging` to `false`. The following example sets `suppress-internal-logging` to `false` for the file-based access logger:

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-log-publisher-prop \
  --advanced --publisher-name "File-Based Access Logger" \
  --set suppress-internal-operations:false
```

Configuring Log Retention Policies

Log retention policies dictate size and space limits for log files. Oracle Unified Directory provides the following three log retention policies:

- File count retention (`file-count`). By default, this policy sets the maximum number of log files to 10, for a specified type of log file.
- Free disk space retention (`free-disk-space`). By default, this policy sets a minimum remaining free disk space limit to 500 Mb, for a specified type of log file.
- Size limit retention (`size-limit`). By default, this policy sets the disk spaced used to a maximum of 500 Mb, for a specified type of log file.

By default, the log retention policy that is enabled is File count retention.

You can also create your own custom log retention policies.

▼ To View the Log Retention Policies

1 To view a list of the existing log retention policies run the following `dsconfig` command:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
  list-log-retention-policies
```

The default output will be similar to the following:

```
Log Retention Policy             : Type            : disk-space-used : free-disk-space : number-of-files
---------------------------------:-----------------:-----------------:-----------------:----------------
File Count Retention Policy      : file-count      : -               : -               : 10
Free Disk Space Retention Policy : free-disk-space : -               : 500 mb          : -
Size Limit Retention Policy      : size-limit      : 500 mb          : -               : -
```

2 (Optional) To list the log retention policy properties run the following `dsconfig` command

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
get-log-retention-policy-prop --policy-name "Free Disk Space Retention Policy"
```

▼ To Create a Log Retention Policy

● To create a log retention policy, and to set it as enabled, type:

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n
create-log-retention-policy \
--policy-name MyMaxDiskSpace \
--type size-limit \
--set disk-space-used:100mb
```

To Modify a Log Retention Policy

- **To modify the properties of an existing log retention policy run the following `dsconfig` command:**

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n
set-log-retention-policy-prop \
--policy-name "File Count Retention Policy" \
--set number-of-files:20
```

Instead of setting a property value, you can add, reset or remove a property value, using the `--add`, `--reset`, or `--remove` subcommands instead of the `--set` subcommand. For details, see "dsconfig" in *Oracle Fusion Middleware Command-Line Usage Guide for Oracle Unified Directory*.

Configuring Log Rotation Policies

Log rotation policies dictate how often the files are rotated, that is to say, how long log files are kept based on various criteria. Oracle Unified Directory provides the following four log rotation policies:

- 24 Hours time limit rotation policy. By default, this policy sets the rotation interval to one day. Time of day can be configured.
- 7 Days time limit rotation policy. By default, this policy sets the rotation interval to one week. Time of day can be configured.
- Fixed time limit rotation policy. By default, this policy sets the time of day that log files are to be rotated, to one minute before midnight.
- Size time limit rotation policy. By default, this policy sets a maximum size that log files can reach to 100 Mb, before the log file is rotated.

The type of log rotation policy enabled by default depends on the log type.

- For access and audit logs, the following are enabled:
  - 24 Hours time limit rotation policy
  - Size time limit rotation policy
- For error and replication repair logs, the following are enabled:
  - 7 Days time limit rotation policy
  - Size time limit rotation policy

You can create your own custom log rotation policies.

Note – When multiple rotation policies are specified for the same log, the first threshold that is reached triggers the rotation.

▼ To View the Log Rotation Policies

1. **To view a list of the existing log rotation policies run the following `dsconfig` command:**

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
list-log-rotation-policies
```

The default output will be similar to the following:

```
Log Rotation Policy                : Type       : file-size-limit : rotation-interval : time-of-day
-----------------------------------:------------:-----------------:-------------------:------------
24 Hours Time Limit Rotation Policy : time-limit : -               : 1 d               : -
7 Days Time Limit Rotation Policy   : time-limit : -               : 1 w               : -
Fixed Time Rotation Policy          : fixed-time : -               : -                 : 2359
Size Limit Rotation Policy          : size-limit : 100 mb          : -                 : -
```

2. **(Optional) To list the log rotation policy properties, type**

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n \
get-log-rotation-policy-prop "Fixed Time Rotation Policy"
```

▼ To Create a Log Rotation Policy

● **To create a log rotation policy run the following `dsconfig` command:**

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -X -n
create-log-rotation-policy \
--policy-name my2DayPolicy \
--type time-limit \
--set rotation-interval:2d
```

The policy type can be one of the following:

- `size-limit`
- `fixed-time`
- `time-limit`

▼ To Set Log Rotation or Retention for a Specific Log File

In order to set a log rotation policy on a specific log file, you must create a log publisher and set the log rotation or log retention policy.

● **To set log rotation or retention for a specific log file run the following `dsconfig` command:**

```
$ dsconfig -h localhost -p 1444 -D "cn=Directoy manager" -w password -n -X \
create-log-publisher \
--publisher-name myPublisher \
--type file-based-access \
--set log-file:logs/myLogs \
--set enabled:true \
--set retention-policy:MyMaxDiskSpace \
--set rotation-policy:my2DayPolicy
```

Differences Between Logging in Oracle Unified Directory and Oracle Directory Server Enterprise Edition

The logging architectures of Oracle Unified Directory and Oracle Directory Server Enterprise Edition differ significantly. The most notable differences include the following:

- Oracle Unified Directory allows for several loggers of any type to be defined and active at any time. This feature makes it possible to log messages to different locations and to different types of repositories. You can also define different sets of criteria for what to include in the logs. For example, one access log might hold everything, another might hold operations with a non-zero result code only, and yet another might hold write operations only.
- Oracle Directory Server Enterprise Edition defines an *audit logger* that is used to hold information about the changes that are made to directory data. In Oracle Unified Directory, the audit logging capability is still present, but it is classified as a type of access logger.

Note – The current Oracle Unified Directory logging mechanism cannot easily be used to define filters that restrict the types of content to include in the log.

Configuring Alerts and Account Status Notification Handlers

Oracle Unified Directory provides mechanisms for transmitting alert and account status notifications by means of JMX extensions or SMTP extensions. You can configure the directory server to send alert notifications when an event occurs during processing. Typical server events include server starts and shut downs, or problems that are detected by the server, such as an attempt to write to the configuration file.

You can also receive account status notifications when an event occurs during password policy processing, such as when accounts are locked out, accounts expire, passwords expire, and so on.

Alerts and account status notification handlers are configured by using the `dsconfig` command. For more information, see “Managing the Server Configuration With `dsconfig`” on page 25.

For additional information about the topics in this section, see Chapter 11, “Managing Password Policies,” and The Alert Handler Configuration.

Managing Alert Handlers

Oracle Unified Directory supports the following alert handlers:

- JMX alert handler for JMX notifications
- SMTP alert handler for email notifications.
- Custom alert handlers

▼ To View All Configured Alert Handlers

Oracle Unified Directory stores alert handlers information in the configuration file under the `cn=Alert Handlers,cn=config` subtree. You can access the information using the `dsconfig` command.

● **To display a list of alert handlers, run the following `dsconfig` command:**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
 list-alert-handlers

Alert Handler     : Type : enabled
------------------:------:--------
JMX Alert Handler : jmx  : false
```

▼ To Enable an Alert Handler

The JMX alert handler is disabled by default. Before you begin, you must configure JMX on the server. For more information, see "Monitoring the Server With JConsole" on page 493.

1 **To list the alert handler's properties, use the `dsconfig` command as follows.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  get-alert-handler-prop \
  --handler-name "JMX Alert Handler"

Property            : Value(s)
--------------------:--------------------------------------------
disabled-alert-type : -
enabled             : false
enabled-alert-type  : -
```

2 **To enable the alert handler, use `dsconfig` as follows.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-alert-handler-prop \
  --handler-name "JMX Alert Handler" --set enabled:true
```

3 **(Optional) Verify the change by using `dsconfig`.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  get-alert-handler-prop \
  --handler-name "JMX Alert Handler"

Property            : Value(s)
--------------------:--------------------------------------------
```

```
disabled-alert-type : -
enabled             : true
enabled-alert-type  : -
```

▼ To Configure an Alert Handler

You can create a new alert handler by using `dsconfig`. This example configures a new SMTP handler. Before starting this procedure, ensure that you have configured an SMTP server for your server.

1 To create an alert handler run `dsconfig` with the `create-alert-handler` subcommand.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  create-alert-handler \
  --handler-name "my SMTP Handler" --type smtp --set enabled:true \
  --set message-body:"Alert Type: %%alert-type%%\n\nAlert ID: \
  %%alert-id%%\n\nAlert Message: %%alert-message%%" \
  --set message-subject:"Alert Message" \
  --set recipient-address:directorymanager@example.com \
  --set sender-address:OUD-Alerts@directory.example.com
```

2 (Optional) View the list of alert handlers by using `dsconfig`.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
 list-alert-handlers
```

Supported Alert Types

The server sends out message alerts when an alert type event occurs in the system. The supported alert types are defined in the following table.

Alert Type	Description
Access Control Disabled Java Class: `org.opends.server.AccessControlDisabled`	Notify administrator that the access control handler has been disabled.
Access Control Enabled Java Class: `org.opends.server.Enabled`	Notify administrator that the access control handler has been enabled.
Access Control Parse Failed Java Class: `org.opends.server.authentication.dseecompat.ACIParseFailed`	Notify administrator if the Oracle Directory Server Enterprise Edition compatible access control subsystem failed to correctly parse one or more ACI rules when the server is first started.
Backend Environment Unusable Java Class: `org.opends.server.BackendRunRecovery`	Notify administrator that the JE back end throws a `RunRecoveryException` and the directory server needs to be restarted.
Cannot Copy Schema Files Java Class: `org.opends.server.CannotCopySchemaFiles`	Notify administrator if a problem occurs while attempting to create copies of the existing schema configuration before making a schema update, and the schema configuration is left in a potentially inconsistent state.

Alert Type	Description
Cannot Find Recurring Task Java Class: `org.opends.server.CannotFindRecurringTask`	Notify administrator if the directory server is unable to locate a recurring task definition in order to schedule the next iteration once the previous iteration has completed.
Cannot Rename Current Task File Java Class: `org.opends.server.CannotRenameCurrentTaskFile`	Notify administrator if the directory server is unable to rename the current tasks backing file in the process of trying to write an updated version.
Cannot Rename New Task File Java Class: `org.opends.server.CannotRenameNewTaskFile`	Notify administrator if the directory server is unable to rename the new tasks backing file into place.
Cannot Schedule Recurring Iteration Java Class: `org.opends.server.CannotScheduleRecurringIteration`	Notify administrator if the directory server is unable to schedule an iteration of a recurring task.
Cannot Write Configuration Java Class: `org.opends.server.CannotWriteConfig`	Notify administrator if the directory server is unable to write its updated configuration for some reason and so the server cannot exhibit the new configuration if it is restarted.
Cannot Write New Schema Files Java Class: `org.opends.server.CannotWriteNewSchemaFiles`	Notify administrator if a problem occurs while attempting to write new versions of the server schema configuration files, and the schema configuration is left in a potentially inconsistent state.
Cannot Write Task File Java Class: `org.opends.server.CannotWriteTaskFile`	Notify administrator if the directory server is unable to write an updated tasks backing file for some reason.
Distribution Backend Does Not Support PreRead Control Java Class: `com.sun.dps.server.distribution.globalindex.UnsupportedDirectoryBackend`	Notify administrators if the distribution is unable to maintain the content of the global index catalog. This will happen \ if one or more servers do not support the Pre-Read Entry Control (RFC 4527)
Entering Lockdown Mode Java Class: `org.opends.server.EnteringLockdownMode`	Notify administrator that the directory server is entering lockdown mode, in which only root users will be allowed to perform operations and only over the loopback address.
LDAP Connection Handler Consecutive Failures Java Class: `org.opends.server.LDAPHandlerDisabledByConsecutiveFailures`	Notify administrator of consecutive failures that have occurred in the LDAP connection handler that have caused it to become disabled.
LDAP Connection Handler Uncaught Error Java Class: `org.opends.server.LDAPHandlerUncaughtError`	Notify administrator of uncaught errors in the LDAP connection handler that have caused it to become disabled.
LDAP Server Extension Failed Java Class: `com.sun.dps.server.workflowelement.proxyldap.LDAPServerExtension.LDAPServerExtensionDown`	Notify administrator that the LDAP Server Extension has been detected as Down.

Alert Type	Description
LDAP Server Extension is Up Java Class: `com.sun.dps.server.workflowelement.proxyldap.LDAPServerExtension.LDAPServerExtensionUp`	Notify administrator that the LDAP Server Extension has been detected as UP.
LDIF Backend Cannot Write Update Java Class: `org.opends.server.LDIFBackendCannotWriteUpdate`	Notify administrator that an LDIF back end was unable to store an updated copy of the LDIF file after processing a write operation.
LDIF ConnHandler Parse Error Java Class: `org.opends.server.LDIFConnectionHandlerParseError`	Notify administrator that the LDIF connection handler encountered an unrecoverable error while attempting to parse an LDIF file.
LDIF ConnHandler IO Error Java Class: `org.opends.server.LDIFConnectionHandlerIOError`	Notify administrator that the LDIF connection handler encountered an I/O error that prevented it from completing its processing.
Leaving Lockdown Mode Java Class: `org.opends.server.LeavingLockdownMode`	Notify administrator that the directory server is leaving lockdown mode.
Manual Config Edit Handled Java Class: `org.opends.server.ManualConfigEditHandled`	Notify administrator if the directory server detects that its configuration has been manually edited with the server online and those changes were overwritten by another change made through the server. The manually-edited configuration will be copied off to another location.
Manual Config Edit Lost Java Class: `org.opends.server.ManualConfigEditLost`	Notify administrator if the directory server detects that its configuration has been manually edited with the server online and those changes were overwritten by another change made through the server. The manually-edited configuration could not be preserved due to an unexpected error.
New route elected by the SaturationLoadBalancingAlgorithm Java Class: `com.sun.dps.server.SaturationLoadBalancer`	Notify administrator that a new route has been elected as active route by the saturation load balancing algorithm.
New route elected by the FailoverLoadBalancingAlgorithm Java Class: `com.sun.dps.server.FailoverLoadBalancer`	Notify administrator that a new route has been elected as the active route by the failover load balancing algorithm.
Replication Unresolved Conflict Java Class: `org.opends.server.replication.UnresolvedConflict`	Notify administrator if the multimaster replication cannot automatically resolve a conflict.
Server Started Java Class: `org.opends.server.DirectoryServerStarted`	Notify administrator that the directory server has completed its startup process.

Alert Type	Description
Server Shutdown Java Class: `org.opends.server.DirectoryServerShutdown`	Notify administrator that the directory server has begun the process of shutting down.
State change for a Saturation Load Balancing Route Java Class: `com.sun.dps.server.SaturationLoadBalancer`	Notify administrator that the saturation load balancing route state has changed (either from saturated to not saturated or from not saturated to saturated).
Uncaught Exception Java Class: `org.opends.server.UncaughtException`	Notify administrator if a directory server thread has encountered an uncaught exception that caused the thread to terminate abnormally. The impact that this problem has on the directory server depends on which thread was impacted and the nature of the exception.
Unique Attr Sync Conflict Java Class: `org.opends.server.UniqueAttributeSynchronizationConflict`	Notify administrator that a unique attribute conflict has been detected during synchronization processing.
Unique Attr Sync Error Java Class: `org.opends.server.UniqueAttributeSynchronizationError`	Notify administrator that an error occurred while attempting to perform unique attribute conflict detection during synchronization processing.
Unsupported Directory Backend Java Class: `com.sun.dps.server.distribution.globalindex.UnsupportedDirectoryBackend`	Notify administrator that the distribution is unable to maintain the content of the global index catalog. This will happen if one or more servers do not support the Pre-Read Entry Control (RFC 4527).

▼ To Delete an Alert Handler

The following example removes an alert handler from the directory server.

Note – You can simply *disable* an alert handler instead of deleting it. In this case, the alert handler is available if you need to enable it again in the future. For more information, see "To Disable an Alert Type" on page 471.

● **To delete an alert handler use the following `dsconfig` command.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  delete-alert-handler \
  --handler-name "JMX Alert Handler"
```

▼ To Disable an Alert Type

By default, all alert types are allowed. If you specify a value for the `enabled-alert-type` property, only alerts with one of those types are allowed. If you specify a value for the `disabled-alert-type` property, all alert types except for the values in that property are allowed. Alert types are specified by their Java class, as shown in this example.

- **To disable an alert type, specify its Java class as a value of the `disabled-alert-type` property.**

This command disables the startup alert from the JMX Alert Handler.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-alert-handler-prop \
  --handler-name "JMX Alert Handler" \
  --set disabled-alert-type:org.opends.server.DirectoryServerStarted
```

Managing Account Status Notification Handlers

Account status notification handlers provide alerts on events during password policy processing. By default, the Error Log Account Status Notification handler is set to enabled upon initial configuration. The server writes a message to the server error log when one of the following events has been configured in the password policy and occurs during the course of password policy processing:

- `account-temporarily-locked`
- `account-permanently-locked`
- `account-unlocked`
- `account-idle-locked`
- `account-reset-locked`
- `account-disabled`
- `account-expired`
- `password-expired`
- `password expiring`
- `password-reset`
- `password-changed`

The error log is located at *install-dir*`/logs/errors`.

▼ To View the Configured Account Status Notification Handlers

- **Use `dsconfig` with the `list-account-status-notification-handlers` subcommand.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  list-account-status-notification-handlers

Account Status Notification Handler : Type      : enabled
------------------------------------:-----------:--------
Error Log Handler                   : error-log : true
SMTP Handler                        : smtp      : false
```

▼ To Enable Account Status Notification Handlers

You can enable an existing account status notification handler using the `dsconfig` command. By default, the directory server enables the Error Log Handler when the server is initially configured. This example enables the SMTP notification handler.

1 **To view the `enabled` property use `dsconfig` with the `get-account-status-notification-handler-prop` subcommand.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  get-account-status-notification-handler-prop --handler-name "SMTP Handler" \
--property enabled

Property : Value(s)
---------:---------
enabled  : false
```

2 **To enable the notification handler use `dsconfig` with the `set-account-status-notification-handler-prop` subcommand.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-account-status-notification-handler-prop --handler-name "SMTP Handler" \
  --set property:enabled
```

▼ To Create a New Account Status Notification Handler

1 **Use `dsconfig` with the `create-account-status-notification-handler` subcommand to create the handler.**

When you specify the type, you can use either `error-log` or `generic` (default).

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  create-account-status-notification-handler \
  --handler-name "My Password Reset Logger" --type error-log --set enabled:true \
  --set account-status-notification-type:password-reset
```

2 **(Optional) Use `dsconfig` to view the list of account status notification handlers.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  list-account-status-notification-handlers

Account Status Notification Handler : Type      : enabled
------------------------------------:-----------:--------
Error Log Handler                   : error-log : true
my Password Reset Logger            : error-log : true
SMTP Handler                        : smtp      : false
```

▼ To Delete an Account Status Notification Handler

You can disable an account status notification handler instead of deleting it. In this case, the alert handler is available if you need to enable it again in the future.

You can remove an account status notification handler entirely by using `dsconfig`.

● **Use `dsconfig` with the `delete-account-status-notification-handler` subcommand.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  delete-account-status-notification-handler --handler-name "My Password Reset Logger"
```

Monitoring the Server With LDAP

Oracle Unified Directory provides a variety of methods to monitor the current state of the server for debugging or troubleshooting purposes.

The topics in this section assume that you have configured monitoring providers on the server. For more information, see "Configuring Monitor Providers" on page 460.

You can monitor the server over LDAP in the following ways:

- "Viewing Monitoring Information Using the `cn=monitor` Entry" on page 474
- "Monitoring Using the `manage-tasks` Command" on page 493
- "Monitoring the Server With JConsole" on page 493
- "Accessing Logs" on page 496

Viewing Monitoring Information Using the `cn=monitor` Entry

The directory server records system, performance, and version information as an entry with the base DN of `cn=monitor`. This entry provides useful performance metrics and server state information that you can use to monitor and debug a directory server instance.

You can access the `cn=monitor` suffix over the regular LDAP port but there are advantages to using the administration port to access monitoring information. The main advantage of the administration connector is the separation of user traffic and administration traffic.

For example, if you monitor the number of connections on the LDAP Connection Handler ("`cn=Client Connections,cn=LDAP Connection Handler 0.0.0.0 port` *port-number*`,cn=monitor`") over the regular LDAP port, your monitoring data are "polluted" by the monitoring request itself. All of the examples in this section use the administration port, over SSL. For more information, see "Managing Administration Traffic to the Server" on page 62.

Monitored Attributes in the Oracle Unified Directory proxy

Monitoring information related to Oracle Unified Directory proxy can be collected at the level under `cn=Monitor` for dozens of attributes, including those relating to the following:

- Workflows: `cn=workflow,cn=monitor`
- Network Groups: `cn=Network Groups,cn=monitor`
- Load balancers: `cn=load balancing,cn=monitor`
- Distributions: `cn=distribution,cn=monitor`
- Global Index Catalogs: `cn=Global Index Catalogs,cn=monitor`

- Client Connections: `cn=Client Connections,cn=monitor` or under `cn=Client Connections,cn=LDAP Connection Handler` *0.0.0.0* `port`*port number* `,cn=monitor`
- LDAP Connection Handler: `cn=LDAP Connection Handler` *0.0.0.0* `port`*port number* `,cn=monitor`
- LDAP Connection Handler Statistics: `cn=LDAP Connection Handler` *0.0.0.0* `port`*port number* `statistics,cn=monitor`
- SNMP Connection Handler: `cn=SNMP Connection Handler,cn=Monitor`
- JMX Connection Handler: `cn=JMX Connection Handler` *port number* `,cn=monitor`
- Administration Connector: `cn=Administration Connector` *0.0.0.0* `port`*port number* `,cn=monitor`
- System Information: `cn=System Information,cn=monitor`
- Version: `cn=Version,cn=monitor`
- Back-end LDAP servers: `cn=LDAP Servers,cn=monitor`
- JVM stack traces: `cn=JVM Stack Trace,cn=monitor`
- JVM memory usage: `cn=JVM Memory Usage,cn=Monitor`
- SNMP: `cn=SNMP,cn=Monitor`
- Backend Backup: `cn=backup Backend,cn=monitor`
- Monitoring of back-end data: `cn=monitor Backend,cn=monitor`
- Tasks on the Backend Backup: `cn=backup Backend,cn=monitor`
- Entry caches: `cn=Entry Caches,cn=monitor`
- Work queues: `cn=Work Queue,cn=monitor`

Other attributes are monitored under each of the above in the dn tree. For example, client connections are monitored under both `cn=Client Connections,` *0.0.0.0* `port`*port number* `,cn=monitor` and under `cn=Client Connections,cn=Administration Connector` *0.0.0.0* `port`*port number* `,cn=monitor`

A workflow element is monitored under the part of the tree to which that workflow element relates. For example, a load balancing workflow element can be monitored as `cn=load-bal-route1,cn=load balancing,cn=monitor`

Hundreds of statistics are collected by the Oracle Unified Directory proxy for monitoring. For example, for the persistent search function, `psearchCount` lists the number of persistent search operations and `psearchTotalCount` lists the number of persistent search operations since the last restart of the Oracle Unified Directory proxy.

You can list all of these statistics by using the `ldapsearch` command on the `cn=monitor` entry, as described in "To View the Available Monitoring Information" on page 476.

The following procedures use the `ldapsearch` command at the command line interface.

To view status information on the replication of global indexes, you can use the `gicadm status-replication` command. For more information, see "To View the Status of a Replicated Global Index Catalog Configuration" on page 112.

▼ To View the Available Monitoring Information

Use the `ldapsearch` command to inspect the attributes of `cn=monitor`. This example lists the base DNs of each monitor entry.

- **Run the `ldapsearch` command with a search scope of `sub` and the search attribute `1.1`.**

This search attribute indicates that no attributes should be included in the matching entries.

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll  -s sub -b "cn=monitor" "(objectclass=*)" "1.1"
dn: cn=monitor
dn: cn=Client Connections,cn=monitor
dn: cn=ads-truststore Backend,cn=monitor
dn: cn=Network Groups,cn=monitor
dn: cn=internal,cn=Network Groups,cn=monitor
dn: cn=default,cn=Network Groups,cn=monitor
dn: cn=LDAP Connection Handler 0.0.0.0 port 1389 Statistics,cn=monitor
dn: cn=Administration Connector 0.0.0.0 port 4444,cn=monitor
dn: cn=Client Connections,cn=Administration Connector 0.0.0.0 port 4444,cn=monitor
dn: cn=backup Backend,cn=monitor
dn: cn=Version,cn=monitor
dn: cn=Work Queue,cn=monitor
dn: cn=System Information,cn=monitor
dn: cn=userRoot Database Environment,cn=monitor
dn: cn=tasks Backend,cn=monitor
dn: cn=adminRoot Backend,cn=monitor
dn: cn=userRoot Backend,cn=monitor
dn: cn=schema Backend,cn=monitor
dn: cn=LDAP Connection Handler 0.0.0.0 port 1389,cn=monitor
dn: cn=admin,cn=Network Groups,cn=monitor
dn: cn=Client Connections,cn=LDAP Connection Handler 0.0.0.0 port 1389,cn=monitor
dn: cn=JVM Memory Usage,cn=monitor
dn: cn=Administration Connector 0.0.0.0 port 4444 Statistics,cn=monitor
dn: cn=JVM Stack Trace,cn=monitor
dn: cn=Entry Caches,cn=monitor
dn: cn=monitor Backend,cn=monitor
```

▼ To Monitor General-Purpose Server Information

- **Use the `ldapsearch` command with a base DN of `"cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll -s base -b "cn=monitor" "(objectclass=*)"
```

Output will be similar to the following:

```
dn: cn=monitor
startTime: 20110119135658Z
objectClass: extensibleObject
objectClass: top
```

```
objectClass: ds-monitor-entry
cn: monitor
vendorName: Oracle Corporation
currentTime: 20110121121114Z
vendorVersion: Oracle Unified Directory 11.1 (Oracle Unified Directory version = 11.1. 1.5.0)
maxConnections: 3
productName: Oracle Unified Directory
currentConnections: 1
totalConnections: 13
upTime: 1 days 22 hours 14 minutes 16 seconds
```

▼ To Monitor System Information

- **Use the `ldapsearch` command with the base DN "`cn=System Information,cn=monitor`".**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll -s base -b "cn=System Information,cn=monitor" "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
dn: cn=System Information,cn=monitor
javaVersion: 1.6.0_10
jvmArchitecture: 32-bit
jvmArguments: "-Dorg.opends.server.scriptName=start-ds"
jvmVersion: 11.0-b15
classPath: /local/instances/OUD/classes:
/local/instances/OUD/resources/resources.jar:
/local/instances/OUD/lib/activation.jar:
/local/instances/OUD/lib/aspectjrt.jar:
/local/instances/OUD/lib/je.jar:
/local/instances/OUD/lib/mail.jar:
/local/instances/OUD/lib/OUD_de.jar:
/local/instances/OUD/lib/OUD_es.jar:
/local/instances/OUD/lib/OUD_fr.jar:
/local/instances/OUD/lib/OUD_ja.jar:
/local/instances/OUD/lib/OUD.jar:
/local/instances/OUD/lib/OUD_zh_CN.jar:
/local/instances/OUD/lib/quicksetup.jar
usedMemory: 83361792
freeUsedMemory: 21020432
objectClass: extensibleObject
objectClass: top
objectClass: ds-monitor-entry
javaVendor: Oracle Corporation
operatingSystem: SunOS 5.11 x86
cn: System Information
systemName: llandudno
workingDirectory: /local/instances/OUD/bin
maxMemory: 518717440
availableCPUs: 2
javaHome: /usr/jdk/instances/jdk1.6.0/jre
jvmVendor: Oracle Corporation
```

To Monitor Version Information

- **Use the `ldapsearch` command with base DN `"cn=Version,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll -b "cn=Version,cn=Monitor" "(objectclass=*)"
```

The beginning of the output will be similar to the following:

```
dn: cn=Version,cn=monitor
labelNumber: 1012160831
shortName: OUD
objectClass: top
objectClass: ds-monitor-entry
objectClass: extensibleObject
compactVersion: OUD-11.1
pointVersion: 1
cn: Version
buildID: 20101216222159Z
majorVersion: 11
productName: Oracle Unified Directory
minorVersion: 1
versionQualifier: .4.3
fullVersion: Oracle Unified Directory 11.1 (Oracle Unified Directory version = 11.1.1. 5.0)
```

To Monitor the User Root Back End

The `userRoot` back end is the back-end database (the JE environment) for your data. The monitor displays the back end's general properties, such as writability mode, base DN, back-end IDs, entry count, and other properties.

- **Use the `ldapsearch` command with base DN `"cn=userRoot Backend,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll -s base -b "cn=userRoot Backend,cn=monitor" "(objectclass=*)"
dn: cn=userRoot Backend,cn=monitor
```

Depending on your configuration, output will be similar to the following:

```
objectClass: top
objectClass: ds-monitor-entry
objectClass: ds-backend-monitor-entry
ds-backend-is-private: FALSE
cn: userRoot Backend
ds-backend-writability-mode: enabled
ds-backend-entry-count: 2002
ds-backend-id: userRoot
ds-base-dn-entry-count: 2002 dc=example,dc=com
ds-backend-base-dn: dc=example,dc=com
```

▼ To Monitor the Backup Back End

● **Use the `ldapsearch` command with base DN `"cn=backup Backend,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll -s base -b "cn=backup Backend,cn=monitor" "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
dn: cn=backup Backend,cn=monitor
objectClass: top
objectClass: ds-monitor-entry
objectClass: ds-backend-monitor-entry
ds-backend-is-private: TRUE
cn: backup Backend
ds-backend-writability-mode: disabled
ds-backend-entry-count: 1
ds-backend-id: backup
ds-base-dn-entry-count: 1 cn=backups
ds-backend-base-dn: cn=backups
```

▼ To Monitor the Tasks Back End

Tasks are administrative functions (such as `import-ldif`, `export-ldif`, `backup`, and `restore`) that can be scheduled for processing at some future date or on a recurring basis. The monitor displays the tasks back end's general properties, such as writability mode, base DN, back-end IDs, entry count, and other properties.

● **Use the `ldapsearch` command with base DN `"cn=Tasks Backend,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll -s base -b "cn=Tasks Backend,cn=monitor" "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
dn: cn=tasks Backend,cn=monitor
objectClass: top
objectClass: ds-monitor-entry
objectClass: ds-backend-monitor-entry
ds-backend-is-private: TRUE
cn: tasks Backend
ds-backend-writability-mode: enabled
ds-backend-entry-count: 3
ds-backend-id: tasks
ds-base-dn-entry-count: 3 cn=tasks
ds-backend-base-dn: cn=tasks
```

▼ To Monitor the `monitor` Back End

This monitor displays the back end's general properties, such as writability mode, base DN, back-end IDs, entry count, and other properties.

- **Use the `ldapsearch` command with base DN `"cn=monitor Backend,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll -s base -b "cn=monitor Backend,cn=monitor" "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
dn: cn=monitor Backend,cn=monitor
objectClass: top
objectClass: ds-monitor-entry
objectClass: ds-backend-monitor-entry
ds-backend-is-private: TRUE
cn: monitor Backend
ds-backend-writability-mode: disabled
ds-backend-entry-count: 25
ds-backend-id: monitor
ds-base-dn-entry-count: 25 cn=monitor
ds-backend-base-dn: cn=monitor
```

▼ To Monitor the Schema Back End

This monitor displays the schema back end's general properties, such as writability mode, base DN, back-end IDs, entry count, and other properties.

- **Use the `ldapsearch` command with base DN `"cn=schema Backend,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll -s base -b "cn=schema Backend,cn=monitor" "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
dn: cn=schema Backend,cn=monitor
objectClass: top
objectClass: ds-monitor-entry
objectClass: ds-backend-monitor-entry
ds-backend-is-private: TRUE
cn: schema Backend
ds-backend-writability-mode: enabled
ds-backend-entry-count: 1
ds-backend-id: schema
ds-base-dn-entry-count: 1 cn=schema
ds-backend-base-dn: cn=schema
```

▼ To Monitor the `adminRoot` Back End

This monitor displays the `adminRoot` back end's general properties, such as writability mode, base DN, back-end IDs, entry count, and other properties.

- **Use the `ldapsearch` command with base DN `"cn=adminRoot Backend,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll -s base -b "cn=adminRoot Backend,cn=monitor" "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
dn: cn=adminRoot Backend,cn=monitor
objectClass: top
objectClass: ds-monitor-entry
objectClass: ds-backend-monitor-entry
ds-backend-is-private: TRUE
cn: adminRoot Backend
ds-backend-writability-mode: enabled
ds-backend-entry-count: 7
ds-backend-id: adminRoot
ds-base-dn-entry-count: 7 cn=admin data
ds-backend-base-dn: cn=admin data
```

▼ To Monitor the `ads-truststore` Back End

The `ads-truststore` holds a mirror, or copy, of the remote Administrative Directory Service (ADS) host's ADS key entry, so that the new instance can establish trust with existing servers in the ADS domain. The monitor displays the back end's general properties, such as writability mode, base DN, back-end IDs, entry count, and other properties.

● **Use the `ldapsearch` command with base DN `"cn=ads-truststore Backend,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll -s base -b "cn=ads-truststore Backend,cn=monitor" "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
dn: cn=ads-truststore Backend,cn=monitor
objectClass: top
objectClass: ds-monitor-entry
objectClass: ds-backend-monitor-entry
ds-backend-is-private: TRUE
cn: ads-truststore Backend
ds-backend-writability-mode: enabled
ds-backend-entry-count: 3
ds-backend-id: ads-truststore
ds-base-dn-entry-count: 3 cn=ads-truststore
ds-backend-base-dn: cn=ads-truststore
```

▼ To Monitor Client Connections

This monitor represents *all* of the open client connections. Its contents are different to those of the DN `"cn=Client Connections,cn=LDAP Connection Handler 0.0.0.0 port 1389,cn=monitor"`, which describes the open client connections on the LDAP connection handler only.

● **Use the `ldapsearch` command with base DN `"cn=Client Connections,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll -s base -b "cn=Client Connections,cn=monitor" "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
dn: cn=Client Connections,cn=monitor
connection: connID="11" connectTime="20090702125632Z" source="127.0.0.1:54044"
destination="127.0.0.1:1389" ldapVersion="3" authDN="cn=Directory Manager,cn=Root DNs,
cn=config" security="none" opsInProgress="1"
cn: Client Connections
objectClass: extensibleObject
objectClass: top
objectClass: ds-monitor-entry
```

▼ To Monitor the LDAP Connection Handler

This connection handler is used to interact with clients over LDAP.

- **Use the `ldapsearch` command with base DN `"cn=LDAP Connection Handler 0.0.0.0 port` *port-number*`,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll -s base -b "cn=LDAP Connection Handler 0.0.0.0 port 1389,cn=monitor" \
  "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
dn: cn=LDAP Connection Handler 0.0.0.0 port 1389,cn=monitor
ds-connectionhandler-listener: 0.0.0.0:1389
ds-connectionhandler-num-connections: 1
ds-connectionhandler-protocol: LDAP
objectClass: top
objectClass: ds-monitor-entry
objectClass: ds-connectionhandler-monitor-entry
ds-mon-config-dn: cn=ldap connection handler,cn=connection handlers,cn=config
cn: LDAP Connection Handler 0.0.0.0 port 1389
ds-connectionhandler-connection: connID="22" connectTime="20090702133936Z"
source="127.0.0.1:39574" destination="127.0.0.1:1389" ldapVersion="3"
authDN="cn=Directory Manager,cn=Root DNs,cn=config" security="none" opsInProgress="1"
```

▼ To Monitor LDAP Connection Handler Statistics

- **Use the `ldapsearch` command with base DN `"cn=LDAP Connection Handler 0.0.0.0 port` *port-number* `Statistics,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll -s base -b "cn=LDAP Connection Handler 0.0.0.0 port 1389 Statistics,cn=monitor" \
  "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
dn: cn=LDAP Connection Handler 0.0.0.0 port 1389 Statistics,cn=monitor
objectClass: ds-monitor-entry
objectClass: top
objectClass: extensibleObject
operationsCompleted: 37
compareRequests: 0
```

```
bytesWritten: 99488
extendedRequests: 0
addRequests: 0
bindRequests: 19
...(more output)
```

▼ To Monitor Connections on the LDAP Connection Handler

This monitor represents the open client connections on the LDAP connection handler.

- **Use the `ldapsearch` command with base DN `"cn=Client Connections,cn=LDAP Connection Handler 0.0.0.0 port` *port-number*`,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll \
  -b "cn=Client Connections,cn=LDAP Connection Handler 0.0.0.0 port 1389,cn=monitor" \
  "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
dn: cn=Client Connections,cn=LDAP Connection Handler 0.0.0.0 port 1389,cn=monitor
connection: connID="0" connectTime="20090706084747Z" source="127.0.0.1:57523" de
stination="127.0.0.1:1389" ldapVersion="3" authDN="" security="none" opsInProgr
ess="0"
connection: connID="1" connectTime="20090706084747Z" source="127.0.0.1:57524" de
stination="127.0.0.1:1389" ldapVersion="3" authDN="" security="none" opsInProgr
ess="0"
connection: connID="2" connectTime="20090706084747Z" source="127.0.0.1:57525" de
stination="127.0.0.1:1389" ldapVersion="3" authDN="" security="none" opsInProgr
ess="0"
connection: connID="3" connectTime="20090706084747Z" source="127.0.0.1:57526" de
stination="127.0.0.1:1389" ldapVersion="3" authDN="" security="none" opsInProgr
ess="0"
connection: connID="4" connectTime="20090706084747Z" source="127.0.0.1:57527" de
stination="127.0.0.1:1389" ldapVersion="3" authDN="" security="none" opsInProgr
ess="0"
```

▼ To Monitor the Administration Connector

This monitor provides basic information about the administration connector. For more information, see "Managing Administration Traffic to the Server" on page 62.

- **Use the `ldapsearch` command with base DN `"cn=Administration Connector 0.0.0.0 port` *admin-port-number*`,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll -b "cn=Administration Connector 0.0.0.0 port 4444,cn=monitor" \
  "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
objectClass: top
objectClass: ds-monitor-entry
objectClass: ds-connectionhandler-monitor-entry
dn: cn=Administration Connector 0.0.0.0 port 4444,cn=monitor
```

```
ds-connectionhandler-listener: 0.0.0.0:4444
ds-connectionhandler-num-connections: 0
ds-connectionhandler-protocol: LDAPS
cn: Administration Connector 0.0.0.0 port 4444
ds-mon-config-dn: cn=administration connector,cn=config
```

▼ To Monitor Administration Connector Statistics

This monitor provides extensive statistical information about operations that are performed through the administration connector. For more information, see "Managing Administration Traffic to the Server" on page 62.

- **Use the `ldapsearch` command with base DN `"cn=Administration Connector 0.0.0.0 port` *admin-port-number* `Statistics,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll -b "cn=Administration Connector 0.0.0.0 port 4444 Statistics,cn=monitor" \
  "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
dn: cn=Administration Connector 0.0.0.0 port 4444 Statistics,cn=monitor
compareResponses: 0
connectionsClosed: 1
searchResultsDone: 4
ds-mon-resident-time-mod-operations-total-time: 92257568
extendedResponses: 0
bindRequests: 2
operationsAbandoned: 0
bytesWritten: 45056
addResponses: 0
addRequests: 0
ds-mon-resident-time-moddn-operations-total-time: 0
ds-mon-extended-operations-total-count: 0
ds-mon-moddn-operations-total-count: 0
modifyResponses: 1
operationsCompleted: 7
...(more output)...
```

▼ To Monitor Connections on the Administration Connector

This monitor represents the open client connections on the Administration Connector.

- **Use the `ldapsearch` command with base DN `"cn=Client Connections,cn=Administration Connector 0.0.0.0 port` *port-number*`,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll \
  -b "cn=Client Connections,cn=Administration Connector 0.0.0.0 port 4444,cn=monitor" \
  "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
objectClass: top
objectClass: ds-monitor-entry
objectClass: extensibleObject
```

```
dn: cn=Client Connections,cn=Administration Connector 0.0.0.0 port 4444,cn=monitor
connection: connID="339" connectTime="20090707075218Z" source="127.0.0.1:48213"
destination="127.0.0.1:4444" ldapVersion="3" authDN="" security="TLS"
 opsInProgress="1"
cn: Client Connections
```

▼ To Monitor the LDIF Connection Handler

The LDIF connection handler is used to process changes that are read from an LDIF file, using internal operations. Monitoring information for the LDIF connection handler is only available if the connection handler is enabled.

- **Use the `ldapsearch` command with base DN `"cn=LDIF Connection Handler,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll -s base -b "cn=LDIF Connection Handler,cn=monitor" "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
objectClass: top
objectClass: ds-monitor-entry
objectClass: ds-connectionhandler-monitor-entry
dn: cn=LDIF Connection Handler,cn=monitor
ds-connectionhandler-num-connections: 0
ds-connectionhandler-protocol: LDIF
ds-mon-config-dn: cn=ldif connection handler,cn=connection handlers,cn=config
cn: LDIF Connection Handler
```

▼ To Monitor the Work Queue

The work queue keeps track of outstanding client requests and ensures that they are processed.

- **Use the `ldapsearch` command with base DN `"cn=Work Queue,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll -s base -b "cn=Work Queue,cn=monitor" "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
dn: cn=Work Queue,cn=monitor
currentRequestBacklog: 0
objectClass: extensibleObject
objectClass: top
objectClass: ds-monitor-entry
requestsSubmitted: 25
cn: Work Queue
maxRequestBacklog: 0
averageRequestBacklog: 0
requestsRejectedDueToQueueFull: 0
```

▼ To Monitor JVM Stack Trace Information

You can access JVM Stack Trace information for your directory server instance. This resource monitor is implemented in the `org.opends.server.monitors.StackTraceMonitorProvider` class and requires no custom configuration.

- **Use the `ldapsearch` command with the base DN `"cn=JVM Stack Trace,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll -s base -b "cn=JVM Stack Trace,cn=monitor" "(objectclass=*)"
```

Depending on your configuration, the beginning of the output will be similar to the following:

```
dn: cn=JVM Stack Trace,cn=monitor
cn: JVM Stack Trace
jvmThread: id=2 ---------- Reference Handler ----------
jvmThread: id=2 frame[0]=java.lang.Object.wait(Object.java:native)
jvmThread: id=2 frame[1]=java.lang.Object.wait(Object.java:485)
jvmThread: id=2 frame[2]=java.lang.ref.Reference$ReferenceHandler.run(Reference.
java:116)
jvmThread: id=3 ---------- Finalizer ----------
jvmThread: id=3 frame[0]=java.lang.Object.wait(Object.java:native)
jvmThread: id=3 frame[1]=java.lang.ref.ReferenceQueue.remove(ReferenceQueue.java
:116)
jvmThread: id=3 frame[2]=java.lang.ref.ReferenceQueue.remove(ReferenceQueue.java
:132)
jvmThread: id=3 frame[3]=java.lang.ref.Finalizer$FinalizerThread.run(Finalizer.j
ava:159)
jvmThread: id=4 ---------- Signal Dispatcher ----------
jvmThread: id=10 ---------- Time Thread ----------
jvmThread: id=10 frame[0]=sun.misc.Unsafe.park(Unsafe.java:native)
jvmThread: id=10 frame[1]=java.util.concurrent.locks.LockSupport.parkNanos(LockS
upport.java:198)
...(more output)...
```

▼ To Monitor the JVM Memory Usage

- **Use the `ldapsearch` command with base DN `"cn=JVM Memory Usage,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll -s base -b "cn=JVM Memory Usage,cn=monitor" "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
dn: cn=JVM Memory Usage,cn=monitor
ps-eden-space-bytes-used-after-last-collection: 0
ps-mark-sweep-total-collection-count: 0
code-cache-bytes-used-after-last-collection: 0
ps-old-gen-current-bytes-used: 25260472
ps-perm-gen-bytes-used-after-last-collection: 0
ps-scavenge-recent-collection-duration: 3
ps-scavenge-total-collection-count: 17
ps-eden-space-current-bytes-used: 32001992
ps-perm-gen-current-bytes-used: 21179960
ps-old-gen-bytes-used-after-last-collection: 0
ps-mark-sweep-total-collection-duration: 0
ps-mark-sweep-average-collection-duration: 0
ps-scavenge-average-collection-duration: 26
ps-scavenge-total-collection-duration: 443
objectClass: extensibleObject
objectClass: top
objectClass: ds-monitor-entry
ps-mark-sweep-recent-collection-duration: 0
```

```
ps-survivor-space-bytes-used-after-last-collection: 622592
cn: JVM Memory Usage
code-cache-current-bytes-used: 2143680
ps-survivor-space-current-bytes-used: 622592
```

▼ To Monitor the `userRoot` Database Environment

The `userRoot` database environment utilizes the Berkeley DB Java Edition back end. JE monitoring data (data under `cn=*Database Environment,cn=monitor`) is reliable only in the short term. During high server activity (for example, anywhere from an hour to several days depending on the counter), this data can overflow. In such cases, the JE monitoring data can reflect negative values or positive but incorrect values. This is a known issue and is expected to be fixed in the next major release of the Berkeley DB Java Edition. Oracle SR numbers 15979 and 15985 correspond to this issue.

● **Use the `ldapsearch` command with base DN `"cn=userRoot Database Environment,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll -s base -b "cn=userRoot Database Environment,cn=monitor" "(objectclass=*)"
dn: cn=userRoot Database Environment,cn=monitor
```

Depending on your configuration, output will be similar to the following:

```
EnvironmentNTempBufferWrites: 0
EnvironmentNNodesExplicitlyEvicted: 0
EnvironmentCleanerBacklog: 0
EnvironmentTotalLogSize: 5386067
EnvironmentLockBytes: 2000
EnvironmentNFullBINFlush: 2
EnvironmentNBINsStripped: 0
EnvironmentLastCheckpointEnd: 5385359
TransactionNCommits: 24
EnvironmentNCleanerEntriesRead: 0
EnvironmentNRepeatFaultReads: 2
TransactionNXACommits: 0
EnvironmentNClusterLNsProcessed: 0
TransactionNBegins: 24
LockNOwners: 25
...(more output)...
```

▼ To Monitor the Entry Cache

You can access the aggregated state of all active entry caches for your directory server instance by accessing the `cn=Entry Caches,cn=Monitor` entry. The server can also request the "per cache" monitor data for a given instance if the entry cache instances are enabled in the directory server configuration:

- `cn=FIFO Entry Cache,cn=Monitor`
- `cn=Soft Reference Entry Cache,cn=Monitor`
- `cn=File System Entry Cache,cn=Monitor`

Additionally, any arbitrarily named active entry cache instance should provide a monitor, which can be accessed by that instance name, for example `cn=Any Arbitrary Name Entry Cache,cn=Monitor`.

- **Use the `ldapsearch` command with base DN `"cn=Entry Caches,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password --useSSL \
  --trustAll -s base -b "cn=Entry Caches,cn=monitor" "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
dn: cn=Entry Caches,cn=monitor
entryCacheHits: 0
entryCacheTries: 0
currentEntryCacheCount: 0
objectClass: extensibleObject
objectClass: top
objectClass: ds-monitor-entry
entryCacheHitRatio: 0
cn: Entry Caches
...
```

To Monitor Network Groups

- **Use the `ldapsearch` command with the base DN `"cn=Network Groups,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password \
--useSSL --trustAll -b "cn=Network Groups,cn=monitor" "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
objectClass: top
objectClass: ds-monitor-entry
objectClass: ds-mon-branch
dn: cn=Network Groups,cn=monitor
dn: cn=admin,cn=Network Groups,cn=monitor
ds-mon-compare-operations-total-count: 0
ds-mon-failed-referrals-total-count: 15
ds-mon-unbind-operations-total-count: 13
ds-mon-followed-referrals-total-count: 34
ds-mon-violations-schema-total-count: Not implemented
ds-mon-bind-operations-total-count: 98
ds-mon-persistent-searchs-count: Not implemented
ds-mon-add-operations-total-count: 37
ds-mon-abandon-operations-total-count: 0
ds-mon-moddn-operations-total-count: 0
ds-mon-extended-operations-total-count: 0
ds-mon-searchsubtree-operations-total-count: 310
objectClass: top
objectClass: ds-monitor-entry
objectClass: extensibleObject
ds-mon-discarded-referrals-total-count: Not implemented
ds-mon-mod-operations-total-count: 1
ds-mon-forwarded-referrals-total-count: Not implemented
cn: admin
ds-mon-searchonelevel-operations-total-count: 92966
```

```
ds-mon-delete-operations-total-count: 0

dn: cn=default,cn=Network Groups,cn=monitor
...
```

▼ To Monitor Distributions

● **Use the `ldapsearch` command with the base DN `"cn=Distribution,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=directory manager" -w password \
  --useSSL --trustAll -b "cn=Distribution,cn=monitor" "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
objectClass: top
objectClass: ds-monitor-entry
objectClass: ds-mon-branch
dn: cn=distribution,cn=monitor

cn: distrib-we
ds-mon-searchonelevel-operations-total-count: 0
ds-mon-residenttime-bind-operations-max-time: 0
...

ds-mon-delete-operations-total-count: 0

dn: cn=algorithm,cn=distrib-we,cn=distribution,cn=monitor
ds-mon-residenttime-total-time: 0
ds-mon-residenttime-max-time: 0
cn: algorithm
ds-mon-runs-total-count: 0
ds-mon-residenttime-min-time: 0
objectClass: top
objectClass: ds-monitor-entry
objectClass: extensibleObject

dn: cn=partitions,cn=algorithm,cn=distrib-we,cn=distribution,cn=monitor
objectClass: top
objectClass: ds-monitor-entry
objectClass: ds-mon-branch

dn: cn=distrib-part1,cn=partitions,cn=algorithm,cn=distrib-we,cn=distribution,cn
 =monitor
...
objectClass: top
objectClass: ds-monitor-entry
objectClass: extensibleObject
ds-mon-modify-operations-total-count: 0
cn: distrib-part1
ds-mon-searchonelevel-operations-total-count: 0
ds-mon-delete-operations-total-count: 0

dn: cn=distrib-part2,cn=partitions,cn=algorithm,cn=distrib-we,cn=distribution,cn
 =monitor

...
```

▼ To Monitor Load Balancing

- **Use the `ldapsearch` command with the base DN `"cn=load balancing,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=Directory Manager" -w password \
  --useSSL --trustAll -b "cn=load balancing,cn=monitor" "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
objectClass: top
objectClass: ds-monitor-entry
objectClass: ds-mon-branch
dn: cn=load balancing,cn=monitor
dn: cn=load-bal-we1,cn=load balancing,cn=monitor
ds-mon-aborted-add-operations-total-count: 0
...
dn: cn=algorithm,cn=load-bal-we1,cn=load balancing,cn=monitor

dn: cn=routes,cn=algorithm,cn=load-bal-we1,cn=load balancing,cn=monitor
...
dn: cn=load-bal-route1,cn=routes,cn=algorithm,cn=load-bal-we1,cn=load balancing,
 cn=monitor
...
dn: cn=load-bal-we2,cn=load balancing,cn=monitor
...
dn: cn=algorithm,cn=load-bal-we2,cn=load balancing,cn=monitor
...
dn: cn=routes,cn=algorithm,cn=load-bal-we2,cn=load balancing,cn=monitor

dn: cn=load-bal-route1,cn=routes,cn=algorithm,cn=load-bal-we2,cn=load balancing,
 cn=monitor
...
cn: load-bal-route1

dn: cn=load-bal-route2,cn=routes,cn=algorithm,cn=load-bal-we1,cn=load balancing,
 cn=monitor
...
cn: load-bal-route2

dn: cn=load-bal-route2,cn=routes,cn=algorithm,cn=load-bal-we2,cn=load balancing,
 cn=monitor

cn: load-bal-route2
ds-mon-searchonelevel-operations-total-count: 9
ds-mon-delete-operations-total-count: 0
```

▼ To Monitor Remote LDAP Servers

- **Use the `ldapsearch` command with the base DN `"cn=LDAP Servers,cn=monitor"`.**

```
$ ldapsearch -h localhost -p 4444 -D "cn=Directory Manager" -w password \
  --useSSL --trustAll -b "cn=LDAP Servers,cn=monitor" "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
objectClass: top
objectClass: ds-monitor-entry
```

```
objectClass: ds-mon-branch
dn: cn=LDAP Servers,cn=monitor

dn: cn=proxy1,cn=LDAP Servers,cn=monitor
ds-mon-aborted-add-operations-total-count: 0
...
cn: proxy1
ds-mon-searchonelevel-operations-total-count: 0
...
objectClass: top
objectClass: ds-monitor-entry
objectClass: extensibleObject

dn: cn=proxy2,cn=LDAP Servers,cn=monitor
ds-mon-aborted-add-operations-total-count: 0
...
cn: proxy2
ds-mon-searchonelevel-operations-total-count: 0
...
objectClass: top
objectClass: ds-monitor-entry
objectClass: extensibleObject
...
dn: cn=proxy3,cn=LDAP Servers,cn=monitor
...
cn: proxy3
ds-mon-searchonelevel-operations-total-count: 0
...
objectClass: top
objectClass: ds-monitor-entry
objectClass: extensibleObject
...
dn: cn=proxy4,cn=LDAP Servers,cn=monitor
...
cn: proxy4
...
objectClass: top
objectClass: ds-monitor-entry
objectClass: extensibleObject
```

▼ To Monitor a Global Index

● **Use the `ldapsearch` command with the base DN `"cn=givenname,cn=gi-catalog,cn=Global Index Catalogs,cn=monitor"`.**

Ensure that givenname corresponds to the name of the indexed attribute (for example cn, if you indexed cn), and that gi-catalog corresponds to the name of the global index catalog.

```
$ ldapsearch -h localhost -p 4444 -D "cn=Directory Manager" -w password --useSSL \
  --trustAll -b "cn=givenname,cn=gi-catalog,cn=Global Index Catalogs,cn=monitor"
  "(objectclass=*)"
```

Depending on your configuration, output will be similar to the following:

```
dn: cn=givenname,cn=gi-catalog,cn=Global Index Catalogs,cn=monitor
ds-mon-add-operations-min-time: 0
ds-mon-add-operations-aborted-count: 0
```

```
ds-mon-lookup-operations-min-time: 0
ds-mon-getpartitions-operations-total-count: 0
ds-mon-add-operations-max-time: 0
ds-mon-lookup-operations-total-count: 0
ds-mon-memorized-remove-operations-count: 0
ds-mon-remove-operations-aborted-count: 0
ds-mon-add-operations-total-time: 0
ds-mon-getpartitions-operations-aborted-count: 0
ds-mon-lookup-operations-total-time: 0
ds-mon-index-entries: 0
ds-mon-remove-operations-failed-count: 0
ds-mon-getpartitions-operations-min-time: 0
ds-mon-lookup-operations-max-time: 0
ds-mon-getpartitions-operations-average-time: 0
ds-mon-index-creation-date: 1252483187019
ds-mon-getpartitions-operations-last-access-date: 0
ds-mon-remove-operations-total-count: 0
ds-mon-lookup-operations-failed-count: 0
ds-mon-add-operations-failed-count: 0
ds-mon-remove-operations-min-time: 0
ds-mon-add-operations-average-time: 0
ds-mon-lookup-operations-aborted-count: 0
ds-mon-getpartitions-operations-total-time: 0
ds-mon-remove-operations-max-time: 0
ds-mon-getpartitions-operations-max-time: 0
ds-mon-lookup-operations-last-access-date: 0
ds-mon-add-operations-total-count: 0
ds-mon-remove-operations-total-time: 0
ds-mon-remove-operations-average-time: 0
ds-mon-getpartitions-operations-failed-count: 0
objectClass: ds-monitor-entry
objectClass: top
objectClass: extensibleObject
ds-mon-lookup-operations-average-time: 0
ds-mon-remove-operations-last-access-date: 0
cn: givenname
ds-mon-add-operations-last-access-date: 0
```

▼ To Monitor a Global Index Catalog

- **Use the `ldapsearch` command with the base DN `"cn=gi-catalog,cn=Global Index Catalogs,cn=monitor"`.**

  Ensure that `givenname` corresponds to the name of the indexed attribute (for example cn, if you indexed cn), and that `gi-catalog` corresponds to the name of the global index catalog.

  ```
  $ ldapsearch -h localhost -p 4444 -D "cn=Directory Manager" -w password --useSSL \
    --trustAll -b "cn=gi-catalog,cn=Global Index Catalogs,cn=monitor" "(objectclass=*)"
  ```

  Depending on your configuration, output will be similar to the following:

  ```
  dn: cn=gi-catalog,cn=Global Index Catalogs,cn=monitor
  ds-mon-replication-received-update-message-errors: 0
  ds-mon-configured-index-number: 1
  ds-mon-replication-full-update-pending-attribute:
  ds-mon-replication-full-update-status: NONE
  ds-mon-state: RUNNING_STANDALONE
  ```

```
ds-mon-replication-published-update-message-number: 0
ds-mon-replication-active: false
ds-mon-replication-auto-sync-retries: 0
ds-mon-replication-published-update-message-errors: 0
ds-mon-replication-full-update-errors: 0
ds-mon-replication-received-update-message-number: 0
ds-mon-replication-auto-sync-is-running: false
objectClass: ds-monitor-entry
objectClass: top
objectClass: extensibleObject
ds-mon-replication-configured: false
cn: gi-catalog
```

Monitoring Using the `manage-tasks` Command

Oracle Unified Directory provides a tasks back end that provides a mechanism for scheduling and processing certain tasks, such as `import-ldif`, `export-ldif`, `backup`, and `restore`. You can schedule a task to run at specific times and at recurring periods. To monitor scheduled tasks, use the `manage-tasks` command. For more information, see "Configuring Commands As Tasks" on page 64.

Monitoring the Server With JConsole

The JConsole (`jconsole`) Java utility is a JMX-compliant, graphical tool that connects to a running Java Virtual Machine that has been started with the management agent. This generic tool can be used to access server monitoring information.

▼ To Configure JMX on a Server Instance

1 **Start the server.**

2 **Enable the JMX Connection Handler and set the port number to be used with JMX.**

Choose a port that is not in use and to which the user that is running the server has access rights.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-connection-handler-prop \
  --handler-name "JMX Connection Handler" --set enabled:true --set listen-port:1689
```

3 **Add the JMX read, write, and notify privileges to the root DN.**

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  set-root-dn-prop \
  --add default-root-privilege-name:jmx-read \
  --add default-root-privilege-name:jmx-write \
  --add default-root-privilege-name:jmx-notify
```

4 **Restart the server.**

Starting JConsole

Start the console by typing `jconsole` in a terminal window.

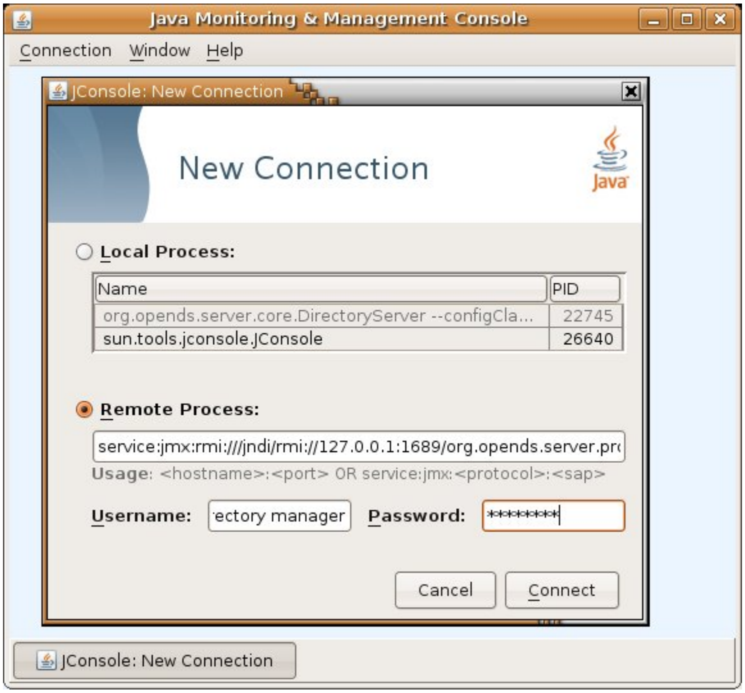
To run `jconsole` from the command line, you might have to add *JAVA_HOME*`/bin` to your path, where *JAVA_HOME* is the directory containing the JDK. Alternatively, you can enter the full path when you type the command.

For more information about using JConsole, see Using JConsole.

Accessing a Server Instance From JConsole

To connect JConsole to a server instance, use the Remote Process fields.

FIGURE 13–1 New Connection to a Server



Name	PID
org.opends.server.core.DirectoryServer --configCla...	22745
sun.tools.jconsole.JConsole	26640

service:jmx:rmi:///jndi/rmi://127.0.0.1:1689/org.opends.server.pr(

Usage: <hostname>:<port> OR service:jmx:<protocol>:<sap>

Username: ectory manager Password: ********

The following fields are required:

- **JMX URL**:

  ```
  service:jmx:rmi:///jndi/rmi://''host'':''port''/
  org.opends.server.protocols.jmx.client-unknown
  ```

  - *host* is a host name, an IPv4 numeric host address, or an IPv6 numeric address enclosed in square brackets.
  - *port* is the decimal port number of the JMX connector. (See "Configuring Alerts and Account Status Notification Handlers" on page 466).

  The default JMX URL is:

  ```
  service:jmx:rmi:///jndi/rmi://127.0.0.1:1689/
  org.opends.server.protocols.jmx.client-unknown
  ```

- **User Name.** A valid LDAP user name.

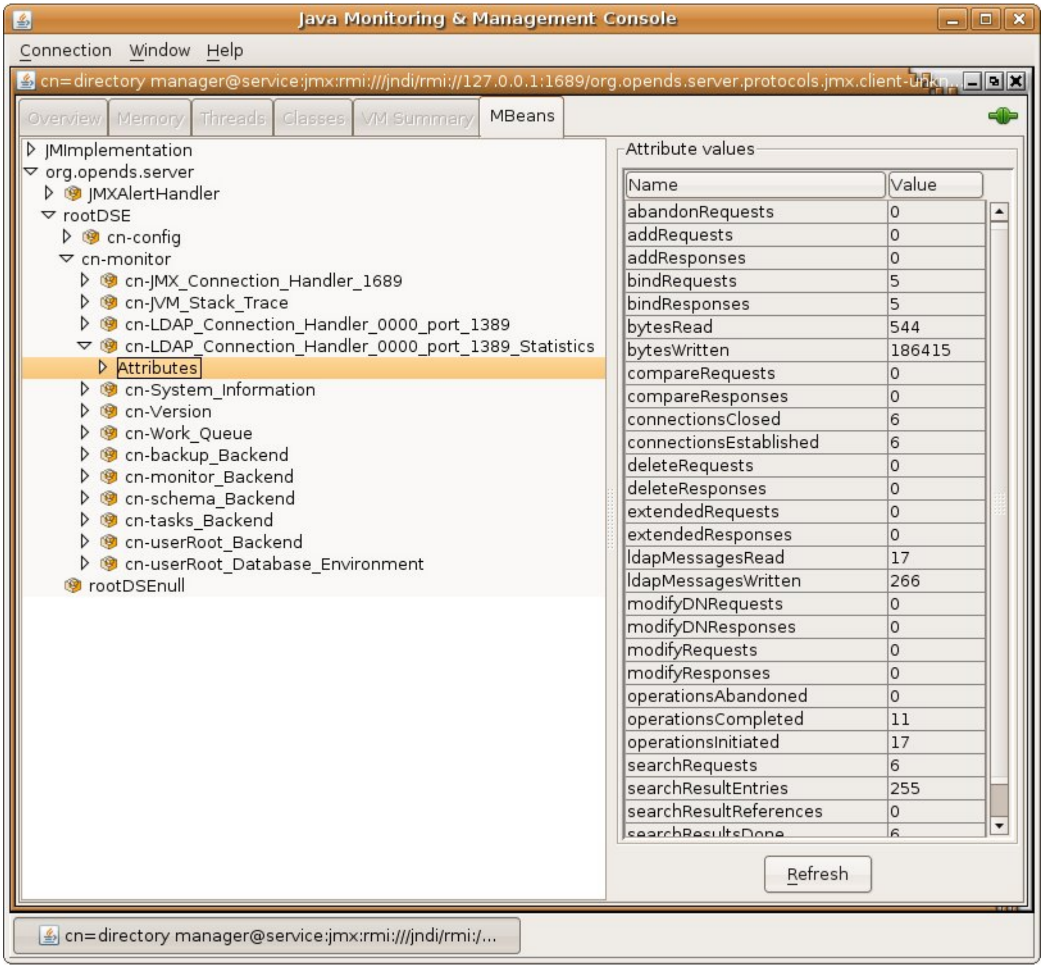
  The default Directory Manager user name is `cn=Directory Manager`.
- **Password.** The user's LDAP password.

Viewing Monitoring Information With JConsole

When JConsole is connected to a server instance, it displays management objects (MBeans). The tree on the left pane shows all MBeans currently available. You can access server monitoring information in the right hand pane by selecting the associated MBean.

The following figure shows the attribute list for a server `cn=LDAP Connection Handler 0.0.0.0 port 1389 Statistics,cn=monitor`.

FIGURE 13–2 Java Monitoring and Management Console


Java Monitoring & Management Console
Connection
Window
Help
cn=directory manager@service:jmx:rmi:///jndi/rmi://127.0.0.1:1689/org.opends.server.protocols.jmx.client-unkn...
Overview
Memory
Threads
Classes
VM Summary
MBeans
Refresh
cn=directory manager@service:jmx:rmi:///jndi/rmi:/...

```
▷ JMImplementation
▽ org.opends.server
  ▷ JMXAlertHandler
  ▽ rootDSE
    ▷ cn-config
    ▽ cn-monitor
      ▷ cn-JMX_Connection_Handler_1689
      ▷ cn-JVM_Stack_Trace
      ▷ cn-LDAP_Connection_Handler_0000_port_1389
      ▽ cn-LDAP_Connection_Handler_0000_port_1389_Statistics
        ▷ Attributes
      ▷ cn-System_Information
      ▷ cn-Version
      ▷ cn-Work_Queue
      ▷ cn-backup_Backend
      ▷ cn-monitor_Backend
      ▷ cn-schema_Backend
      ▷ cn-tasks_Backend
      ▷ cn-userRoot_Backend
      ▷ cn-userRoot_Database_Environment
    rootDSEnull
```

Attribute values

Name	Value
abandonRequests	0
addRequests	0
addResponses	0
bindRequests	5
bindResponses	5
bytesRead	544
bytesWritten	186415
compareRequests	0
compareResponses	0
connectionsClosed	6
connectionsEstablished	6
deleteRequests	0
deleteResponses	0
extendedRequests	0
extendedResponses	0
ldapMessagesRead	17
ldapMessagesWritten	266
modifyDNRequests	0
modifyDNResponses	0
modifyRequests	0
modifyResponses	0
operationsAbandoned	0
operationsCompleted	11
operationsInitiated	17
searchRequests	6
searchResultEntries	255
searchResultReferences	0
searchResultsDone	6

Accessing Logs

The server provides logging mechanisms to record access, error, or debugging information for the server instance. Multiple loggers of a given type can be active at any time, which makes it possible to create logs for specific subtrees or different repositories. The server does not currently provide logging filters to restrict the type of information in the logs.

The following logs are provided:

- **Access logs**. Access logs record information about the types of operations processed by the directory server.
- **Audit logs**. Audit logs are a type of access log and record all activity on the directory server.

- **Debug logs**. Debug logs record information that can be used for troubleshooting directory server problems or for providing detailed information about the directory server's processing.
- **Error logs**. Error logs record all warnings, errors, or significant events that occur during directory server processing.
- **Replication repair logs**. Replication repair logs record inconsistencies on a single directory server in a topology.

  The replication repair log is read-only and its use is restricted to enabling replication conflict resolution.
- **vdp-setup logs**. The vdp-setup logs record the equivalent command line arguments executed during the installation of the Oracle Unified Directory proxy using the graphical or command line versions of `vdp-setup`.
- **server.out logs**. The server.out logs record the bootstrapping configuration process, list extensions loaded from jar files, and indicate connection and alert notification activity.

To View the Access Logs

1 Change to the logs directory of the server instance.

```
$ cd install-dir/logs
```

2 Open the `access` file by using a text editor or the UNIX `cat` command.

```
$ cat access | more
[24/Oct/2008:16:02:52 -0500] CONNECT conn=0 from=127.0.0.1 to=127.0.0.1 protocol=LDAP
[24/Oct/2008:16:02:52 -0500] BIND conn=0 op=0 msgID=1 type=SIMPLE dn="cn=Directory
  Manager"
[24/Oct/2008:16:02:53 -0500] BIND conn=0 op=0 msgID=1 result="Success"
authDN="cn=Directory Manager,cn=Root DNs,cn=config" etime=57
...(more output)...
```

To View the Audit Logs

1 Change to the logs directory of the server instance.

```
$ cd install-dir/logs
```

2 Open the `audit` file by using a text editor or the UNIX `cat` command.

```
$ cat audit | more
# 05/Nov/2008:13:32:58 -0600; conn=21; op=51
dn: cn=File-Based Audit Logger,cn=Loggers,cn=config
changetype: modify
replace: ds-cfg-enabled
ds-cfg-enabled: true
-
replace: modifiersName
modifiersName: cn=Directory Manager,cn=Root DNs,cn=config
-
```

```
replace: modifyTimestamp
modifyTimestamp: 20081105193257Z
# 05/Nov/2008:13:33:17 -0600; conn=21; op=57
dn: cn=File-Based Debug Logger,cn=Loggers,cn=config
changetype: modify
replace: ds-cfg-enabled
ds-cfg-enabled: true
-
replace: modifiersName
modifiersName: cn=Directory Manager,cn=Root DNs,cn=config
-
replace: modifyTimestamp
modifyTimestamp: 20081105193316Z
...(more output)...
```

▼ To View the Debug Logs

1. **Change to the logs directory of the server instance.**

   ```
   $ cd install-dir/logs
   ```

2. **Open the `debug` file by using a text editor or the UNIX `cat` command.**

   ```
   $ cat debug | more
   [24/Oct/2008:16:02:52 -0500] CONNECT conn=0 from=127.0.0.1 to=127.0.0.1 protocol=LDAP
   [24/Oct/2008:16:02:52 -0500] BIND conn=0 op=0 msgID=1 type=SIMPLE dn="cn=Directory
     Manager"
   [24/Oct/2008:16:02:53 -0500] BIND conn=0 op=0 msgID=1 result="Success"
   authDN="cn=Directory Manager,cn=Root DNs,cn=config" etime=57
   ...(more output)...
   ```

▼ To View the Error Logs

1. **Change to the logs directory of the server instance.**

   ```
   $ cd install-dir/logs
   ```

2. **Open the `errors` file by using a text editor or the UNIX `cat` command.**

   ```
   $ cat errors | more
   [24/Oct/2007:16:02:10 -0500] category=CONFIG severity=NOTICE msgID=3605006
   msg=Access control has been enabled and will use the
   org.opends.server.authorization.dseecompat.AciHandler implementation
   [24/Oct/2007:16:02:17 -0500] category=JEB severity=NOTICE msgID=8847402
   msg=The database backend userRoot containing 160 entries has started
   [24/Oct/2007:16:02:21 -0500] category=CORE severity=NOTICE msgID=458887
   msg=The Directory Server has started successfully
   ...(more output)...
   ```

▼ To View the Replication Repair Logs

1. **Change to the logs directory of the server instance.**

   ```
   $ cd install-dir/logs
   ```

2 **Open the `replication` file by using a text editor or the UNIX `cat` command.**

```
$ cat replication | more
[09/Oct/2007:11:02:22 -0500] category=SYNC severity=NOTICE msgID=15138878
msg=Replication Server sr1-carb-08/129.123.131.98:8989 now used for Replication
Domain cn=admin data
[09/Oct/2007:11:02:23 -0500] category=SYNC severity=NOTICE msgID=15138878
msg=Replication Server sr1-carb-08/129.123.131.98:8989 now used for Replication
Domain cn=schema
[09/Oct/2007:11:02:23 -0500] category=SYNC severity=NOTICE msgID=15138878
msg=Replication Server sr1-carb-08/129.123.131.98:8989 now used for Replication
Domain dc=example,dc=com
...(more output)...
```

▼ To View the server.out Logs

1 **Change to the logs directory of the server instance.**

$ cd *install-dir*/logs

2 **Open the `server.out` file by using a text editor or the UNIX `cat` command.**

```
$ cat server.out | more
[19/Jan/2011:14:56:53 +0100] category=CORE severity=INFORMATION msgID=132
  msg=The Directory Server is beginning the configuration bootstrapping process
[19/Jan/2011:14:56:55 +0100] category=EXTENSIONS severity=INFORMATION msgID=1049147
  msg=Loaded extension from file '/local/instances/OracleJavaDirectory.11.1.1.4.3/lib/
  extensions/distribution.jar' (build 1.0.0, revision unknown)
[19/Jan/2011:14:56:55 +0100] category=EXTENSIONS severity=INFORMATION msgID=1049147
  msg=Loaded extension from file '/local/instances/OracleJavaDirectory.11.1.1.4.3/lib/
  extensions/globalindex.jar' (build 1.0.0, revision unknown)
[19/Jan/2011:14:56:55 +0100] category=EXTENSIONS severity=INFORMATION msgID=1049147
  msg=Loaded extension from file '/local/instances/OracleJavaDirectory.11.1.1.4.3/lib/
  extensions/loadbalancing.jar' (build 1.0.0, revision unknown)
[19/Jan/2011:14:56:56 +0100] category=EXTENSIONS severity=INFORMATION msgID=1049147
  msg=Loaded extension from file '/local/instances/OracleJavaDirectory.11.1.1.4.3/lib/
  extensions/proxyldap.jar' (build 1.0.0, revision unknown)
[19/Jan/2011:14:56:56 +0100] category=EXTENSIONS severity=INFORMATION msgID=1049147
  msg=Loaded extension from file '/local/instances/OracleJavaDirectory.11.1.1.4.3/lib/
  extensions/replication-gateway.jar' (build 1.0.0, revision unknown)
[19/Jan/2011:14:56:56 +0100] category=EXTENSIONS severity=INFORMATION msgID=1049147
  msg=Loaded extension from file '/local/instances/OracleJavaDirectory.11.1.1.4.3/lib/
  extensions/snmp-mib2605.jar' (build 11.1.1.4.3, revision unknown)
[19/Jan/2011:14:56:56 +0100] category=EXTENSIONS severity=INFORMATION msgID=1049147
  msg=Loaded extension from file '/local/instances/OracleJavaDirectory.11.1.1.4.3/lib/
  extensions/virtualization.jar' (build 1.0.0, revision unknown>)
[19/Jan/2011:14:56:58 +0100] category=CORE severity=NOTICE msgID=458886 msg=Oracle Unified
  Directory 11.1 (Oracle Unified Directory version = 11.1.1.4.3) (build 20101216222159Z, R1012160831)
  starting up
[19/Jan/2011:14:57:09 +0100] category=RUNTIME_INFORMATION severity=NOTICE msgID=20381717
  msg=Installation Directory:  /local/instances/OracleJavaDirectory.11.1.1.4.3
[19/Jan/2011:14:57:09 +0100] category=RUNTIME_INFORMATION severity=NOTICE msgID=20381719
  msg=Instance Directory:      /local/instances/OracleJavaDirectory.11.1.1.4.3
...
more output
...
```

▼ To View the vdp-setup Logs

1. **Change to the logs directory of the server instance.**

   $ cd *install-dir*/logs

2. **Open the `vdp-setup` file by using a text editor or the UNIX `cat` command.**

```
$ cat vdp-setup | more
Jun 24, 2009 6:22:12 PM com.sun.dps.ui.deploy.SetupLog initLogFileHandler
INFO: vdp-setup application launched June 24, 2009 6:22:12 PM MEST
Jun 24, 2009 6:32:08 PM com.sun.dps.ui.deploy.step.ProgressThread executeConfigPhase
INFO: /installationdir/vdp-setup --cli
--ldapPort 5389 --adminConnectorPort 4454 --rootUserDN cn=Directory\ Manager
--rootUserPassword ****** --doNotStart
Jun 24, 2009 6:33:00 PM com.sun.dps.ui.deploy.step.ProgressThread executeConfigPhase
INFO: /installationdir/bin/start-ds --timeout 0
Jun 24, 2009 6:33:06 PM com.sun.dps.ui.deploy.step.ProgressThread executeConfigPhase
INFO: /installationdir/bin/dsconfig
create-trust-manager-provider --provider-name Backend\ Servers
--type file-based --set enabled:true --set trust-store-file:/installationdir/co
nfig/backend-servers-truststore --set trust-store-type:JKS
--set trust-store-pin-file:/installationdir/config/backend-servers-truststore.pin
--hostname midgard --port 4454 --bind
DN cn=Directory\ Manager --bindPassword ****** --trustAll --no-prompt
...(more output)...
```

Monitoring the Server With SNMP

Oracle Unified Directory provides a jar file extension that contains a Simple Network Management Protocol (SNMP) connection handler for Management Information Base (MIB) 2605 support. The extension contains the SNMP connection handler, the required classes to support MIB 2605 objects and SNMP requests, and the SNMP adapter that allows an SNMP manager to access the server monitoring information.

Before you start on the procedures in this section, ensure that you have set up an SNMP-managed network for your particular system.

Configuring the SNMP Connection Handler and Its Dependencies

Oracle Unified Directory provides an SNMP connection handler that you can enable and configure. The SNMP connection handler is provided as a jar file extension and is located in *install-dir*/`lib/extensions/snmp-mib2605.jar`.

▼ To Configure SNMP in the Server

Oracle Unified Directory can be configured for monitoring through the Simple Network Management Protocol (SNMP). The server uses the Java Dynamic Management Kit (JDMK) to create smart agents for the SNMP connection handler.

1. **Verify that you have the SNMP connection handler.**

   Use `dsconfig` to view the list of current connection handlers.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  list-connection-handlers

Connection Handler       : Type : enabled : listen-port : use-ssl
-------------------------:------:---------:-------------:--------
JMX Connection Handler   : jmx  : false   : 1689        : false
LDAP Connection Handler  : ldap : true    : 1389        : false
LDAPS Connection Handler : ldap : false   : 636         : true
LDIF Connection Handler  : ldif : true    : -           : -
SNMP Connection Handler  : snmp : false   : 161         : -
```

2. **Use the `dsconfig` command to enable SNMP for the server.**

```
$ dsconfig -h localhost -p 4444 -D "cn=Directory Manager" -w password -n -X \
  set-connection-handler-prop \
  --handler-name "SNMP Connection Handler" --set enabled:true --set listen-port:8085
```

▼ To View the SNMP Connection Handler Properties

● **Verify that you have the SNMP connection handler.**

Use the following `dsconfig` command.

```
$ dsconfig -h localhost -p 4444 -D "cn=directory manager" -w password -n \
  get-connection-handler-prop \
  --handler-name "SNMP Connection Handler"
```

The connection handler properties are listed with their values, as follows.

```
Property            : Value(s)
--------------------:------------------------------------------
allowed-client      : -
allowed-manager     : *
allowed-user        : *
community           : OUD
denied-client       : -
enabled             : false
listen-port         : 161
opendmk-jarfile     : -
registered-mbean    : false
security-agent-file : config/snmp/security/oud-snmp.security
security-level      : authnopriv
trap-port           : 162
traps-community     : OUD
traps-destination   : -
```

▼ To Access SNMP on a Server Instance

1 **Restart the server by using `stop-ds` and `start-ds`.**

If the server was started and no modifications were made to the configuration, the restart operation is not required.

2 **Check that your SNMP Connection Handler is up and running.**

```
$ snmpwalk -v 2c -c OUD@OUD localhost:8085 mib-2.66
SNMPv2-SMI::mib-2.66.1.1.1.1 = STRING: "Oracle Unified Directory Server 11.1.1.5.0 -
  20090310152800Z"
SNMPv2-SMI::mib-2.66.1.1.2.1 = STRING: "instance-dir/bin"
SNMPv2-SMI::mib-2.66.1.1.3.1 = Gauge32: 35
SNMPv2-SMI::mib-2.66.1.1.4.1 = Gauge32: 1
SNMPv2-SMI::mib-2.66.1.1.5.1 = Gauge32: 0
SNMPv2-SMI::mib-2.66.1.1.6.1 = Counter32: 0
SNMPv2-SMI::mib-2.66.1.1.7.1 = Counter32: 1
SNMPv2-SMI::mib-2.66.2.1.1.1.1 = INTEGER: 1
SNMPv2-SMI::mib-2.66.2.1.1.1.2 = INTEGER: 2
SNMPv2-SMI::mib-2.66.2.1.1.1.3 = INTEGER: 3
SNMPv2-SMI::mib-2.66.2.1.2.1.1 = OID: SNMPv2-SMI::internet.27.3.8085
SNMPv2-SMI::mib-2.66.2.1.2.1.2 = OID: SNMPv2-SMI::internet.27.3.1389
SNMPv2-SMI::mib-2.66.2.1.2.1.3 = OID: SNMPv2-SMI::enterprises.42
SNMPv2-SMI::mib-2.66.2.1.3.1.1 = Counter32: 1
SNMPv2-SMI::mib-2.66.2.1.3.1.2 = Counter32: 1
SNMPv2-SMI::mib-2.66.2.1.3.1.3 = Counter32: 1
SNMPv2-SMI::mib-2.66.2.1.4.1.1 = Counter32: 1
SNMPv2-SMI::mib-2.66.2.1.4.1.2 = Counter32: 1
SNMPv2-SMI::mib-2.66.2.1.4.1.3 = Counter32: 1
SNMPv2-SMI::mib-2.66.2.1.5.1.1 = Counter32: 1
SNMPv2-SMI::mib-2.66.2.1.5.1.2 = Counter32: 1
...
```

The managed objects included in the MIB 2605 are divided into three tables: `dsTable`, `dsAppliIfOpsTable`, and `dsIntTable`. Currently, the `dsIntTable` table is not implemented.

SNMP Security Configuration

SNMP security configuration depends on the version of SNMP as you are using. This topic discusses security configuration for SNMP V1 and V2c, and vor V3.

SNMP Security Configuration: V1 and V2c

Under SNMP v1 and SNMP v2c, agents act as information servers, and the IP-based access control protects this information from unauthorized access. By default, the MIB 2605 is accessible in v1 and v2c by using the community string `OUD@OUD`. All managers are allowed to read the monitoring information exposed by the MIB 2605.

Note – Only read access is authorized on the MIB 2605.

You can configure SNMP v1 and SNMP v2c by setting the SNMP connection handler properties with the `dsconfig` command. Properties related to the SNMP v1 and SNMP v2c security configuration include:

- `allowed-manager`
- `community`

SNMP v1 traps are sent on server startup and server shutdown. By default, these traps are sent to `localhost` and use the trap community string "OUD".

Note – The default trap port might have to be changed to a value that is allowed by the system.

SNMP traps are also configured by setting the SNMP connection properties with the `dsconfig` command. Properties related to SNMP traps include:

- `trap-port`
- `traps-community`
- `traps-destination`

The ACL file that corresponds to the default values of the SNMP connection handler would be represented as follows:

```
acl = {
{
communities = OUD
access = read-only
managers = all
}
}
trap = {
{
traps-community = OUD
hosts = localhost
}
}
```

SNMP Security Configuration: V3

The SNMP v3 protocol provides more sophisticated security mechanisms than SNMP v1 and SNMP v2c. SNMP v3 implements a user-based security model (USM) that authenticates and encrypts the requests sent between agents and their managers, and provides user-based access control. A `defaultUser` template is provided for adding authorized users in the agent engine using the SNMP cloning mechanism.

Under SNMP v3, the community string described in the previous section is used as the "context" from which the MIB 2605 is registered. By default, the MIB2605 is accessible in v3 by using the context "OUD". All users have access to it.

The SNMP v3 UACL is configured by setting the SNMP connection handler properties with the `dsconfig` command-line utility. The properties related to SNMP v3 UACL configuration include:

- community
- allowed-user
- security-level

The UACL file corresponding to the default values of the SNMP connection handler would be represented as follows:

```
uacl = {
{
context-names = OUD
access = read-only
security-level = authNoPriv
users = *
}
}
```

SNMP USM Configuration: V3

The USM MIB (that is, the MIB that defines allowed users) is registered in the `null` context and only a `snmpAdmin` user with a security level `authNoPriv` has `read-write` access to it. This `snmpAdmin` user can add additional users who can access the MIB 2605 information.

The SNMP v3 USM configuration is read from a template file that is located at *install-dir*`/config/snmp/security/oud-snmp.security`. The template file is not encrypted.

To access the MIB 2605 in the server agent, use the SNMP clone mechanism to add a user in the security file. Use `snmpAdmin` to send the SNMP request for the clone mechanism as shown here. The user to clone is `defaultUser`. The `snmpAdmin` and `defaultUser` users cannot access the MIB 2605 information.

- Admin User to add and configure other users.

  ```
  userEntry=localEngineID,snmpAdmin,null,usmHMACMD5AuthProtocol,passadmin
  ```
- Template user to be cloned with no read or write access.

  ```
  userEntry=localEngineID,defaultUser,,usmHMACMD5AuthProtocol,password,,,3,true
  ```

Note – The security file is also used to make the users persistent.

Monitoring a Replicated Topology

These topics describe how to monitor a replicated topology by using the `dsreplication status` command, and how to use the `ldapsearch` command to obtain more advanced monitoring information.

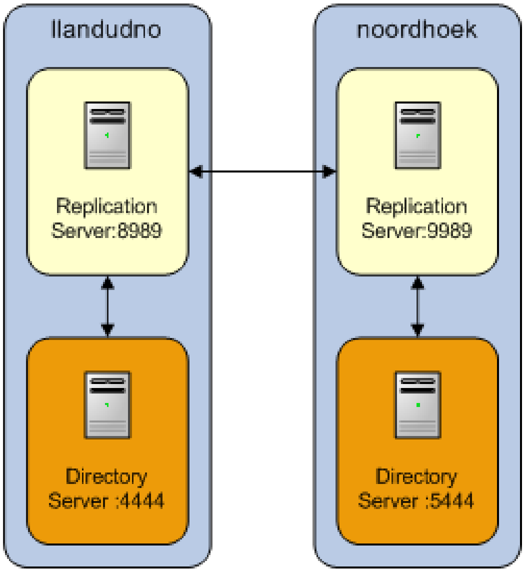
Monitoring Replication Status With `dsreplication`

The simplest way to monitor replication is to use the `dsreplication status` command. This command provides a tabular view of the replication status, including the following information:

- The topology and its connections
- The latency between replicated servers
- The data consistency across replicated servers
- The security configuration between replicated servers
- The replication protocol peer to peer

The examples in the remainder of this section assume the following simple replication topology.

FIGURE 13–3 Simple Replication Topology



To obtain the replication status, run the following command:

```
$ dsreplication status --adminUID admin --adminPassword password -X \
 --hostname host1 --port 4444

dc=example,dc=com - Replication Enabled
=======================================
Server     :Entries:M.C.[1]:A.O.M.C.[2]:Port[3]:Encryption[4]:Trust[5]:U.C.[6]:Status[7]
-----------:-------:-------:-----------:-------:-------------:--------:-------:---------
host1:4444 :2003   :0      :N/A        :8989   :Disabled     :Trusted :N/A    :Normal
host2:4444 :2003   :0      :N/A        :8989   :Disabled     :Trusted :N/A    :Normal

[1] The number of changes that are still missing on this server (and that have been applied
    to at least one other server).
[2] Age of oldest missing change: the age (in seconds) of the oldest change that has not yet
    arrived on this server.
[3] The port used to communicate between the servers whose contents are being replicated.
[4] Whether the replication communication through the replication port is encrypted or not.
[5] Whether this directory server is trusted or not. Updates coming from an untrusted server
    are discarded and not propagated.
[6] The number of untrusted changes. These are changes generated on this server while it is
    untrusted.
    Those changes are not propagated to the rest of the topology but are effective on the
    untrusted server.
[7] The status of the replication domain on this directory server.
```

The output of this command includes the following:

- **Server.** Lists the LDAP servers in the topology and the port on which they are listening for LDAP connections.
- **Entries.** Indicates the number of entries on each server for the specified base DN. If the information in this column is not the same across all the servers, the replication topology is not synchronized.
- **M.C.** Indicates the number of updates already pushed by the other LDAP servers in the topology, but not yet replayed on the specified LDAP server. If this number is high on a particular server, investigate the latency of that server.
- **A.O.M.C.** Specifies the approximate date of the oldest update pushed by the other directory servers in the topology, but not yet processed on the specified LDAP server.
- **Port.** Indicates the port of the replication server to which the specified LDAP server is directly connected.
- **Encryption.** Indicates whether SSL encryption is enabled between the LDAP server and its replication server.
- **Trust.** Indicates whether this server is configured as a trusted or untrusted server. For more information, see “Using Isolated Replicas” on page 350.
- **U.C.** Specifies the number of changes that have been made on an untrusted server, and not yet replicated to the topology. For more information, see “Using Isolated Replicas” on page 350.
- **Status.** Indicates the status of the replication domain on this directory server. The status can be one of the following:

- **Normal.** The connection to a replication server is established with the correct data set. Replication is working. If assured mode is used, then acknowledgements from this directory server are sent.
- **Degraded.** The connection to a replication server is established with the correct data set. Replication is working in degraded mode as the directory server has numerous changes that are pending in the replication server queue. If assured mode is used, then acknowledgements from this directory server are not expected.
- **Full Update.** The connection to a replication server is established and a new data set is received from this connection (online import), to initialize the local back end.
- **Bad Data Set.** The connection to a replication server is established with a data set that is different from the rest of the topology. Replication is not working. Either the other directory servers of the topology should be initialized with a compatible data set, or this server should be initialized with another data set that is compatible with the other servers.
- **Not Connected.** The directory server is not connected to any replication server.

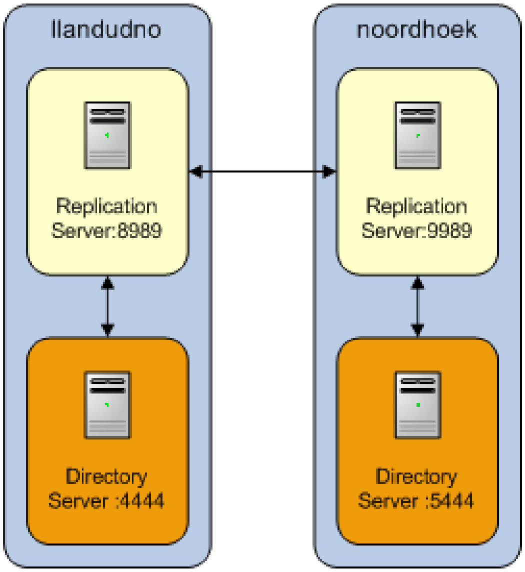
Note – Additional replication monitoring information is available under the `cn=monitor` entry. You can use the `ldapsearch` command to track specific monitoring attributes, which will provide you with a comprehensive view of the replication status. For more information, see "Advanced Replication Monitoring" on page 507.

Advanced Replication Monitoring

The easiest way to monitor replication status is by using the `dsreplication status` command. However, in depth replication monitoring information is available under the `cn=monitor` entry. You can use the `ldapsearch` command to track specific monitoring attributes, which provide you with a comprehensive view of the replication status. Monitoring information is consolidated by replication servers. Therefore, monitoring information can only be retrieved by searching a directory server that hosts a running replication server.

The examples in the remainder of this section assume the following simple replication topology.

FIGURE 13–4 Simple Replication Topology



These examples access the `cn=monitor` entry on the administration port over SSL (`--useSSL`) and automatically trust the certificate that is presented by the server (`--trustAll`).

The information under `cn=monitor` can be filtered to include a single replicated base DN. You can do this in two ways:

- Specify the `domain-name` attribute as a filter, for example:

  ```
  $ ldapsearch -p 4444 --useSSL --trustAll -b "cn=monitor" \
    "(domain-name=dc=example,dc=com)"
  ```
- Include the base DN in the search base, for example:

  ```
  $ ldapsearch -p 4444 --useSSL --trustAll \
    -b "cn=dc_example_dc_com,cn=replication,cn=monitor" "(objectclass=*)"
  ```

To Monitor the Topology and Its Connections

Each directory server contains a list of candidate replication servers for each replicated base DN. However, a directory server is *connected* to only one replication server at a time.

To obtain an overview of the replication topology and its connections, run the following search on any directory server in the topology that hosts a replication server:

```
$ ldapsearch -p 4444 --useSSL --trustAll -b "cn=monitor" "(connected-to=*)" \
  "connected-to" "lost-connections"
dn: cn=Replication Domain 30839,cn=dc_example_dc_com,cn=replication,cn=monitor
lost-connections: 0
connected-to: llandudno/0:0:0:0:0:0:0:1:8989
```

```
dn: cn=Replication Domain 14142,cn=cn_schema,cn=replication,cn=monitor
lost-connections: 0
connected-to: llandudno/0:0:0:0:0:0:0:1:8989

dn: cn=Connected Replica llandudno 27742,cn=Replication Server 8989  1740,cn=cn_
admin data,cn=replication,cn=monitor
connected-to: Replication Server 8989 1740

dn: cn=Connected Replica llandudno 30839,cn=Replication Server 8989  1740,cn=dc_
example_dc_com,cn=replication,cn=monitor
connected-to: Replication Server 8989 1740

dn: cn=Connected Replica llandudno 14142,cn=Replication Server 8989  1740,cn=cn_
schema,cn=replication,cn=monitor
connected-to: Replication Server 8989 1740

dn: cn=Undirect Replica  22052,cn=Connected Replication Server noordhoek:9989 71
64,cn=Replication Server 8989  1740,cn=cn_schema,cn=replication,cn=monitor
connected-to: Connected Replication Server noordhoek:9989 7164,cn=Replication Se
rver 8989  1740,cn=cn_schema,cn=replication

dn: cn=Undirect Replica  19984,cn=Connected Replication Server noordhoek:9989 71
64,cn=Replication Server 8989  1740,cn=dc_example_dc_com,cn=replication,cn=moni
tor
connected-to: Connected Replication Server noordhoek:9989 7164,cn=Replication Se
rver 8989  1740,cn=dc_example_dc_com,cn=replication

dn: cn=Undirect Replica  30030,cn=Connected Replication Server noordhoek:9989 71
64,cn=Replication Server 8989  1740,cn=cn_admin data,cn=replication,cn=monitor
connected-to: Connected Replication Server noordhoek:9989 7164,cn=Replication Se
rver 8989  1740,cn=cn_admin data,cn=replication

dn: cn=Replication Domain 27742,cn=cn_admin data,cn=replication,cn=monitor
lost-connections: 0
connected-to: llandudno/0:0:0:0:0:0:0:1:8989
```

The connected-to attribute specifies the replication server to which each directory server is currently connected for a particular base DN. If a directory server is directly connected to the replication server, its DN includes cn=Connected Replica. A directory server that is in the topology but is connected to a different replication server has cn=Undirect Replica in its DN. Because all replication servers are permanently connected to all other replication servers, the connected-to attribute does not exist for replication servers.

The lost-connections attribute indicates the number of connection breaks between directory servers and replication servers. The value of this attribute on each directory server should be close to the number of times that replication has been stopped on that server. If the value of this attribute is much higher, there are unexpected connection losses that must be investigated.

To Monitor Replication Latency

Monitoring replication latency enables you to establish whether a specific replication server is lagging behind other servers in the topology. This provides a complete view of any replication delays and the current quality of service.

To monitor replication latency, run the following search on any server in the topology that hosts a replication server:

```
$ ldapsearch -p 4444 --useSSL --trustAll -b "cn=monitor" \
  "domain-name=dc=example,dc=com" "missing-changes" \
  "approx-older-change-not-synchronized"
dn: cn=Replication Domain 30839,cn=dc_example_dc_com,cn=replication,cn=monitor

dn: cn=Replication Server 8989 1740,cn=dc_example_dc_com,cn=replication,cn=monitor
missing-changes: 0

dn: cn=Connected Replica llandudno 30839,cn=Replication Server 8989  1740,cn=dc_
example_dc_com,cn=replication,cn=monitor
missing-changes: 0

dn: cn=Connected Replication Server noordhoek:9989 7164,cn=Replication Server 8989
  1740,cn=dc_example_dc_com,cn=replication,cn=monitor
missing-changes: 0

dn: cn=Undirect Replica 19984,cn=Connected Replication Server noordhoek:9989
7164,cn=Replication Server 8989 1740,cn=dc_example_dc_com,cn=replication,cn=monitor
missing-changes: 0
```

The `missing-changes` attribute specifies the number of updates already pushed by the other directory servers in the topology, but not yet replayed on the specified directory server.

The `approx-older-change-not-synchronized` attribute specifies the approximate date of the oldest update pushed by the other directory servers in the topology, but not yet processed on the specified directory server.

Note – If the replication latency, as defined by these attributes, is high, look at the number of updates sent and received to identify the servers in the topology that are causing the latency. These attributes are described later in this document.

To Monitor Data Consistency

Monitoring data consistency enables you to establish whether each replication server in the topology is synchronized and up-to-date with the latest changes that have occurred in the topology.

To monitor the data consistency across the directory servers in the topology, run the following search on any server in the topology that hosts a replication server:

```
$ ldapsearch -p 4444 --useSSL --trustAll -b "cn=monitor" "(generation-id=*)" \
  "generation-id"
dn: cn=Replication Server 8989  1740,cn=cn_admin data,cn=replication,cn=monitor
generation-id: cn=admin data 94310

dn: cn=Connected Replication Server noordhoek:9989 7164,cn=Replication Server 8989
  1740,cn=cn_admin data,cn=replication,cn=monitor
generation-id: 94310
```

```
dn: cn=Replication Domain 30839,cn=dc_example_dc_com,cn=replication,cn=monitor
generation-id: 19399981

dn: cn=Replication Domain 14142,cn=cn_schema,cn=replication,cn=monitor
generation-id: 8468

dn: cn=Connected Replica llandudno 27742,cn=Replication Server 8989  1740,cn=cn_
admin data,cn=replication,cn=monitor
generation-id: 94310

dn: cn=Replication Server 8989  1740,cn=cn_schema,cn=replication,cn=monitor
generation-id: cn=schema 8468

dn: cn=Replication Server 8989  1740,cn=dc_example_dc_com,cn=replication,cn=monitor
generation-id: dc=example,dc=com 19399981

dn: cn=Connected Replica llandudno 30839,cn=Replication Server 8989  1740,cn=dc_
example_dc_com,cn=replication,cn=monitor
generation-id: 19399981

dn: cn=Connected Replication Server noordhoek:9989 7164,cn=Replication Server 8989
  1740,cn=cn_schema,cn=replication,cn=monitor
generation-id: 8468

dn: cn=Connected Replica llandudno 14142,cn=Replication Server 8989  1740,cn=cn_
schema,cn=replication,cn=monitor
generation-id: 8468

dn: cn=Connected Replication Server noordhoek:9989 7164,cn=Replication Server 8989
  1740,cn=dc_example_dc_com,cn=replication,cn=monitor
generation-id: 19399981

dn: cn=Replication Domain 27742,cn=cn_admin data,cn=replication,cn=monitor
generation-id: 94310
```

The `generation-id` attribute indicates the *version* of the data in each replicated base DN, for each directory server. Note that the generation ID on all servers for the base DN `dc=example,dc=com` is `19399981`. The consistency of the generation IDs means that the data on those servers is the same for that base DN.

Each directory server is also aware of the generation ID of the replication server to which it is connected. The generation ID of a replication server relates to the updates that are stored in its change log database for that base DN.

Replication is considered to be working correctly between two directory servers, for a specified base DN, when those servers and their replication server all have the same generation ID.

To Monitor Replication Security

A secure replication topology has SSL encryption enabled between servers, for a particular base DN.

To monitor replication security, run the following search on any server in the topology that hosts a replication server:

```
$ ldapsearch -p 4444 --useSSL --trustAll -b "cn=monitor" "(ssl-encryption=*)" \
  "ssl-encryption"
dn: cn=Connected Replication Server noordhoek:9989 7164,cn=Replication Server 89
89  1740,cn=cn_admin data,cn=replication,cn=monitor
ssl-encryption: true

dn: cn=Replication Domain 30839,cn=dc_example_dc_com,cn=replication,cn=monitor
ssl-encryption: true

dn: cn=Replication Domain 14142,cn=cn_schema,cn=replication,cn=monitor
ssl-encryption: true

dn: cn=Connected Replica llandudno 27742,cn=Replication Server 8989  1740,cn=cn_
admin data,cn=replication,cn=monitor
ssl-encryption: true

dn: cn=Connected Replica llandudno 30839,cn=Replication Server 8989  1740,cn=dc_
example_dc_com,cn=replication,cn=monitor
ssl-encryption: true

dn: cn=Connected Replication Server noordhoek:9989 7164,cn=Replication Server 89
89  1740,cn=cn_schema,cn=replication,cn=monitor
ssl-encryption: true

dn: cn=Connected Replica llandudno 14142,cn=Replication Server 8989  1740,cn=cn_
schema,cn=replication,cn=monitor
ssl-encryption: true

dn: cn=Connected Replication Server noordhoek:9989 7164,cn=Replication Server 8989
  1740,cn=dc_example_dc_com,cn=replication,cn=monitor
ssl-encryption: true

dn: cn=Replication Domain 27742,cn=cn_admin data,cn=replication,cn=monitor
ssl-encryption: true
```

The `ssl-encryption` attribute specifies whether the replication protocol is encrypted between two servers for a specified base DN. This information is available for each directory server or replication server. Authentication of replication sessions is not monitored.

To Monitor Replicated Updates

Monitoring the number of updates that have been sent and received by the servers in a topology provides an indication of how well replication is working.

To monitor sent and received updates, type the following command:

```
$ ldapsearch -p 4444 --useSSL --trustAll -b "cn=monitor" \
  "(&(sent-updates=*)(received-updates=*))" "sent-updates" "received-updates"
dn: cn=Connected Replication Server noordhoek:9989 7164,cn=Replication Server 8989
  1740,cn=cn_admin data,cn=replication,cn=monitor
sent-updates: 7
received-updates: 0

dn: cn=Replication Domain 30839,cn=dc_example_dc_com,cn=replication,cn=monitor
received-updates: 28
sent-updates: 0
```

```
dn: cn=Replication Domain 14142,cn=cn_schema,cn=replication,cn=monitor
received-updates: 0
sent-updates: 0

dn: cn=Connected Replica llandudno 27742,cn=Replication Server 8989  1740,cn=cn_
admin data,cn=replication,cn=monitor
sent-updates: 0
received-updates: 0

dn: cn=Connected Replica llandudno 30839,cn=Replication Server 8989  1740,cn=dc_
example_dc_com,cn=replication,cn=monitor
sent-updates: 28
received-updates: 0

dn: cn=Connected Replication Server noordhoek:9989 7164,cn=Replication Server 8989
  1740,cn=cn_schema,cn=replication,cn=monitor
sent-updates: 0
received-updates: 0

dn: cn=Connected Replica llandudno 14142,cn=Replication Server 8989  1740,cn=cn_
schema,cn=replication,cn=monitor
sent-updates: 0
received-updates: 0

dn: cn=Connected Replication Server noordhoek:9989 7164,cn=Replication Server 8989
  1740,cn=dc_example_dc_com,cn=replication,cn=monitor
sent-updates: 0
received-updates: 28

dn: cn=Replication Domain 27742,cn=cn_admin data,cn=replication,cn=monitor
received-updates: 0
sent-updates: 0
```

The `sent-updates` attribute indicates the number of updates that have been sent by this directory server or replication server.

The `received-updates` attribute indicates the number of updates that have been received by this directory server or replication server.

The values of these attributes assist in determining the flow of updates within a topology. When replication appears to be very slow, it is helpful to monitor these attributes. If the number of updates sent by one server is consistently much higher than the number of updates received by another server, it is likely that the second server is a bottleneck in the topology.

The replication protocol controls the flow of updates between two servers. This ensures that when a high number of updates is exchanged between two servers, the servers are not prevented from processing operations with a higher priority. This functionality relies on a window mechanism where the recipient server periodically provides the sending server with the number of updates that the sending server can send.

You can specify the size of the send and receive windows, by setting the `max-send-window` and `max-rcv-window` configuration attributes. For more information, see "Modifying the Replication Configuration With `dsconfig`" on page 317.

The current-send-window monitoring attribute indicates how many changes can be sent by the sending server to the recipient server at that specific time. If the value of the current-send-window attribute is often equal to 0, transmission is stopped and the recipient server is probably a bottleneck in the topology. If the value of the current-send-window attribute is often equal to the value of the max-send-window attribute, and you are experiencing high replication latency, it is likely that the sending server is a bottleneck in the topology.

To obtain the value of the current-send-window property, type the following command:

```
$ ldapsearch -p 4444 --useSSL --trustAll -b "cn=monitor" "(current-send-window=*)" \
  "current-send-window"
dn: cn=Connected Replication Server noordhoek:9989 7164,cn=Replication Server 8989
  1740,cn=cn_admin data,cn=replication,cn=monitor
current-send-window: 93

dn: cn=Replication Domain 30839,cn=dc_example_dc_com,cn=replication,cn=monitor
current-send-window: 100

dn: cn=Replication Domain 14142,cn=cn_schema,cn=replication,cn=monitor
current-send-window: 100

dn: cn=Connected Replica llandudno 27742,cn=Replication Server 8989  1740,cn=cn_
admin data,cn=replication,cn=monitor
current-send-window: 100

dn: cn=Connected Replica llandudno 30839,cn=Replication Server 8989  1740,cn=dc_
example_dc_com,cn=replication,cn=monitor
current-send-window: 72

dn: cn=Connected Replication Server noordhoek:9989 7164,cn=Replication Server 8989
  1740,cn=cn_schema,cn=replication,cn=monitor
current-send-window: 100

dn: cn=Connected Replica llandudno 14142,cn=Replication Server 8989  1740,cn=cn_
schema,cn=replication,cn=monitor
current-send-window: 100

dn: cn=Connected Replication Server noordhoek:9989 7164,cn=Replication Server 8989
  1740,cn=dc_example_dc_com,cn=replication,cn=monitor
current-send-window: 100

dn: cn=Replication Domain 27742,cn=cn_admin data,cn=replication,cn=monitor
current-send-window: 100
```

To Monitor Replication Conflicts

When multiple operations are performed on the same entry at the same time, replication conflicts can occur. In some cases, the replication mechanism is able to resolve these conflicts. In other cases, manual conflict resolution is required.

Three types of conflict attributes can be monitored:

- `unresolved-naming-conflicts`. Indicates the number of naming conflicts that could not be resolved by the replication mechanism.
- `resolved-naming-conflicts`. Indicates the number of naming conflicts that have been resolved.
- `resolved-modify-conflicts`. Indicates the number of modify conflicts that have been resolved.

To monitor resolved and unresolved replication conflicts, run the following command:

```
$ ldapsearch -p 4444 --useSSL --trustAll -b "cn=monitor" \
  "(&(unresolved-naming-conflicts=*)(resolved-naming-conflicts=*)
  (resolved-modify-conflicts=*))" "unresolved-naming-conflicts"
  "resolved-naming-conflicts" "resolved-modify-conflicts"
dn: cn=Replication Domain 30839,cn=dc_example_dc_com,cn=replication,cn=monitor
resolved-naming-conflicts: 0
unresolved-naming-conflicts: 0
resolved-modify-conflicts: 0

dn: cn=Replication Domain 14142,cn=cn_schema,cn=replication,cn=monitor
resolved-naming-conflicts: 0
unresolved-naming-conflicts: 0
resolved-modify-conflicts: 0

dn: cn=Replication Domain 27742,cn=cn_admin data,cn=replication,cn=monitor
resolved-naming-conflicts: 0
unresolved-naming-conflicts: 0
resolved-modify-conflicts: 0
```

General Purpose Enterprise Monitoring Solutions

You can use a variety of general UNIX tools to monitor your server environment. For information about these tools, see the man pages on your UNIX system.

General UNIX Monitoring Tools

The following general purpose UNIX monitoring tools can be used with Oracle Unified Directory.

Tool	Description
`iostat`	Provides information about disk I/O and CPU usage.
`lsof`	Provides information about open file descriptors.
`lslk`	Provides information about file system locks.

Tool	Description
`netstat`	Provides statistics about network functions.
`nslookup`	Allows you to query DNS servers for information about hosts and domains.
`ping`	Allows you to query the status of a remote host or network gateway.
`sar`	UNIX System V performance monitoring tool.
`tcpdump`	Allows you to debug and monitor network traffic.
`top`	Provides quick, easy monitoring of processes and CPU activities.
`trace`	Provides information about which system calls a process makes.
`traceroute`	Provides the path a packet takes throughout the Internet to reach its final destination.
`vmstat`	Provides statistics about process, virtual memory, disk, trap, and CPU activity.

Solaris Monitoring Tools

The following Solaris monitoring tools can be used with Oracle Unified Directory.

Tool	Description
`lockstat`	Provides information about OS and application locking. Requires DTrace privileges.
`mpstat`	Provides statistics about each processor on the system.
`pmap`	Provides a breakdown of how much memory a process is using.
`proctool`	Monitors processes and threads.
`snoop`	Monitors network traffic. Indispensable when debugging low-level packets.
`SymbEL/Virtual\\Adrian`	Provides functionality of the above listed tools and more.
`truss`	Provides information about which system calls a process makes.

HP-UX Monitoring Tools

The following HP-UX monitoring tools can be used with Oracle Unified Directory.

Tool	Description
`glance`	Provides detailed system information about open file descriptors, locks, and threads.
`gpm`	GlancePlus is a graphical real-time performance diagnostic tool. Glance is the character-based component.
`tusc`	Provides a system call trapper.
`sysdef`	Provides information about kernel parameters.
`landiag`	Monitors network statistics.
`sam`	Provides a general system administration tool.

CHAPTER 14

Tuning Performance

Oracle Unified Directory aims to be high-performing and highly-scalable. Although the server can achieve impressive results with the "out-of-the-box" server configuration and default JVM settings, performance can often be improved significantly through some basic tuning.

The default settings of Oracle Unified Directory are targeted at evaluators and developers who are running equipment with limited resources. When you deploy Oracle Unified Directory in a production environment, it useful to do some initial tuning of the Java Virtual Machine (JVM) and of the server configuration to improve scalability and performance (particularly for write operations).

This section covers the following topics:

- "Assessing Performance Problems" on page 519
- "General Performance Tuning" on page 520
- "Tuning Java Virtual Machine Settings" on page 520
- "Tuning the Server Configuration" on page 522

Assessing Performance Problems

You can obtain a quick idea of whether performance issues are related to problems with the server or with the client by examining the access log at *install-dir*/`logs/access`. This log contains entries of the form:

```
[09/Sep/2009:15:36:18 +0200] SEARCH RES conn=1 op=16 msgID=17
  result=0 nentries=1 etime=1
```

The value of the `etime` field is the time (in milliseconds) that the server spent processing the request. Large `etimes` generally indicate an issue on the server side (which can usually be resolved by appropriate performance tuning or indexing. If you are experiencing performance problems but the `etimes` are small, the issue is more likely to be with your client application.

General Performance Tuning

The following items can improve performance in specific deployment scenarios.

- **Java Version**. Use the most recent Java Runtime Environment (JRE) release available. Although the server is designed to work with Java SE 5 (minimum version 1.5.0_08), use the latest Java SE 6 for noticeably better performance.
- **Environment Variables**. The server uses the `OPENDS_JAVA_HOME` environment variable to point to your installed JRE. If you have multiple versions of Java installed on a system, set the `JAVA_HOME` environment variable to point to the root of the desired installation. In this way, the version of the JRE specified by the `JAVA_HOME` variable can be used by other applications but not by Oracle Unified Directory.

  To specify a JRE installation for the server, do one of the following:

  - Use the `dsjavaproperties` command to set the appropriate environment variables.

    For more information, see "dsjavaproperties" in *Oracle Fusion Middleware Command-Line Usage Guide for Oracle Unified Directory*.
  - Set the `OPENDS_JAVA_BIN` environment variable (with the JAVA binary path).
  - Set the `OPENDS_JAVA_HOME` environment variable (with the JAVA installation path).

Tuning Java Virtual Machine Settings

You can use the `JAVA_ARGS` environment variable to provide global configuration arguments that can be passed to the JVM, or you can use the `java.properties` file. Any argument that can be used with the `java` command can be used with both methods.

For more information, see "dsjavaproperties" in *Oracle Fusion Middleware Command-Line Usage Guide for Oracle Unified Directory*.

For additional information about tuning the JVM, see the Java Performance Documentation. The Java Tuning White Paper and the Garbage Collection Tuning documents are particularly useful.

The main JVM tunable options include the following:

`-server`

Always use the server JVM instead of the client JVM. The client VM is better optimized for processes that run for a short period of time and need to start as quickly as possible. The server VM can take longer to warm up but is faster in the long run.

`-d32` or `-d64`

Select the 32-bit or 64-bit version of the JVM (if applicable for the underlying system). Use the 64–bit JVM if you require a heap greater than 4 Gbytes.

`-XX:+UseCompressedOops`
Use this option if you use the 64–bit JVM and if the heap size is less than 32 Gbytes.

`-Xms2g` and `-Xmx2g`
This parameter sets the initial and maximum heap size available to the JVM. Increasing the heap size can improve performance, but setting it too high can have a detrimental effect in the form of longer pauses for full garbage collection runs. The initial and maximum sizes should generally be set to the same values.

For maximum performance, size the heap so that the entire DB can be cached in memory. In general, you should allocate enough heap for the server runtime and the rest to the DB cache.

`-XX:NewSize=512M`
The total heap space is divided into the old generation and the young generation. This parameter sets the size of the young generation. The remaining memory (old generation) must be sufficient to hold the DB cache plus some overhead.

`-XX:+UseConcMarkSweepGC`
Use the Concurrent Mark Sweep (CMS) garbage collector. This option allows the JVM to minimize the response time of LDAP operations, but it can have a small impact on the overall performance (throughput) of the server. Use this option of long pause times are not tolerated.

Additional JVM arguments that are related to performance and scalability include the following:

`-XX:CMSInitiatingOccupancyFraction=<percentage>`
Specify the level at which the CMS garbage collection is started. The default value is approximately 68%. Use this value if you want to set the percentage to something other than the default value.

`-XX:+UseBiasedLocking`
Improve locking performance in the server in cases where there is not expected to be a high degree of contention.

`-XX:LargePageSizeInBytes=256m`
Use large pages for the information it stores in memory. This argument applies primarily to systems using the UltraSPARC T1 processor.

`-XX:+UseParallelGC`
Specify that the system should use parallel garbage collection, which is particularly useful on systems with a large number of CPUs.

`-XX:+UseParallelOldGC`
Specify that the JVM should use parallel garbage collection for the old (tenured) generation.

`-XX:ParallelGCThreads=8`
Specify that the JVM should use 8 threads when performing parallel garbage collection. The default is to use a number of threads equal to the number of CPUs, but this can be inappropriate on systems with a very large number of CPUs or on CMT-based systems like those using the UltraSPARC T1 processor.

Tuning the Server Configuration

Various components of the server can be tuned to provide performance improvements in specific scenarios. Most performance tuning recommendations depend on several variables, including the anticipated workload, the types of data that are stored, and the hardware and resources available. The following general tuning recommendations can improve performance in specific deployments.

- **Back End Tuning Parameters**. The following Berkeley DB JE tuning parameters can be used to tune performance:
  - `preload-time-limit`. You can configure the server to preload some of the database contents into memory on startup. For large databases, preloading the database cache avoids a long *warmup* period after server startup. For more information, see the Local DB Backend Configuration.
  - Use the `db-cache-percent` and `db-cache-size` properties to configure the amount of memory that the database cache uses. For best performance, consider configuring the server so that the whole database fits into the database cache.

    Determine the approximate size of the database after an import. For example, after doing an import into the `userRoot` back end, run the following command (on UNIX systems) to determine the size of the database:

    ```
    $ cd install-dir/db
    $ du -sk userRoot/
    910616 userRoot/
    ```

    On Windows systems, use an equivalent procedure to determine the database size. Remember that the database size is not static and can increase after an initial import when modifications are made.

    Setting the JVM heap to 2 Gbytes (`-Xms2g -Xmx2g`), and the `db-cache-percent` to 50, will cause the DB cache to use 1 Gbyte of memory. To monitor the DB cache size, observe the following properties under the "`dn:cn=userRoot Database Environment,cn=monitor`" entry through Jtrace and JMX:

    - Check that `EnvironmentCacheDataBytes` has a value that is consistent with the expected size of the DB cache.
    - Check that `EnvironmentNCacheMiss` does not have unexpected growth when loading the server.

    - `db-directory`. Ensure that the database is held on a fast file system with adequate storage. The file system should be different to the location of the access logs. By default, the database will grow to twice its original size. For example, if the database is 1 Gbyte after an import, the file system should have at least 2 Gbytes available.
    - `db-evictor-lru-only`. Use this property can be used to control how the database cache retains information. Setting this value to `false` ensures that the internal nodes are maintained in cache, which provides better performance when the JE cache holds only a small percentage of the database contents.
    - `db-txn-durability`. Use this property to configure durability for write operations. Reducing durability can increase write performance, but it can also increase the chance of data loss in the event of a JVM crash or a system crash. This property takes the following values:
        - **write-to-disk.** All data are written synchronously to disk.
        - **write-to-fs.** Data are written to the file system immediately but might stay in the file system before being flushed to disk.
        - **write-to-cache.** Data are written to an internal buffer and flushed to the file system, then to disk when necessary.
    - `db-log-file-max`. Use this property to control the size of JE log files. Increasing the file size can improve write performance, but it can also make it harder to maintain the desired utilization percentage.
    - `db-num-cleaner-threads` and `db-cleaner-min-utilization`. These properties control how the cleaner works, which keeps the database size down and keeps up with high write throughput.
    - On systems with a large number of CPUs, the `db-num-lock-tables` configuration property improves concurrency within the database lock manager.
- **Core Server Tuning Parameters**. The following core server tuning parameters can be used to tune performance:
    - `num-request-handlers`. This property can be configured so that the LDAP connection handler (and the LDAPS connection handler, if it is enabled) use multiple threads for decoding client requests. Increasing the number of threads on systems with a larger number of CPUs can improve performance. As a rule of thumb, you should set this property to half the number of CPUs.

      In some cases disabling the `keep-stats` property can help reduce lock contention in the connection handlers. For more information, see the LDAP Connection Handler Configuration.
    - `num-worker-threads`. The default value of this property is two times the number of CPUs. This value is sufficient in most deployments.
    - `log-file`. Ensure that the access log publisher is on a fast file system, or turn it off altogether by setting the `enabled` property to `false`. For more information see the File Based Access Log Publisher Configuration.

- **Enable an Entry Cache**. In some cases, particularly those involving relatively small directories (for example, up to a few hundred thousand entries), it can be useful to enable an entry cache. In general the FIFO entry cache provides better results than the soft reference entry cache. For more information, see the Entry Cache Configuration.
- **Disable Unused Virtual Attributes**. If the functionality needed by one or more of the virtual attributes is not required, they can be disabled for a slight performance improvement when decoding entries. For more information, see the Virtual Attribute Configuration.
- **Disable Unused Access Logging**. If access logging is not necessary, disabling the server access logger can help improve performance. For more information, see the Log Publisher Configuration.
- **Disable Unused Access Control Handlers**. If you do not need access control processing in the server, then you can disable it by setting the `enabled` configuration property to `false` for the Access Control Handler. You can set the property by using `dsconfig`.
- **Reduce Lock Contention**. On systems with large numbers of CPUs (for example, chip multi-threading (CMT) systems with several hardware threads per core), you can reduce lock contention by setting the `org.opends.server.LockManagerConcurrencyLevel` system property to be equal to the number of worker threads you intend to use.

  Note – This property must be set as a JVM system property, because it can be required very early in the server startup process, even before accessing the server configuration.

◆ ◆ ◆ CHAPTER 15

Advanced Administration

This section contains topics that are not considered everyday administrative activities, or are of particular interest to advanced directory server users:

The section covers the following topics:

- "Running the Server as a Non-Root User" on page 526

Running the Server as a Non-Root User

Like many network daemons, Oracle Directory Server Enterprise Edition has a `setuid` capability that allows it to be started as a root user but then drop privileges to run as a user with fewer capabilities. Oracle Unified Directory does not currently include this capability. However, you can install, start, and run the server as a non-root user. Note that the information in this section applies primarily to UNIX-based platforms, because Windows systems do not historically place as many restrictions on non-administrative users.

Reasons for Running the Server as a Non-Root User

In many cases, running the server as a non-root user from the start is a more attractive option and provides greater functionality than the `setuid` equivalent. Running the server as a non-root user means that administrators do not need root access to the system, which is often desirable from an operational perspective. In addition, more administrative actions can be performed with the server online, because the server can do things that might not have been available after it had dropped root privileges.

The primary reason that servers are typically started and/or run as root users is so that they can listen on a privileged port (namely, ports between 1 and 1024). The standard port for LDAP communication is port 389, and the standard port for LDAPS is 636. On most UNIX-based systems only root users are able to create processes that listen on these ports. There can be other reasons for starting as a root user (for example, the ability to use a larger number of file descriptors), but it is generally easier to configure around these other limitations.

Although the standard LDAP and LDAPS ports are 389 and 636, the server is not required to run on those ports. In some environments, it is common to run the server on ports above 1024 (such as 1389 and 1636) so that it is not necessary to be root to start it. Virtually all LDAP-enabled clients provide the ability to specify the port on which the server is listening. As long as the clients know what port the server is using, any value is allowed. For information about configuring the listen port, see "Configuring the LDAP Connection Handler" on page 35.

How to Run as a Non-Root User on the Standard LDAP Ports

If clients expect the server to be listening on port 389 or 636, other options are still available.

The best option, available on Solaris 10, is to use the process rights management subsystem (also called *least privilege*). The privileges subsystem in Solaris makes it possible to give non-root users and roles capabilities normally available only to the root user (much like the Privilege Subsystem allows within the server). In particular, the `net_privaddr` privilege controls which users can bind to privileged ports If this privilege is granted to a non-root user, that user can bind to privileged ports. To configure a user with this privilege, run the following command, as the root user:

```
# usermod -K defaultpriv=basic,net_privaddr,sys_resource,-proc_info,-file_link_any \
  oud
```

This command configures the `oud` user so that it starts with the `basic` privilege set (which is what non-root users have by default). The command then adds the `net_privaddr` and `sys_resource` privileges, which allow the user to increase the number of file descriptors available, among other things. The command removes the `proc_info` privilege (which allows the user to see processes owned by other users) and the `file_link_any` privilege (which allows the user to create hard links to files that they do not own). After running this command, the `oud` user is able to start the server listening on a privileged port.

Even on systems without a capability like least privilege, it is possible to expose the server on a privileged port such as 389 or 636 without requiring root privileges to be able to start it. One possibility would be to run the server on an unprivileged port and use a directory proxy server listening on the privileged port to forward communication to the server on an unprivileged port. It is also possible to use network hardware to achieve the same purpose or to use firewall rules on the same system. For example, on Linux systems the following commands can be used to redirect traffic targeting port 389 to port 1389:

```
# iptables --append PREROUTING --table nat --protocol tcp --dport 389 \
  --jump REDIRECT --to-port 1389
# iptables -t nat -A OUTPUT -p tcp --dport 389 -j DNAT --to :1389
```