Technical Report

How to configure LDAP in ONTAP

Multiprotocol NAS identity management

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Abstract

This technical report covers how to configure Lightweight Directory Access Protocol (LDAP) identity management for multiprotocol NAS in NetApp® ONTAP® based systems. This document complements, and can be considered a replacement for, TR-4073: Secure Unified Authentication. For information about name services best practices, see TR-4668: Name Services Best Practices Guide.

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Overview

This technical report covers Lightweight Directory Access Protocol (LDAP) configuration as a method for UNIX identity management and name mapping for multiprotocol NAS access on NetApp storage systems that run NetApp ONTAP software. The use of LDAP as a centralized name service provides scale, consistency, and ease of management in multiprotocol NAS environments. Multiprotocol NAS access enables enterprise and scale-out storage systems to provide access to clients that are running both Linux and Windows-based operating systems through the NFS and CIFS/SMB protocols, respectively.

This document focuses on:

- ONTAP 9.7 and later
- CentOS/Red Hat Enterprise Linux (RHEL) 7 and later
- FreeIPA 4.8 and later
- Microsoft Active Directory LDAP on Windows 2012 and later

For other client and LDAP server configurations, contact the product vendor. Most of the earlier ONTAP versions apply to this TR as well, but they might be missing some of the features or commands that are mentioned in this document.

What Is LDAP?

LDAP is a standard directory access protocol that was developed by an international committee called the Internet Engineering Task Force (IETF). LDAP is intended to provide a general-purpose, network-based directory service that you can use across heterogeneous platforms to locate network objects. LDAPv3 is the standard currently implemented version.

LDAP models define how to communicate with the LDAP directory store, how to find an object in the directory, how to describe the objects in the store, and the security that is used to access the directory. LDAP allows customization and extension of the objects that are described in the store. Therefore, you can use an LDAP store to store many types of diverse information. Many of the initial LDAP deployments focused on the use of LDAP as a directory store for applications such as email and web applications and to store employee information. During the past several years, LDAP has been gaining acceptance as a directory store for information that is used in network-based authentication and authorization. Many companies are replacing the Network Information Service (NIS) with LDAP as a network directory store.

LDAP for UNIX identity management can be served through Active Directory or any RFC 2307–compliant LDAP provider. ONTAP software supports a multitude of LDAP servers and can claim support for any LDAP server that adheres to the standards that IETF has laid out.

You can also use LDAP for identity management for cluster administration logins, but this document does not cover the scope of that use. For LDAP use with cluster logins, see the product documentation.

Microsoft Active Directory as a UNIX LDAP Server

Microsoft implemented LDAPv3 as a directory store starting in Windows 2000/2003 Active Directory. The Microsoft LDAP implementation is standards-based, so you can use Microsoft Active Directory LDAP to store UNIX user and group information. With this capability, you can unify the directory service and the directory store of networks based on both Windows and UNIX. Before Windows 2008 R2, native Active Directory LDAP did not contain the definitions of attributes needed to hold information that is necessary for UNIX authentication and authorization. Therefore, the Microsoft Active Directory schema needed to be extended with the necessary objects to hold this information in those versions. Windows 2008 R2 and later offer UNIX schema extensions in Active Directory by default and require no schema modifications to implement them.

What does LDAP store?

LDAP can store the following information that is used in multiprotocol NAS access:

- User names
- Group names
- Numeric user IDs (UIDs) and group IDs (GIDs)
- Home directories
- Login shell
- Netgroups, DNS names, and IP addresses
- Group membership

How does ONTAP interact with LDAP?

ONTAP can use LDAP in one of two ways:

- Querying for user names, numeric IDs, groups, group memberships, netgroups, name mappings, and so on, for NAS protocol operations
- Interacting with Privileged Access Management (PAM) for cluster and ONTAP System Manager logins for cluster administration.

This document covers mostly LDAP for use with NAS protocol operations. However, the section, ”LDAP authentication for cluster administration,” covers the use of LDAP servers to host users and groups in cluster logins/authentication for other access.

What Is multiprotocol NAS?

Multiprotocol NAS is essentially what the name suggests: unified NAS access through multiple NAS protocols. The use of multiprotocol NAS on NetApp storage systems enables users on all operating systems to seamlessly access the same datasets, regardless of the type of protocol that is used. The protocols that are involved in multiprotocol environments are CIFS/SMB and NFS.

Is multiprotocol NAS also called mixed mode?

A common misconception is that multiprotocol NAS is also called mixed mode. This belief creates confusion when implementing a NetApp storage system that runs NAS, because the concept of mixed security style also exists. Mixed security style is covered later in this document, in the section, “Security styles.”

What Is CIFS/SMB?

CIFS (Common Internet File System)/Server Message Block (SMB) is the way that users share files across Ethernet-based networks primarily on operating systems that run Microsoft Windows. CIFS is the native file-sharing protocol that was introduced in Windows 2000. It uses SMB as the underlying protocol for communication between clients and servers in modern operating systems.

CIFS/SMB is also used on other non-Windows operating systems such as Apple, Linux, and Oracle Solaris through third-party implementations, such as Samba. Support of CIFS/SMB on non-Windows operating systems on NetApp storage systems varies and can be found on the Interoperability Matrix Tool (IMT). For more information about CIFS/SMB in ONTAP, see TR-4191: Best Practices Guide for ONTAP 8.2.x Windows File Services.

Note: Although CIFS and SMB are different in many ways, this document uses the terms interchangeably.

What Is NFS?

NFS (Network File System) is the way that users share files across Ethernet-based networks primarily on operating systems that run Linux, Oracle Solaris, UNIX, HP-UX, and so on. NFS follows a series of standards defined by the IETF through documents called Request for Comments (RFC). These standards are followed by all major NFS client and server vendors who intend to deliver enterprise-level NFS access. NFS depends on a series of underlying messages, and those underlying messages depend on the version of NFS that is being used. For more information about NFS in ONTAP, see TR-4067: NFS Best Practices and Implementation Guide.

Authentication in ONTAP

NetApp ONTAP is built on a UNIX-based operating system, so native NFS environments generally have little trouble gaining access. There is ease of access because the underlying methodologies are the same, particularly when volumes and qtrees use UNIX security styles. The section, “Security styles,” in this report presents more information.

However, when volume and qtree security styles are NTFS, to gain access, NFS clients must perform a user mapping to a valid Windows user. This step is necessary because NTFS access control lists (ACLs) are not understood by NFS clients. Therefore, the storage system must act as an arbitrator for the client to determine whether the user can authenticate and has access through the NTFS ACL.

CIFS/SMB environments run into challenges because clients that use those protocols must pass a generic Windows > UNIX user authentication before they gain access to a system, even when volume security styles are NTFS. Also, user mapping to ensure that file owners are represented accurately in mixed-protocol environments can add another wrinkle for storage administrators.

Homogenous versus heterogenous NAS environments

Some sites have pure Windows or pure UNIX environments in which all data is accessed by using only one of the following:

- CIFS/SMB and NTFS file security
- NFS and UNIX file security (mode bits or NFSv4.x ACLs)

However, many sites must enable datasets to be accessed from both Windows and UNIX clients. For these environments, ONTAP has native multiprotocol NAS support. After the user is authenticated on the network and has both appropriate share or export permissions and the necessary file-level permissions, the user can access data from UNIX hosts by using NFS or from Windows hosts by using CIFS/SMB. The use of multiprotocol NAS access does not require the use of mixed-security-style (sometimes referred to as “mixed-mode”) volumes and qtrees, even though it is available as an option.

Why should you use multiprotocol NAS?

By using multiprotocol NAS with ONTAP, you gain several distinct advantages. When clients can use different NAS protocols to seamlessly access datasets simultaneously, you can achieve the following benefits:

- Reduced overall storage administrator management tasks
- Requirement for only a single copy of data to be stored for NAS access from multiple clients
- Protocol-agnostic NAS that enables storage administrators to control the style of ACL and the access control that is presented to end users
- Centralized identity management operations in a NAS environment

ONTAP has provided enterprise-class multiprotocol NAS access for over 25 years and counting. With the advent of scale-out ONTAP clusters and NetApp ONTAP FlexGroup volumes, storage administrators have even more flexibility with multiprotocol NAS environments.

Multiprotocol NAS use cases

The most common ways to use multiprotocol NAS include, but are not limited to:

- Home directories
- Source code repositories
- Research and engineering shares
- Image repositories
- Audio and video editing and rendering

Common challenges in multiprotocol access

Many organizations want to use multiprotocol NAS access for its flexibility. On the contrary, there is a perception of difficulty in multiprotocol NAS that creates a specific set of challenges that are unique to the concept of sharing across protocols. This perception is grounded in reality, but only if the underlying infrastructure has not been prepared for multiprotocol NAS access. For example, standing up an LDAP server for identity management needs can greatly simplify multiprotocol NAS environments.

These challenges include, but are not limited to:

- Requirement of knowledge across multiple protocols, operating systems, and storage systems
- Working knowledge of name service servers, such as DNS, LDAP, and NIS
- External factors such as:
  - Dealing with multiple departments and IT groups (for example, a Windows group and a UNIX group)
  - Company acquisitions
  - Domain consolidation
  - Reorganizations
  - Many moving parts

By using a viable name service such as LDAP for UNIX identity management, you can greatly simplify the way that ONTAP can serve multiprotocol NAS. When you use LDAP along with Active Directory, it provides a centralized name service for both NFS/UNIX and SMB/Windows identities, which further simplifies operations.

LDAP components and considerations

NetApp ONTAP presents storage management by way of a series of concepts known as storage virtual machines (SVMs). These components act as individual storage silos for multitenant storage operations. As such, LDAP configuration and operations are performed at the SVM level, which means that each SVM can use its own LDAP client configuration and schema as desired. ONTAP and its SVMs act as LDAP clients to LDAP servers, just like any other NAS client would. To maintain consistency of users, groups, and name mapping rules without having to configure them at multiple sources, ONTAP and NAS clients can all share the same LDAP server sources.

LDAP basics

The following section covers some high-level basics for LDAP and how it works:

- By default, LDAP operates on TCP port 389 for normal traffic and operates on port 636 for secure LDAP that uses Secure Sockets Layer (SSL). You can modify LDAP ports for security purposes. If you use port 636, ONTAP 9.8 and prior attempt to use LDAPS for binds. If the LDAP server is not configured for that or if the LDAP client in ONTAP is not configured for LDAPS, binds fail. You cannot use alternate ports for LDAPS other than 636 until ONTAP 9.9.1. To use different LDAPS ports, you must specify `-ldaps-enabled true` on the LDAP client configuration and the LDAP servers must also be configured to use alternate ports.
- Active Directory LDAP can also serve LDAP traffic on the global catalog port 3268. The secure global catalog port (3269) can be used in ONTAP 9.9.1 and later by specifying the port with the `-port` option and using `-ldaps-enabled true`.
- LDAP information is stored in flat files in an LDAP server and is organized by way of an LDAP schema. You should configure LDAP clients in a way that coordinates their requests and lookups with the schema on the LDAP server.
- LDAP clients initiate queries by way of an LDAP bind, which is essentially a login to the LDAP server. The LDAP bind configuration on the clients is configured to use the security mechanism that is defined by the LDAP server. At a minimum, LDAP servers allow anonymous binds, which are the least secure. Most LDAP servers rely on some level of security mechanism for binds. Sometimes, they are simple user name and password exchanges. In other cases, binds are secured through SSL or Kerberos/Generic Security Service API (GSSAPI) for encrypted communication. ONTAP supports all these methods for LDAP binds. In addition, ONTAP allows LDAP binds to Windows Active Directory through the CIFS/SMB machine account.
- User and group information that is stored in LDAP is queried by clients by using standard LDAP search requests as defined in RFC 2307. In addition, newer mechanisms, such as RFC 2307bis, allow more streamlined user and group lookups. You can also configure these lookups and replies to be protected by encryption by way of LDAP client and server configuration.
- LDAP servers can store user and group information as well as netgroup information for use with NFS export rule configuration.
- If the initial requests are not found on the initial server, LDAP servers can refer requests to other LDAP servers by way of chase referrals. Starting in version 9.5, ONTAP supports chase referrals; for more information, see the section, "LDAP referrals (chase referrals)."
- LDAP chase referrals cannot use LDAPS or other encrypted search methods in ONTAP 9.8 and prior. ONTAP 9.9.1 and later provides support for secure LDAP referrals via LDAPS/TLS. See bug 1144216 for more information.
- You can configure LDAP queries in ONTAP to time out after a set number of seconds. By default, queries time out after 3 seconds.
- To speed up queries and to avoid crawling large LDAP schemas, you can filter down LDAP queries based on specified locations and distinguished names (DNs).
- You can define LDAP servers in the LDAP client configuration in ONTAP through IP address or host name, or you can simply use DNS service (SRV) records to find the associated LDAP servers.

How ONTAP processes authentication requests by using LDAP

When a user attempts to authenticate into an ONTAP NAS share, ONTAP tries to figure out the identity of the user to establish whether that user can access what they are requesting. Name lookups are also vital to name mappings in ONTAP.

An initial authentication occurs, which is a verification of the user to gather numeric UID, GID, and group membership. This authentication is also to determine whether the user who is requesting access actually exists in the system. Where ONTAP gathers this information depends on how you configure the name service switch (`ns-switch`) for the SVM. Valid name service sources for user and group information are local files (`passwd` and `group`), NIS, and LDAP. ONTAP queries the specified name service sources in the order that they are listed.

Configure the name service switch through the `ns-switch` command set.

```
cluster::> ns-switch ?
  (vserver services name-service ns-switch)
  create                      Create a new Name Service Switch table entry
  delete                      Remove a Name Service Switch table entry
  modify                      Change a Name Service Switch table entry
  show                        Display Name Service Switch configuration

cluster::> ns-switch show -vserver DEMO
  (vserver services name-service ns-switch show)
                               Source
Vserver         Database       Order
--------------- ------------   ---------
DEMO            hosts          dns,
                               files
DEMO            group          ldap,
                               files
DEMO            passwd         ldap,
                               files
DEMO            netgroup       files,
                               ldap
DEMO            namemap        ldap,
                               files
```

If you specify LDAP, then when a user lookup is needed, ONTAP uses logical interfaces (LIFs) in the SVM that have access to the LDAP servers. These LIFs can be either data LIFs or SVM management LIFs. If no LIFs in the SVM can reach LDAP servers, name service requests fail.

When ONTAP has determined that LDAP will be used for the name lookup, the following process occurs:

1. ONTAP first checks the connection cache to see whether connections to LDAP servers are already established. If no connections are cached, ONTAP uses the LDAP client configuration to make a connection attempt to the servers that are specified in the configuration. If host names are specified, DNS lookups are performed. If Active Directory domains are used, DNS SRV record lookups are performed.
2. If the TCP connection over the defined LDAP service port is successful, then ONTAP attempts to "bind" (log in) to the LDAP server by using the defined credentials in the client configuration.
3. If the bind is successful, then ONTAP uses the client schema that is defined in the LDAP client to make an LDAP search query to the LDAP server. The following information is passed to the server in the query:
   – Base/user DN (to narrow search scopes)
   – Search scope type (`subtree`, `base`, `onelevel`)
   – Object class (to search only for objects in that class)
   – UID/user name
   – Requested attributes (`uid`, `uidNumber`, `gidNumber`, `unixUserPassword`, `name`, `unixHomeDirectory`, `loginShell`)
4. If the user is not found in the first request and chase referrals are enabled, ONTAP tries other LDAP servers. If the user is not found and multiple DNs are defined in the client configuration, ONTAP tries other DNs. If the user is not found in any scenario, an error is returned and ONTAP tries the next available `ns-switch` source. If no user is found there, the request fails and access is denied.
5. If the request is successful, ONTAP stores the user attributes in a cache for future use.

The flow of operations is important to remember if failures occur, because it can help narrow down why and how LDAP requests might not be working. For more information about LDAP lookup failures, see the section, "Common issues and troubleshooting steps."

Security styles

In ONTAP, permissions are managed by how the security style is configured for a volume, qtree, file, or folder. ONTAP storage administrators can manage security styles from the cluster for volumes and qtrees only. File and folder security styles are set based on where the file or folder is written. For example, if a file is written or copied to a volume with the NTFS security style, then the file also is assigned the NTFS security style. Flipping the security style of a volume or qtree does not change the security styles or ACLs of existing files or folders. In ONTAP, each volume can have its own independent security style, and each qtree can also have its own security style. This approach allows flexibility in management of user data, especially in-home directory scenarios, where some users might want to manage permissions from Windows clients and other users might want to manage permissions from Linux clients.

Security styles are used to help maintain a consistent set of permissions, especially when you use both the NFS and SMB protocols on the same sets of data in a cluster. Security styles are just a way of saying permission styles—how do you want to manage the ACLs for your data?

ONTAP has three security styles for use with multiprotocol NAS:

- **NTFS.** This style uses standard Windows permission models and logic. The same rules that apply to Windows permissions apply to NTFS security style volumes and qtrees. Only Windows clients can change permissions and owners on volumes and qtrees by using NTFS security styles. NFS clients that try to change permissions fail. You might or might not see an error, depending on the way that you configure the NFS server and export policies for NFS.

  You can also manage NTFS permissions from the ONTAP cluster CLI by using Storage-Level Access Guard or the `vserver security file-directory` command sets, all the way down to the file and folder level.
- **UNIX.** This security style uses UNIX-style permission structures. It includes mode bits (for example, `chmod 755`) for read/write/execute with owner/group/others, as well as NFSv4.x ACLs for more granular ACL management for users and groups. It does not include POSIX ACLs, which are not supported in ONTAP. UNIX security style volumes and qtrees manage permissions by using only NFS clients. Windows clients can view mode bit permissions depending on the CIFS server settings, but NFSv.x ACL viewing is possible only over SMB 1.0, which is deprecated. SMB 2.0 and later versions can't parse the NFSv4.x ACL information properly. Windows clients cannot change UNIX permissions or owners.

  You can set UNIX mode bit permissions from the cluster CLI, but only on top-level volumes and qtrees. File permissions are set from clients. You can set file owners from the ONTAP CLI only when you use NetApp FlexClone® volume technology. You can set NFSv4.x ACLs only from clients that use NFSv4.x, and only if you have enabled NFSv4.x ACL support on the NFS server in ONTAP. This ACL management limitation includes security and audit style ACLs.
- **Mixed.** This security style is always either NTFS or UNIX at an effective level. However, unlike the other security styles, mixed allows the effective style to change based on the style of ACL that last changed permissions on the file or folder. This style is useful when clients must be able to change permissions from any protocol at any given moment, such as applications that might write from NFS clients and then need to modify permissions later from Windows clients. The nature of mixed security style and its ability to change can create complexity in multiprotocol NAS environments, especially when name mapping or name services are not configured properly. As such, NetApp does not recommend mixed security styles unless you need a specific use case.

For information about how to view security styles and permissions from the ONTAP CLI, see the subsection titled "vserver security file-directory show."

Name mapping in ONTAP

Name mapping is the way that ONTAP (on a Linux/UNIX-based operating system) handles multiprotocol NAS access between NFS and CIFS/SMB protocols. Because volumes are always either UNIX or NTFS security styles, name mapping is a way to verify that the appropriate ACLs that you set on data objects are being enforced.

By default, ONTAP maps users with identical names in Windows and UNIX without the need for any administrator intervention by way of name mapping rules. For example, a UNIX user named `techontap` maps implicitly to a Windows user named `techontap` without needing any special name mappings.

If a user has a different name in Windows from what they have in UNIX (or conversely), then ONTAP needs more information to properly map users. This information can come from one of three places:

- Name service mapping (such as LDAP)
- Name mapping rules that are set at the SVM level
- Default UNIX or Windows user (set at the NFS or CIFS server level)

If no valid name mapping exists for a user, the authentication request fails, and a client sees access or permission denied when attempting to access NAS data that is hosted in ONTAP.

If a valid name mapping exists but maps a UNIX or Windows user to the wrong Windows or UNIX user, a range of outcomes can result. Outcomes range from incorrect access to files and folders to incorrect owners being set on files and folders (such as CIFS files showing up as nobody or 65534 on NFS exports).

Name mapping rules

In ONTAP, you can configure name mapping rules for individually specified users or even for host names and clients. Name mapping rules cannot be used for group-to-user mappings, however.

You can use name mapping rules for three different directional purposes, which are specified by the option `-direction`:

- **Win-unix** is used for mapping Windows user names to UNIX user names. You can specify the Windows Active Directory domain in the user name by using `DOMAIN\\user format`. These name mapping rules help ONTAP determine the appropriate UNIX user to use when determining permissions and access rights on UNIX security style objects.
- **Unix-win** is used for mapping UNIX names to Window names. UNIX names are specified by user name because they are needed to map into Windows. ONTAP must be able to translate incoming UNIX numeric UIDs to names through name service servers or local files. Otherwise, if no UNIX user name can map to the UID, then the mapping request uses the numeric UID to look for a Windows user of `DOMAIN/{numericID}`. These name mapping rules help ONTAP determine the appropriate Windows user to use when determining permissions and access rights on NTFS security style objects.
- **Krb-unix** is used for NFS Kerberos service principal name (SPN) mappings. By default, NFS Kerberos SPNs attempt to map by using either the service name (such as the `nfs` portion of `nfs/host@DOMAIN.COM`) or the user/machine account portion of `NAME@DOMAIN.COM` in Kerberos requests. Sometimes, storage administrators might want to control the name mapping of those SPNs rather than letting ONTAP map 1:1. TR-4616 covers these scenarios in more detail.

Regular expressions

ONTAP allows the use of standard regular expression (regex) values in name mapping rules. They can provide global replacement and wildcard functionality for name mapping rules when UNIX and Windows names are not 1:1 but are close enough to take care of with a simple regex value.

For example, if all Windows names follow the format `first.last` for names and the UNIX environment uses `first_last`, then you could use a regex to map all dots to underscores in user names. That regex would look like the following:

```
cluster::*> vserver name-mapping show -vserver DEMO -direction win-unix
```

```
Vserver:   DEMO
Direction: win-unix
Position Hostname         IP Address/Mask
-------- ---------------- ----------------
1        -                -                  Pattern: (.+)\\(.+)\.(.+)
                                         Replacement: \2_\3
```

Without the preceding rule, user names like user.name would map to the default user:

```
cluster::*> diag secd name-mapping show -node ontap9-tme-8040-01 -vserver DEMO -direction win-
unix -name NTAP\user.name

'NTAP\user.name' maps to ‘pcuser'
```

With that rule, `DOMAIN\user.name` maps to the UNIX user `user_name`.

```
cluster::*> diag secd name-mapping show -node ontap9-tme-8040-01 -vserver DEMO -direction win-
unix -name NTAP\user.name

'NTAP\user.name' maps to 'user_name'
```

Mapping the administrator to the root (and vice versa)

ONTAP provides options for mapping all administrative users to the root and for mapping the root to the Windows administrator. The purpose is to treat all administrative users the same across multiple NAS protocols regardless of name mapping rules.

For example, if a Windows user named `prof1` has a valid UNIX user name of `prof1`, then the default name mapping is `NTAP\prof1 == prof1`.

If Windows user `prof1` is a member of the domain or local administrators group, then enabling the CIFS/SMB option `-is-admin-users-mapped-to-root-enabled` maps that user to the root.

The following example shows output of the `show-creds` command for the `NTAP\prof1` Windows user. Note the name mapping and the Windows group membership (in **bold**):

```
cluster::*> cifs option show -vserver DEMO -fields is-admin-users-mapped-to-root-enabled
vserver is-admin-users-mapped-to-root-enabled
------- -------------------------------------
DEMO    true

cluster::*> vserver services access-check authentication show-creds -vserver DEMO -win-name
NTAP\prof1

 UNIX UID: prof1 <> Windows User: NTAP\prof1 (Windows Domain User)

 GID: ProfGroup
 Supplementary GIDs:
  ProfGroup
  group1
  group2
  group3
  sharedgroup

 Primary Group SID: NTAP\DomainUsers (Windows Domain group)

 Windows Membership:
  NTAP\group2 (Windows Domain group)
  NTAP\DomainUsers (Windows Domain group)
  NTAP\sharedgroup (Windows Domain group)
  NTAP\group1 (Windows Domain group)
  NTAP\group3 (Windows Domain group)
  NTAP\ProfGroup (Windows Domain group)
  Service asserted identity (Windows Well known group)
  BUILTIN\Backup Operators (Windows Alias)
  BUILTIN\Users (Windows Alias)
 User is also a member of Everyone, Authenticated Users, and Network Users

 Privileges (0x2086):
  SeBackupPrivilege
  SeRestorePrivilege
  SeChangeNotifyPrivilege
```

When that user is added to the local administrators group for the SVM, it now gets mapped to the root.

```
cluster::*> local-group add-members -vserver DEMO -group-name BUILTIN\administrators -member-
names NTAP\prof1
  (vserver cifs users-and-groups local-group add-members)

cluster::*> local-group show-members -vserver DEMO -group-name administrators
  (vserver cifs users-and-groups local-group show-members)

           Vserver: DEMO
        Group Name: BUILTIN\Administrators
       Member Name: DEMO\Administrator
                    NTAP\Domain Admins
                    NTAP\prof1

cluster::*> vserver services access-check authentication show-creds -vserver DEMO -win-name
NTAP\prof1

 UNIX UID: root <> Windows User: NTAP\prof1 (Windows Domain User)

 GID: daemon
 Supplementary GIDs:
  daemon

 Primary Group SID: NTAP\DomainUsers (Windows Domain group)

 Windows Membership:
  NTAP\group2 (Windows Domain group)
  NTAP\DomainUsers (Windows Domain group)
  NTAP\sharedgroup (Windows Domain group)
  NTAP\group1 (Windows Domain group)
  NTAP\group3 (Windows Domain group)
  NTAP\ProfGroup (Windows Domain group)
  Service asserted identity (Windows Well known group)
  BUILTIN\Backup Operators (Windows Alias)
  BUILTIN\Administrators (Windows Alias)
  BUILTIN\Users (Windows Alias)
 User is also a member of Everyone, Authenticated Users, and Network Users

 Privileges (0x22b7):
  SeBackupPrivilege
  SeRestorePrivilege
  SeTakeOwnershipPrivilege
  SeSecurityPrivilege
  SeChangeNotifyPrivilege
```

When a user is mapped to the root and writes files to a NAS share, then the ownership reflects that name mapping. In the following example, `prof1` wrote a file from SMB called `mappedroot.txt` and the owner became `root`:

```
# su prof1
sh-4.2$ cd /profgroup
sh-4.2$ ls -la
total 8
drwxrwxrwx  2 root                 root      4096 Feb 21 14:59 .
drwxrwxrwx 11 root                 root      4096 Feb  3 09:34 ..
-rwxrwxrwx  1 root                 ProfGroup    0 Feb 21 14:59 mappedroot.txt
-rw-r--r--  1 prof1                ProfGroup    0 Aug 30 10:30 newfile1
-rw-r--r--  1 prof1                ProfGroup    0 Aug 30 10:30 newfile2
```

Use of LDAP for name mapping

LDAP can be a name mapping resource, if the LDAP schema on the server has been populated properly and that the ONTAP SVM's LDAP client schema reflects the assigned LDAP attributes that are used for name mapping. For example, to map UNIX users to corresponding Windows user names that do not match 1:1, you can use a combination of `uid` (for UNIX user names) and `sAMAccountName` (for Windows user names) in the LDAP client configuration. The attributes that are used depend on what is found during the LDAP preconfiguration steps, which are covered in the section, "Configuration."

LDAP schemas

LDAP schemas are how LDAP servers organize and collect information. LDAP server schemas generally follow the same standards, but different LDAP server providers might have variations on how schemas are presented. ONTAP has built-in read-only schemas that are available to administrators. You can use these schemas to configure LDAP, or you can copy them to read/writable schemas. These options allow modification of the schema attributes for LDAP servers that do not contain the same attributes as any of the default schemas. LDAP schemas must exist before you configure an LDAP client.

In LDAP queries by the cluster, schemas are used to speed up name lookups because they enable the use of specific attributes to find information about a user, such as the UID. The schema attributes must exist in the LDAP server for the cluster to be able to find the entry. Otherwise, LDAP queries might return no data and authentication requests might fail.

For example, if a UID number (such as `root=0`) must be queried by the cluster and the cluster is configured to use AD-IDMU schema styles, then the schema attribute `RFC 2307 uidNumber Attribute` is used. The default schema for AD-IDMU uses the attribute `uidNumber` for that query.

If the LDAP server uses a different schema attribute for that information, then the query can't find that information.

For ease of use and configuration, ONTAP provides several default, read-only schema templates. These schema templates generally correspond with specific LDAP servers. Table 2 shows the LDAP schema templates that ONTAP provides and the corresponding LDAP server for each. In other words, if you use a specific type of LDAP server, then the schema that is listed with it should work for that server usually.

RFC 2307bis

RFC 2307 is the Request for Comments memo titled "An Approach for Using LDAP as a Network Information Service." RFC 2307bis is an extension of RFC 2307 and adds support for `posixGroup`, which enables dynamic lookups for auxiliary groups by using the `uniqueMember` attribute, rather than by using the `memberUid` attribute in the LDAP schema. Instead of using just the name of the user, this attribute contains the full distinguished name (DN) of another object in the LDAP database. Therefore, groups can have other groups as members, which allows nesting of groups. Support for RFC 2307bis also adds support for the object class `groupOfUniqueNames`.

This RFC extension fits nicely into how Microsoft Active Directory manages users and groups through the usual management tools. For example, without RFC 2307bis support, if you want to ensure that a user's supplemental groups are populated in LDAP queries, you must populate the `memberUid` field in the necessary groups with the users that live in that group. You perform this step through the classic UNIX Attributes tab, which is available in older versions of Active Directory (deprecated in Windows 2012 and later), or through the Attributes Editor tab or Windows PowerShell in newer versions of Windows. That task is an additional step to the normal Windows group management method of simply adding users as members of groups.

With RFC 2307bis, when you add a Windows user to a group (and if that group has a valid numeric GID), LDAP lookups pull the necessary supplemental group information from the usual Windows attribute and find the numeric GIDs automatically.

As such, NetApp highly recommends that you enable RFC 2307bis when you configure LDAP clients in ONTAP. You enable it through the schema creation, and it is available by default with the `MS-AD-BIS` schema that ONTAP provides.

Group membership and supplemental groups

You can use LDAP to control group membership for users and to return supplemental groups for a user. This behavior is controlled through schema attributes.

Primary GID

For ONTAP to be able to search properly, LDAP users must always have a primary GID defined. The user's primary GID is defined by the schema attribute `-gid-number-attribute`. Usually, that attribute is `gidNumber`. Sometimes, it might be `gid` or `primaryGid`. Be sure to check with your LDAP administrator for the proper attribute.

If a user has no primary numeric UNIX GID, then ONTAP fails the request, even if the user has a valid UNIX UID and numeric.

```
cluster::*> getxxbyyy getpwbyname -node node1 -vserver DEMO -username test -show-source true
-use-cache false -show-granular-err true
  (vserver services name-service getxxbyyy getpwbyname)
NIS:
Error code:    NS_ERROR_NONE
Error message: No error
LDAP:
Error code:    NS_ERROR_NOT_FOUND
Error message: Entry not found
DNS:
Error code:    NS_ERROR_NONE
Error message: No error
FILES:
Error code:    NS_ERROR_NOT_FOUND
Error message: Entry not found
Deterministic Result: Authoritative Error


Error: command failed: Failed to resolve test. Reason: Entry not found for "username: test".
```

Secondary, supplemental, and auxiliary GIDs

Secondary, supplemental, and auxiliary groups are groups that a user is a member of outside of their primary GID. They are defined in two ways in LDAP:

- `memberUid`
- RFC 2307bis

LDAP can query group membership based on the LDAP schema configuration in use. For example, if RFC 2307bis is enabled, then LDAP searches based on the RFC 2307bis attributes that are defined in the schema (see the "RFC 2307bis" section of this document). If supplemental groups do not appear as expected for a user, then the likely issue is that the LDAP client schema is misconfigured. For more information, see section, "Common issues and troubleshooting steps."

Increasing the number of allowed supplemental and auxiliary GIDs

Remote Procedure Call (RPC) has a specific limitation for the maximum number of auxiliary GIDs that can be honored in a single NFS request. The maximum for `AUTH_SYS/AUTH_UNIX` is 16, and for `AUTH_GSS` (Kerberos), it is 32. This protocol limitation affects many NFS servers, not just ONTAP. To work around this NFS limitation in ONTAP, use the following NFS server options:

```
auth-sys-extended-groups
```

```
extended-groups-limit
```

Also, the LDAP client schema can increase the supported groups for use with RFC 2307bis, which defaults to 256 and can increase to 1,024.

```
-maximum-groups-rfc2307bis
```

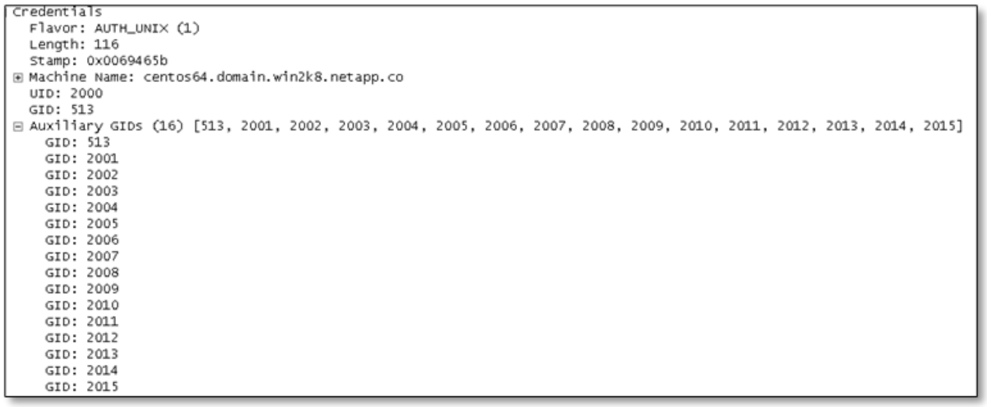
How it works

The options to extend the group limitation work the same way that the `manage-gids` option for other NFS servers works. Basically, rather than dumping the entire list of auxiliary GIDs that a user belongs to, the option performs a lookup for the GID on the file or folder and returns that value instead (Figure 1).

From the manual page for mountd:

```
/.'\
```

Figure 1) RPC packet with 16 GIDs.



```
Credentials
  Flavor: AUTH_UNIX (1)
  Length: 116
  Stamp: 0x0069465b
⊞ Machine Name: centos64.domain.win2k8.netapp.co
  UID: 2000
  GID: 513
⊟ Auxiliary GIDs (16) [513, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015]
    GID: 513
    GID: 2001
    GID: 2002
    GID: 2003
    GID: 2004
    GID: 2005
    GID: 2006
    GID: 2007
    GID: 2008
    GID: 2009
    GID: 2010
    GID: 2011
    GID: 2012
    GID: 2013
    GID: 2014
    GID: 2015
```

Any GID past the limit of 16 is dropped by the protocol. With the extended GID option in ONTAP, when a new NFS request comes in, ONTAP requests information about the user's group membership. You can use extended GIDs with external name services, or if the users and groups are configured properly, you can use them locally on the cluster. If you use local files, make sure that a local UNIX user is a member of multiple groups with the `unix-group adduser(s)` command.

```
COMMANDS
     adduser - Add a user to a local UNIX group

     addusers - Add a list of users to a local UNIX group
```

Performance effect of extended GIDs

Extended groups have a minimal performance penalty, generally in the low single-digit percentages. Higher metadata NFS workloads likely have more effect, particularly on the system's caches. Performance can also be affected by the speed and workload of the name service servers. Overloaded name service servers are slower to respond, causing delays in prefetching the GID.

Considerations for extended GIDs with Active Directory LDAP

By default, in Microsoft Active Directory LDAP servers, the `MaxPageSize` attribute is set to a default of 1,000. That setting means that groups beyond 1,000 would be truncated in LDAP queries. To enable full support with the 1,024 value for extended groups, the `MaxPageSize` attribute must be modified to reflect the 1,024 value. For information about how to change that value, see the Microsoft TechNet article How to View and Set LDAP Policy in Active Directory by Using Ntdsutil.exe.

If you have concerns about modifying this value, contact Microsoft support and review the TechNet library article [MaxPageSize Is Set Too High](#).

LDAP search distinguished names and scopes

The following section covers LDAP schema architecture and how searches are conducted through the search using distinguished names (DNs) and scopes.

Distinguished names

A DN is a sequence of relative DNs (RDNs), separated by commas. In LDAP, it is essentially a folder structure that specifies the locality of objects such as users, groups, machine accounts, and netgroups.

In Active Directory, for instance, the domain itself can be represented as a DN. A domain of `domain.netapp.com` becomes a DN of `dc=domain,dc=netapp,dc=com`.

Table 1 shows what common RDN types are used in DNs.

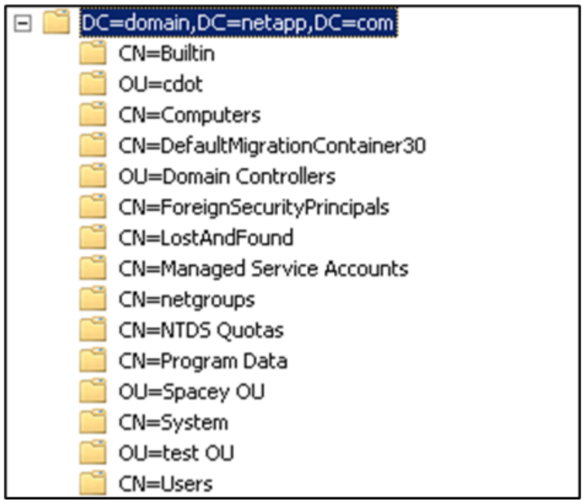
Table 1) Common RDN values in LDAP.

String	Attribute type
DC	`domainComponent`
CN	`commonName`
OU	`organizationalUnitName`
O	`organizationName`

In ONTAP LDAP client configuration, it is possible to specify a DN for base, user, group, and netgroup LDAP searches.

In Figure 2, ADSI Edit is used to display the folder structure of the LDAP DNs.

Figure 2) LDAP DN folder structure.



DC=domain,DC=netapp,DC=com
- CN=Builtin
- OU=cdot
- CN=Computers
- CN=DefaultMigrationContainer30
- OU=Domain Controllers
- CN=ForeignSecurityPrincipals
- CN=LostAndFound
- CN=Managed Service Accounts
- CN=netgroups
- CN=NTDS Quotas
- CN=Program Data
- OU=Spacey OU
- CN=System
- OU=test OU
- CN=Users

Why should you specify a DN?

In Figure 2, numerous folders could contain users, groups, or netgroups. If the base DN of `dc=domain,dc=netapp,dc=com` represents the domain of `domain.netapp.com`, the LDAP client could certainly be pointed to use the base DN. However, all queries would potentially need to crawl each DN that is listed below `dc=domain,dc=netapp,dc=com`, depending on the search scope. That process could add latency to name service and authentication lookups, which could cause authentication failures, access issues, or client connectivity problems. To avoid issues, it is critical that name service queries be returned as quickly as possible. Specification of DNs in the user, group, and netgroup lookups can help achieve the necessary speed by filtering requests to the LDAP server.

For example, if a user exists in the DN of `cn=Users,dc=domain,dc=netapp,dc=com`, then the user DN client configuration field can be specified to search in that DN for user objects, rather than in the base DN of `dc=domain,dc=netapp,dc=com`. That setting eliminates the need to look in any of the other DNs that exist below the base. This approach is especially critical in large environments, where there can be hundreds or even thousands of DNs.

Multiple DNs

It is possible to specify multiple DNs for object searches. Therefore, users, groups, and netgroups can exist in multiple locations in LDAP, and you can still filter searches by DN. When you specify multiple DNs, be sure to enclose the entry in double quotes, or else the command fails.

```
cluster::*> ldap client modify -client-config DOMAIN -vserver SVM -user-dn
cn=users,dc=domain,dc=netapp,dc=com;OU=cdot,dc=domain,dc=netapp,dc=com
  (vserver services ldap client modify)

Error: "OU=cdot,dc=domain,dc=netapp,dc=com" is not a recognized command
```

Note: Be sure that the entries use a semicolon separator between DNs. If you use a comma to separate the values, the cluster sees the entry as a single DN.

If a user exists with the same user name in multiple DNs but has different numeric UIDs, then NFS lookups should work well, provided that those numeric UIDs don’t exist elsewhere in the LDAP environment.

NFS numeric ID operations

NFSv3 uses only numeric IDs for access unless NTFS ACLs are involved. For instance, if a user accesses an NFSv3 mount as user 1234 and the underlying permissions are UNIX style, then all ONTAP cares about is the 1234 UID to allow or to deny access.

However, NFSv4.x can have two different approaches for UID-to-name resolution. By default, NFSv4.x uses the numeric IDs, similar to NFSv3 use of the `v4-numeric-ids` option.

```
[-v4-numeric-ids {enabled|disabled}] - NFSv4 Support for Numeric Owner IDs
This optional parameter specifies whether to enable the support for numeric string identifiers in
NFSv4 owner attributes. The default setting is enabled at the time of creation.
```

Alternatively, NFSv4.x can use ID strings, in which a numeric ID must resolve to a user name, and that username must then exist in the same domain on the client and server. For instance, UID 1234 must map to a user name, such as `user@DOMAIN.COM`. Otherwise, that user gets squashed to a `nobody` user specified in the client’s NFSv4.x configuration files. To force ID string resolution, `v4-numeric-ids` must be disabled.

Example of identical user names, different UIDs

For example, if a user named `v4user` exists locally on the client machine and in LDAP with two different numeric UIDs, then the behavior of file creation and access varies depending on the `ns-switch` configuration (which controls what UID is used) and NFS server settings.

If `ns-switch` uses LDAP first on the client, then the user becomes whatever LDAP has stored for the user information. In this example, the client’s `ns-switch` is set up for user resolution as follows:

```
passwd:     sss files
```

That setup means that users (`passwd`) use LDAP and then local files. It is similar to how multiple LDAP servers with the same user name and with different UIDs operate.

On the example client, the following is the `v4user` when the LDAP client is disabled and local files are used:

```
# id v4user
uid=1005(v4user) gid=1005(v4user) groups=1005(v4user)
```

When the LDAP client is running, the user appears as follows:

```
# id v4user
uid=877(v4user) gid=10000(Domain Users) groups=10000(Domain Users)
```

If a file gets written when the LDAP client is not running, then the UID becomes 1005.

```
-rwx------   1       1005       1005   23 Feb  3 16:38 v4user_file
```

If a file gets written when the LDAP client is running, then the UID becomes 877, even though the user name is identical across all the files.

```
-rwx------   1        877      10000   22 Feb  3 16:39 v4user_file3

# ls -la | grep v4user
-rwx------   1 v4user                v4user                   23 Feb  3 16:38 v4user_file
-rwx------   1 v4user                v4user                   26 Feb  3 16:19 v4user_file2
-rwx------   1 v4user                Domain Users             22 Feb  3 16:39 v4user_file3
-rwx------   1 v4user                Domain Users              0 Feb  3 10:34 v4user_file4

# ls -lan | grep v4user
-rwx------   1       1005       1005   23 Feb  3 16:38 v4user_file
-rwx------   1       1005       1005   26 Feb  3 16:19 v4user_file2
-rwx------   1        877      10000   22 Feb  3 16:39 v4user_file3
-rwx------   1        877      10000    0 Feb  3 10:34 v4user_file4
```

When the `v4-numeric-ids` option is disabled on the NFS server, then only the user that can be resolved through LDAP is shown properly. That user is the only one that ONTAP knows how to translate for NFSv4.x access, even though the client knows about both users.

```
cluster::*> nfs server show -vserver DEMO -fields v4-numeric-ids
vserver v4-numeric-ids
------- --------------
DEMO    disabled

sh-4.2$ ls -la | grep v4user
-rwx------   1 nobody                nobody         23 Feb  3 16:38 v4user_file
-rwx------   1 nobody                nobody         26 Feb  3 16:19 v4user_file2
-rwx------   1 v4user                Domain Users   22 Feb  3 16:39 v4user_file3
-rwx------   1 v4user                Domain Users    0 Feb  3 10:34 v4user_file4

sh-4.2$ ls -lan | grep v4user
-rwx------   1   99    99   23 Feb  3 16:38 v4user_file
-rwx------   1   99    99   26 Feb  3 16:19 v4user_file2
-rwx------   1  877 10000   22 Feb  3 16:39 v4user_file3
-rwx------   1  877 10000    0 Feb  3 10:34 v4user_file4
```

The issue with having multiple user names with the same name but different UIDs is that it affects access. Access depends on the permissions for the UID, not for the user name. Although the clients might see the same user name, because the underlying UIDs are different, access might be denied.

In the following example, UID 1005 (`v4user`) has ownership of `v4user_file`. Other users and groups have no access to that file.

```
-rwx------   1       1005       1005   23 Feb  3 16:38 v4user_file
```

However, the user who accesses the NFS mount is actually UID 877.

```
sh-4.2$ id
uid=877(v4user) gid=10000(Domain Users) groups=10000(Domain Users)
```

As a result, access to the file that 1005 owns is denied, because `v4user` (877) is not the same as `v4user` (1005).

```
sh-4.2$ cat v4user_file
cat: v4user_file: Permission denied
```

Because this user is UID 877, then access to `v4user_file3` succeeds, because the owner is also 877.

```
-rwx------   1        877      10000   22 Feb  3 16:39 v4user_file3

sh-4.2$ cat v4user_file3
This is the LDAP user
```

To prevent confusion over access, disable `v4-numeric-ids` to allow the files to show as owned by `nobody`. However, ultimately, if you use multiple DNs, to achieve predictable access permissions, ensure that all UIDs and user names are unique.

Search scopes

In addition to DNs, you can specify search scopes for LDAP queries. A scope is the starting point for LDAP queries and indicates at what depth from the base DN the search should occur. The following search scopes are valid for LDAP queries in ONTAP: `base`, `subtree`, and `onelevel`.

base

A `base` search scope indicates that LDAP searches should occur only for the specified base DN.

For example, if a user DN is set to `cn=users,dc=domain,dc=netapp,dc=com`, and a base search scope is specified, then LDAP search occurs only for `cn=users,dc=domain,dc=netapp,dc=com`. It does not include objects that are inside the DN. Because base is a very literal search scope, NetApp does not recommend it.

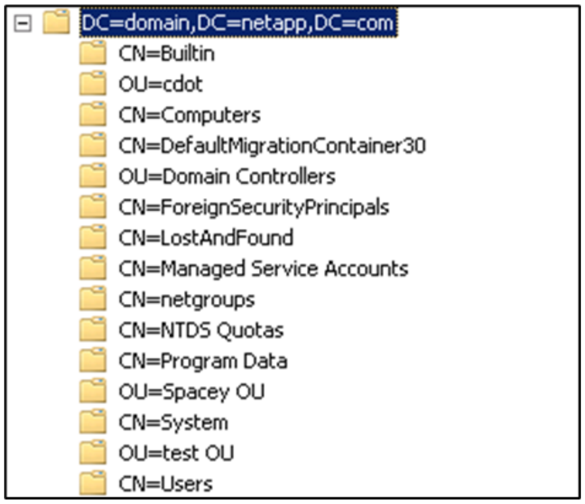
subtree

A `subtree` search scope searches all levels below the specified DN.

For example, if a user DN is set to `cn=users,dc=domain,dc=netapp,dc=com`, and a subtree search scope is specified, then LDAP search occurs for all objects below `cn=users,dc=domain,dc=netapp,dc=com`, including other containers. NetApp recommends subtree as a search scope in most cases, as long as the DN that you specify is at a low enough level to filter effectively.

In Figure 3, the DN of `dc=domain,dc=netapp,dc=com` has several containers beneath it. If a search scope of `subtree` is used, then LDAP queries look in each DN below `dc=domain,dc=netapp,dc=com`. You might prefer to specify the DN at a more granular level for `subtree` searches, such as `cn=users,dc=domain,dc=netapp,dc=com`.

Figure 3) LDAP DN containers.



DC=domain,DC=netapp,DC=com
CN=Builtin
OU=cdot
CN=Computers
CN=DefaultMigrationContainer30
OU=Domain Controllers
CN=ForeignSecurityPrincipals
CN=LostAndFound
CN=Managed Service Accounts
CN=netgroups
CN=NTDS Quotas
CN=Program Data
OU=Spacey OU
CN=System
OU=test OU
CN=Users

onelevel

A `onelevel` search scope searches only at one level below the specified DN, including the DN itself, but does not search entries below that one level.

For example, if a user DN is set to `cn=users,dc=domain,dc=netapp,dc=com`, and a onelevel search scope is specified, then LDAP search occurs only in DNs that are one level below `cn=users,dc=domain,dc=netapp,dc=com`.

```
cluster::*> ldap client modify -client-config DOMAIN -vserver SVM -user-dn
"cn=users,dc=domain,dc=netapp,dc=com" -user-scope onelevel
  (vserver services ldap client modify)
```

In ONTAP 8.3 and later versions, you can query the user ID from the advanced privilege with the following command:

```
cluster::*> getxxbyyy getpwbyname -vserver DEMO -username prof1 -node node1
  (vserver services name-service getxxbyyy getpwbyname)
pw_name: prof1
pw_passwd:
pw_uid: 1100
pw_gid: 1101
pw_gecos:
pw_dir:
pw_shell:
```

In ONTAP 9.6 and later, you can also use the following command:

```
cluster::*> access-check authentication translate -vserver DEMO -unix-user-name prof1
```

If the DN is set at a level higher, the lookup fails.

```
cluster::*> ldap client modify -client-config DOMAIN -vserver SVM -user-dn
"dc=domain,dc=netapp,dc=com" -user-scope onelevel
  (vserver services ldap client modify)

cluster::*> access-check authentication translate -vserver DEMO -unix-user-name prof1

Vserver: SVM (internal ID: 3)

Error: Acquire UNIX credentials procedure failed
  [  0 ms] Name 'prof1' not found in UNIX authorization source
           LOCAL
  [     0] Connecting to LDAP (NIS & Name Mapping) server
```

```
            10.x.x.x
  [      5] Using a new connection to 10.x.x.x
  [      7] Name 'prof1' not found in UNIX authorization source
            LDAP
  [      7] Could not get a user ID for name 'prof1' using any
            NS-SWITCH authorization source
**[      7] FAILURE: Unable to retrieve UID for UNIX user prof1

Error: command failed: Failed to resolve user name to a UNIX ID. Reason: "SecD Error: object not
found".
```

For filtering at a very granular level, `onelevel` search scopes are optimal. However, if the correct DNs are not specified, use of `onelevel` search scopes can result in lookup failures.

Centrify integration and considerations

Windows Active Directory LDAP servers that run Windows 2016 and later have deprecated the UNIX Attributes tab in the Properties dialog box. The preferred method is Windows PowerShell and/or advanced Attributes management from the Active Directory Users and Computers GUI.

Management of large environments with many users can be cumbersome, so third-party products, such as Centrify, attempt to simplify user authentication across Windows and Linux clients by providing a single-pane-of-glass approach to identity management.

ONTAP is fully compatible with any LDAP provider, as long as the provider follows the RFC 2307 standards.

To use ONTAP with a third-party LDAP provider such as Centrify, you must contact the LDAP administrator to get information about how the LDAP server presents users, groups, netgroups, and group memberships in their schemas. For instance, some LDAP providers use `uid` for user names; others might use `uid` to mean the numeric IDs for the users. Sometimes, object classes might differ greatly between LDAP providers. Before you configure ONTAP as an LDAP client, you must find out the following schema attributes for users:

- User object classes
- User names
- Numeric UIDs
- Primary GIDs
- Home directory
- UNIX password
- Gecos

You must obtain the following information for groups and group memberships:

- Group object classes
- Numeric GID
- Group names
- Whether `memberUid` is populated for group memberships
- Whether the LDAP server is using RFC 2307bis for group memberships (which Active Directory can do)

For Windows Active Directory, you can use PowerShell to query LDAP users and groups for these attributes.

For UNIX LDAP servers, you can use utilities such as `ldapsearch`.

After you have gathered the necessary information, use the steps in the “Create custom LDAP schemas”” section of this document to create a custom schema to configure the Centrify LDAP lookups.

LDAP referrals (chase referrals)

LDAP referrals provide a way for ONTAP to support environments in which UNIX users and groups exist in multiple LDAP servers. When LDAP referrals are disabled (default), ONTAP looks for a user in an LDAP server. If that user does not exist in the LDAP server, then the query is done, and the lookup fails.

When LDAP referrals are enabled (`-referral-enabled true`) and multiple LDAP servers are listed, if a user is not found on the first LDAP server, a referral is issued to other LDAP servers in the list to see whether the user exists there. LDAP queries take longer to perform these additional searches, and the amount of extra time needed depends on network latency, size of the LDAP schemas, and number of LDAP servers specified. If searches are timing out with LDAP referrals enabled, you can increase the LDAP query timeout from the default of 3 seconds up to a maximum of 10 seconds with the `-query-timeout` option.

LDAP referrals are not supported when LDAP over StartTLS/LDAPS is used in ONTAP 9.8 and prior. ONTAP 9.9.1 adds support for secure chase referrals.

Configuration

This section covers only the LDAP client configuration for NetApp ONTAP. For NFS client LDAP configuration, see the client documentation. For LDAP server configuration, see the documentation for your specific LDAP server.

Because ONTAP System Manager configuration support is limited mostly to default schemas, is missing some configuration values, and focuses mostly on Microsoft Active Directory LDAP configuration, this TR covers CLI configuration only.

LDAP configuration generally consists of the following steps:

1. Gather configuration information (server IP addresses and names, LDAP schema information, bind information, and so on).
2. Select or create an LDAP schema.
3. Create the LDAP client configuration.
4. Create the LDAP configuration.
5. Modify `ns-switch` to use LDAP.
6. Test LDAP.

LDAP environment information—Preconfiguration

Before you configure ONTAP as an LDAP client, you should gather some information to make it easier for you to set up everything.

Before you start

Before you set up LDAP on a production SVM, it might be better to create a new test SVM to get the LDAP configuration correct before you deploy it in a production SVM. If you try to deploy the LDAP client configuration in a production environment, you run the risk of breaking user authentication if LDAP isn't working properly.

A new test SVM requires only a data LIF that can contact the same LDAP servers that will be used in the production environment.

Success criteria will be based on admin-generated LDAP calls, which are covered in the section, "Test LDAP functionality."

LDAP security decisions

LDAP connectivity can use encryption for binds and LDAP searches. ONTAP offers a few options to secure LDAP connections, including:

- Binding as a CIFS/SMB server (by using the CIFS/SMB machine account to bind through NT LAN Manager [NTLM] or Kerberos)
- SMB signing and sealing (when you use Windows Active Directory for LDAP)
- StartTLS or LDAP over SSL (only one can be enabled at a time)

It is important to coordinate with the LDAP administrator to find out what security methods are being used. Sometimes, security for LDAP is being enforced, so LDAP client configuration in ONTAP would need to use the provided security method simply to get LDAP working.

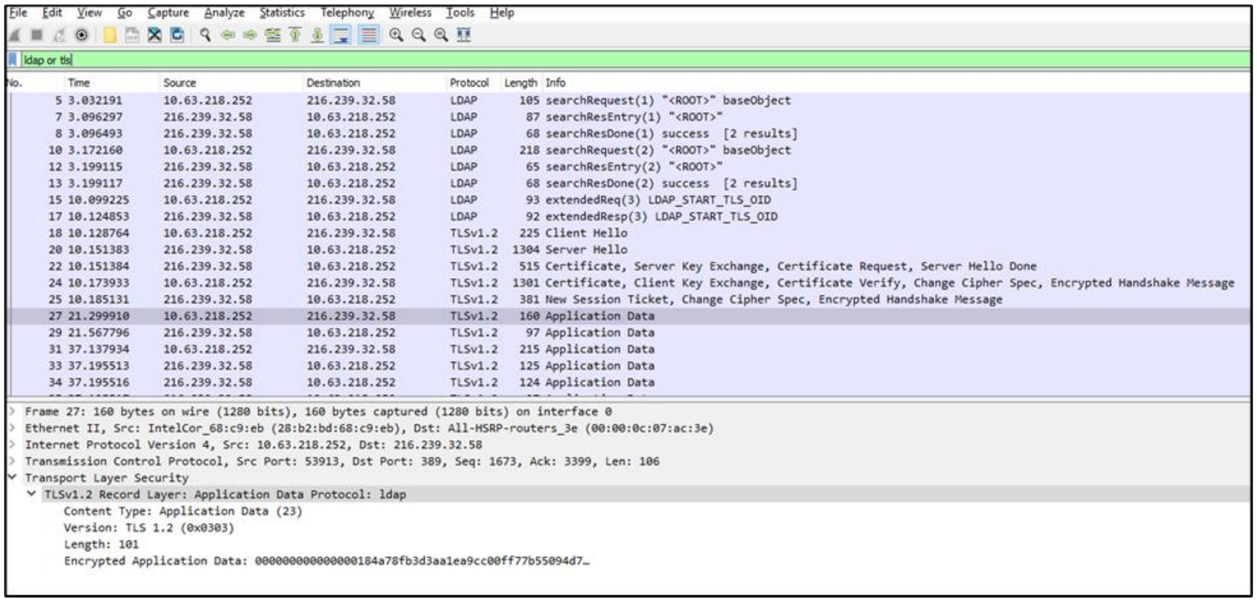
For information about configuring LDAP over SSL or StartTLS in ONTAP for LDAP, see the section, “Configure secure LDAP.”

Start Transport Layer Security versus LDAP over SSL

ONTAP offers both LDAP over SSL (LDAPS) that uses port 636 and LDAP that uses Start Transport Layer Security (StartTLS) (port 389). LDAPS is considered legacy at this point, with RFC 1777 having been published in 1995. LDAP over StartTLS was introduced with RFC 2830 in 2000 and was combined into the LDAPv3 standard with RFC 4511 in 2006. After StartTLS was made a standard, LDAP vendors began to refer to LDAPS as deprecated.

Originally, ONTAP supported only StartTLS for LDAP encryption, but popular demand brought LDAPS into ONTAP 9.5 and later versions. Usually, you want to use StartTLS (or LDAP signing and sealing if you use Windows Active Directory) as your LDAP encryption, even though StartTLS uses the plaintext, well-known LDAP port 389. With StartTLS, after the initial LDAP connection has been made, a StartTLS OID is exchanged, certificates are compared, and then all traffic is encrypted by using TLS. The packet capture shown in Figure 4 shows the LDAP bind, StartTLS handshake and subsequent TLS-encrypted LDAP traffic.

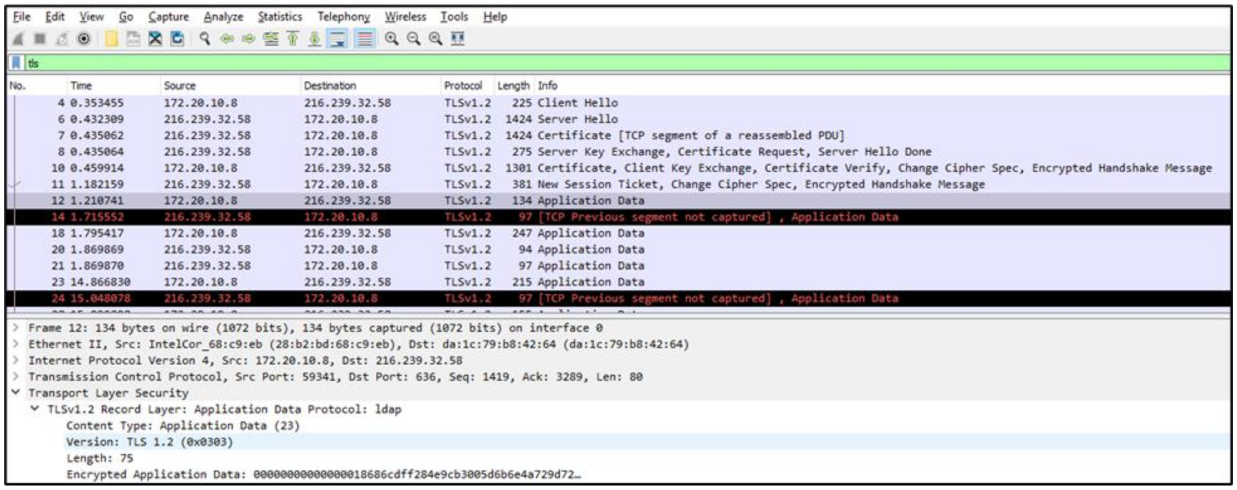
Figure 4) Packet trace of StartTLS LDAP traffic.



```
ldap or tls
No.  Time       Source          Destination     Protocol Length Info
  5 3.032191   10.63.218.252   216.239.32.58   LDAP      105 searchRequest(1) "<ROOT>" baseObject
  7 3.096297   216.239.32.58   10.63.218.252   LDAP       87 searchResEntry(1) "<ROOT>"
  8 3.096493   216.239.32.58   10.63.218.252   LDAP       68 searchResDone(1) success  [2 results]
 10 3.172160   10.63.218.252   216.239.32.58   LDAP      218 searchRequest(2) "<ROOT>" baseObject
 12 3.199115   216.239.32.58   10.63.218.252   LDAP       65 searchResEntry(2) "<ROOT>"
 13 3.199117   216.239.32.58   10.63.218.252   LDAP       68 searchResDone(2) success  [2 results]
 15 10.099225  10.63.218.252   216.239.32.58   LDAP       93 extendedReq(3) LDAP_START_TLS_OID
 17 10.124853  216.239.32.58   10.63.218.252   LDAP       92 extendedResp(3) LDAP_START_TLS_OID
 18 10.128764  10.63.218.252   216.239.32.58   TLSv1.2   225 Client Hello
 20 10.151383  216.239.32.58   10.63.218.252   TLSv1.2  1304 Server Hello
 22 10.151384  216.239.32.58   10.63.218.252   TLSv1.2   515 Certificate, Server Key Exchange, Certificate Request, Server Hello Done
 24 10.173933  10.63.218.252   216.239.32.58   TLSv1.2  1301 Certificate, Client Key Exchange, Certificate Verify, Change Cipher Spec, Encrypted Handshake Message
 25 10.185131  216.239.32.58   10.63.218.252   TLSv1.2   381 New Session Ticket, Change Cipher Spec, Encrypted Handshake Message
 27 21.299910  10.63.218.252   216.239.32.58   TLSv1.2   160 Application Data
 29 21.567796  216.239.32.58   10.63.218.252   TLSv1.2    97 Application Data
 31 37.137934  10.63.218.252   216.239.32.58   TLSv1.2   215 Application Data
 33 37.195513  216.239.32.58   10.63.218.252   TLSv1.2   125 Application Data
 34 37.195516  216.239.32.58   10.63.218.252   TLSv1.2   124 Application Data

> Frame 27: 160 bytes on wire (1280 bits), 160 bytes captured (1280 bits) on interface 0
> Ethernet II, Src: IntelCor_68:c9:eb (28:b2:bd:68:c9:eb), Dst: All-HSRP-routers_3e (00:00:0c:07:ac:3e)
> Internet Protocol Version 4, Src: 10.63.218.252, Dst: 216.239.32.58
> Transmission Control Protocol, Src Port: 53913, Dst Port: 389, Seq: 1673, Ack: 3399, Len: 106
v Transport Layer Security
  v TLSv1.2 Record Layer: Application Data Protocol: ldap
      Content Type: Application Data (23)
      Version: TLS 1.2 (0x0303)
      Length: 101
      Encrypted Application Data: 000000000000000184a78fb3d3aa1ea9cc00ff77b55094d7…
```

LDAPS also uses certificate exchange and encrypts by using TLS. A trace shows traffic only over port 636. Figure 5 shows the traffic in a packet capture from an LDAPS conversation.

Figure 5) Packet trace of LDAPS traffic.



```
tls

No.   Time        Source          Destination     Protocol  Length Info
    4 0.353455    172.20.10.8     216.239.32.58   TLSv1.2    225 Client Hello
    6 0.432309    216.239.32.58   172.20.10.8     TLSv1.2   1424 Server Hello
    7 0.435062    216.239.32.58   172.20.10.8     TLSv1.2   1424 Certificate [TCP segment of a reassembled PDU]
    8 0.435064    216.239.32.58   172.20.10.8     TLSv1.2    275 Server Key Exchange, Certificate Request, Server Hello Done
   10 0.459914    172.20.10.8     216.239.32.58   TLSv1.2   1301 Certificate, Client Key Exchange, Certificate Verify, Change Cipher Spec, Encrypted Handshake Message
   11 1.182159    216.239.32.58   172.20.10.8     TLSv1.2    381 New Session Ticket, Change Cipher Spec, Encrypted Handshake Message
   12 1.210741    172.20.10.8     216.239.32.58   TLSv1.2    134 Application Data
   14 1.715552    216.239.32.58   172.20.10.8     TLSv1.2     97 [TCP Previous segment not captured] , Application Data
   18 1.795417    172.20.10.8     216.239.32.58   TLSv1.2    247 Application Data
   20 1.869869    216.239.32.58   172.20.10.8     TLSv1.2     94 Application Data
   21 1.869870    216.239.32.58   172.20.10.8     TLSv1.2     97 Application Data
   23 14.866830   172.20.10.8     216.239.32.58   TLSv1.2    215 Application Data
   24 15.048078   216.239.32.58   172.20.10.8     TLSv1.2     97 [TCP Previous segment not captured] , Application Data

> Frame 12: 134 bytes on wire (1072 bits), 134 bytes captured (1072 bits) on interface 0
> Ethernet II, Src: IntelCor_68:c9:eb (28:b2:bd:68:c9:eb), Dst: da:1c:79:b8:42:64 (da:1c:79:b8:42:64)
> Internet Protocol Version 4, Src: 172.20.10.8, Dst: 216.239.32.58
> Transmission Control Protocol, Src Port: 59341, Dst Port: 636, Seq: 1419, Ack: 3289, Len: 80
v Transport Layer Security
  v TLSv1.2 Record Layer: Application Data Protocol: ldap
      Content Type: Application Data (23)
      Version: TLS 1.2 (0x0303)
      Length: 75
      Encrypted Application Data: 0000000000000018686cdff284e9cb3005d6b6e4a729d72…
```

There are two main differences between LDAPS and StartTLS:

- StartTLS is part of the LDAP standard; LDAPS is not. As a result, LDAP library support might vary, and functionality might or might not work in all cases.
- If encryption fails, StartTLS allows the configuration to fall back to regular LDAP. LDAPS does not. As a result, StartTLS offers some flexibility and resiliency, but it also presents security risks if it is misconfigured.

Choosing StartTLS or LDAPS is a matter of preference in most cases, but for full standard compliance, NetApp recommends StartTLS.

Note: With ONTAP LDAP clients, you can set only LDAPS (by setting port 636) or StartTLS (`-use-start-tls true` and port 389). You cannot enable them together.

Security considerations with StartTLS

StartTLS enables administrators to fall back to regular LDAP traffic if they want to, but for security purposes, most LDAP administrators do not want to allow it. NetApp recommends the following to secure StartTLS to help secure LDAP communication:

- Ensure that StartTLS is enabled and that certificates are configured.
- For internal environments, you can use self-signed certificates, but for external LDAP, use a certificate authority. For more information about certificates, see the Microsoft TechNet article Difference Between Self Signed SSL & Certificate Authority.
- Prevent LDAP queries and binds that do not use StartTLS. Follow the configuration steps for the LDAP server from the LDAP server vendor.
- Restrict LDAP clients from sending plaintext credentials by setting the minimum bind level (`-min-bind-level`) on the LDAP client in ONTAP to SASL.

Microsoft LDAP channel binding requirement

Because of a vulnerability with Windows Active Directory domain controllers, a default setting is being changed for Windows servers that could affect LDAP interaction with ONTAP. For details, see Microsoft Security Advisory ADV190023.

Essentially, Microsoft Windows will start recommending that administrators enable LDAP signing and channel binding. If the LDAP client supports channel binding tokens and LDAP signing, channel binding and signing will be required, and registry options will be set by the new Microsoft patch.

Impact for ONTAP

The impact for ONTAP will be the same as for any LDAP client. For things that the client supports, those things will be required. If the security setting is not supported, no changes will be necessary. However, for ONTAP, it means two things:

- ONTAP does not currently support channel binding, so no changes will be necessary.
- ONTAP does support LDAP signing. Therefore, when the patch is applied to Windows, if LDAP signing is not enabled, ONTAP LDAP communication will fail for both SMB and LDAP UNIX identity management.

Remediation steps

After the Windows patch has been applied, if you have explicitly set the LDAP signing requirement to `off`, then no remediation is necessary. The patch will not overwrite the explicit change. However, if you have never set that option, then the patch will change the option to `on`. So that ONTAP can manage those changes before ONTAP 9.8, if you are using CIFS/SMB, you should set the CIFS/SMB server option `-session-security-for-ad-ldap` to `sign`. If you use LDAP with Active Directory for UNIX user and group lookups, you also need to use either StartTLS (`-use-start-tls`), LDAPS (port 636 and certificates), or LDAP signing and sealing (`-session-security sign`).

Note: Bug 1289739 addresses this issue without user interaction in ONTAP 9.8.

For more information, see the NetApp Knowledgebase article titled Impact of "Microsoft Security Advisory ADV190023" for Remote Authentication using LDAP."

DNS

LDAP servers often employ DNS, especially when Active Directory is in use.

Before you configure the SVM for LDAP, you should create the DNS configuration that contains records for the LDAP servers and services. DNS calls require that at least one data or SVM management LIF in the SVM can contact the DNS servers.

This configuration is performed at the SVM level.

```
cluster::> dns create ?
   [-vserver] <vserver name>          Vserver
   [-domains] <text>, ...             Domains
   [-name-servers] <IP Address>, ...  Name Servers
  [[-timeout] {1..5}]                 Timeout (secs) (default: 2)
  [ -attempts {1..4} ]                Maximum Attempts (default: 1)
  [ -skip-config-validation [true] ]  Skip Configuration Validation
```

For information about how to test whether DNS is working, see the section, "Troubleshooting tools."

LDAP server information

The LDAP server information that you should gather includes:

- Type of LDAP server (Windows Active Directory, Red Hat, and so on)
- LDAP server IP address, host name, or Active Directory domain
- Search DN and scope information
- DNS SRV record information for LDAP
- Whether the LDAP servers are behind a load balancer/network address translation (NAT) address
- LDAP server port
- LDAP server security level for binds (anonymous, simple, or SASL)
- Whether LDAP over SSL is being used

- Whether chase referrals are in use (for more information about referrals, see RFC 4511)

LDAP schema configuration

Before you can configure SVMs in ONTAP as LDAP clients, you must choose and configure a schema. As mentioned previously, ONTAP has several default schema templates to assist you. You can use Table 2 as guidance for which schema template to use. Usually, you can use the defaults. If variations exist, you can use these schema templates as a starting point by copying them to custom LDAP schemas and then modifying the desired specific attributes.

Note: These schema templates apply most of the time, but they might vary for third-party LDAP management tools such as Centrify or Quest.

Table 2) ONTAP LDAP schema templates and corresponding LDAP servers.

LDAP schema	LDAP server support
AD-SFU	Windows 2003 and earlier
AD-IDMU	Windows 2003 R2 and later
MS-AD-BIS	Windows 2003 R2 and later (For more information, see the “RFC 2307bis” section.)
RFC 2307	Most UNIX/Linux-based LDAP servers (Such as Red Hat and Apple)

Before you select a schema, verify whether the LDAP schema attributes that are being used match the schemas that ONTAP provides. To verify, you might have to contact the team who is managing the LDAP environment. You might also be able to query the schema through `ldapsearch` commands (by dumping the output of a user and group to see the attributes) or through PowerShell (if you are using Microsoft Active Directory). Consult your LDAP administrator for information.

Example of `ldapsearch` to dump a user’s information:

Examples of Common LDAP Searches

Example of PowerShell commands to dump a user’s or a group’s information:

```
C:\> Get-ADUser -Identity [username] -Properties *
C:\> Get-ADGroup -Identity [groupname] -Properties *
```

Attributes versus object classes

In the LDAP schema output, you see two different types of values that you can specify: attributes and object classes.

Object classes are how the LDAP queries look for specific objects. For example, if you are looking for a user object, then the object class that was defined tells the query to look for all objects in that class.

Attributes are the values in the actual objects that make each object unique.

For example, multiple users are in the same object class, but each user has a unique name and numeric UID.

The output from the LDAP queries helps you select the proper LDAP schema to use. Object classes vary depending on the LDAP server in use. See Table 3.

Table 3) LDAP schema object classes.

Value	LDAP schema object class (LDAP schema type)
`User/posixAccount` object class	`User` (Active Directory)* `posixAccount` (RFC 2307)*

Value	LDAP schema object class (LDAP schema type)
`Group/posixGroup` object class	`Group` (Active Directory)* `posixGroup` (RFC 2307)*
NIS netgroup object class	`nisNetgroup` (all default schemas)*
`groupOfUniqueNames` object class	`groupOfUniqueNames` (RFC 2307)* `Group` (Active Directory)*
`windowsToUnix` name mapping object class	`posixAccount` (RFC 2307)* User (Active Directory)*
NIS object class	`nisObject` (all default schemas)*

* Preferred or default value.

The attribute values that you are most concerned with are listed in Table 4.

Table 4) LDAP schema attributes.

Value	LDAP schema attribute (LDAP schema type)
User name	`UID` (all default schemas)* `Name` (Active Directory) `GivenName` (Active Directory) `sAMAccountName` (Active Directory)
Group name	`CN` (all default schemas)* `Name` (Active Directory) `sAMAccountName` (Active Directory)
Numeric UID	`uidNumber` (all default schemas)*
Numeric GID	`uidNumber` (all default schemas)*
Home directory	`homeDirectory` (RFC 2307)* `unixHomeDirectory` (Active Directory)*
Group membership	`memberUid` (RFC 2307)* `memberUid` (Active Directory 2008 and earlier) `Member` (Active Directory 2008 R2 and later)* `UniqueMember` (RFC 2307bis)*
Windows-to-UNIX name mapping (for asymmetric name mapping)	`sAMAccountName` (Active Directory)* `windowsAccount` (RFC 2307)*
NIS Map Name	`nisMapName` (all default schemas)*
NIS Map Entry	`nisMapEntry` (all default schemas)*
NIS netgroup triple	`nisNetgroupTriple` (all default schemas)*
NIS netgroup member	`memberNisNetgroup` (all default schemas)*

*Preferred or default value.

LDAP environment configuration

Now that you have gathered the necessary information, you can start to create your LDAP configuration. Because some steps depend on other steps, you must follow a specific order. Generally, you follow this order:

1. Select, create, or configure an LDAP client schema.

2. Create the LDAP client configuration for the SVM.
3. Enable LDAP for use with the SVM.
4. Modify `ns-switch` to use LDAP.
5. Test LDAP lookups.

LDAP schemas

First, you need an LDAP schema, because LDAP client configuration requires a schema during the creation step. To ensure that you have collected the proper information before you select a schema, review section, “LDAP schema configuration,” in this report.

Select an LDAP schema

After you have figured out what the appropriate LDAP schema might be, you can compare and contrast LDAP schema templates in ONTAP with what you have in your LDAP server environment.

Note: You can find LDAP schema template examples in the appendix of this report, under “LDAP schema templates.”

If the available schema templates have what you need, then you can move on to the LDAP client configuration step. If you need a more customized LDAP schema, select the LDAP schema template that is closest to what you need and continue to the next section, “Create custom LDAP schemas.”

Create custom LDAP schemas

The default templates are read-only, so if you need to use LDAP schemas that do not exist in the available default templates, you must create a new schema. To create a new schema, you can copy a schema from a template to a new LDAP client schema.

To copy an LDAP schema template to a new LDAP schema for modification and customization, use the following command:

```
cluster::*> ldap client schema copy ?
  [ -vserver <vserver name> ]              *Vserver
   [-schema] <text (size 1..32)>           *Schema Template
   [-new-schema-name] <text (size 1..32)>  *New Schema Template Name
```

After you have a new schema to work with, you can use the LDAP client schema modify commands to make changes.

```
cluster::*> ldap client schema modify ?
  [ -vserver <vserver name> ]                         Vserver (default: cluster)
   [-schema] <text (size 1..32)>                      Schema Template
  [[-comment] <text>]                                 Comment
  [ -posix-account-object-class <text> ]              RFC 2307 posixAccount Object Class
  [ -posix-group-object-class <text> ]                RFC 2307 posixGroup Object Class
  [ -nis-netgroup-object-class <text> ]               RFC 2307 nisNetgroup Object Class
  [ -uid-attribute <text> ]                           RFC 2307 uid Attribute
  [ -uid-number-attribute <text> ]                    RFC 2307 uidNumber Attribute
  [ -gid-number-attribute <text> ]                    RFC 2307 gidNumber Attribute
  [ -cn-group-attribute <text> ]                      RFC 2307 cn (for Groups) Attribute
  [ -cn-netgroup-attribute <text> ]                   RFC 2307 cn (for Netgroups) Attribute
  [ -user-password-attribute <text> ]                 RFC 2307 userPassword Attribute
  [ -gecos-attribute <text> ]                         RFC 2307 gecos Attribute
  [ -home-directory-attribute <text> ]                RFC 2307 homeDirectory Attribute
  [ -login-shell-attribute <text> ]                   RFC 2307 loginShell Attribute
  [ -member-uid-attribute <text> ]                    RFC 2307 memberUid Attribute
  [ -member-nis-netgroup-attribute <text> ]           RFC 2307 memberNisNetgroup Attribute
  [ -nis-netgroup-triple-attribute <text> ]           RFC 2307 nisNetgroupTriple Attribute
  [ -enable-rfc2307bis {true|false} ]                 Enable Support for Draft RFC 2307bis
  [ -group-of-unique-names-object-class <text> ]      RFC 2307bis groupOfUniqueNames Object Class
  [ -unique-member-attribute <text> ]                 RFC 2307bis uniqueMember Attribute
  [ -windows-to-unix-object-class <text> ]     Data ONTAP Name Mapping windowsToUnix Object Class
  [ -windows-account-attribute <text> ]        Data ONTAP Name Mapping windowsAccount Attribute
  [ -windows-to-unix-attribute <text> ]        Data ONTAP Name Mapping windowsToUnix Attribute
  [ -windows-to-unix-no-domain-prefix {true|false} ]
                                               No Domain Prefix for windowsToUnix Name Mapping
  [ -maximum-groups-rfc2307bis {1..1024} ]     *Maximum groups supported when RFC 2307bis enabled
  [ -nis-object-class <text> ]                        RFC 2307 nisObject Object Class
  [ -nis-mapname-attribute <text> ]                   RFC 2307 nisMapName Attribute
  [ -nis-mapentry-attribute <text> ]                  RFC 2307 nisMapEntry Attribute
```

Note: In most cases, you do not need a custom schema. You can use the default schemas to begin with.

LDAP client configuration

Now that you have a valid LDAP schema to work with, you can create the LDAP client configuration. This configuration defines the necessary parameters for connecting and querying your LDAP servers. To construct the client configuration for the ONTAP SVM, use the data that you gathered according to the “LDAP server information” section of this report.

Table 5 lists the LDAP client configuration options for modification from the diag privilege.

Table 5) LDAP client configuration options (diag privilege).

Configuration option	What it means
`-vserver`	Specify the SVM (vserver) that owns the LDAP configuration.
`-client-config`	This option is the name of the client configuration.
`-ldap-servers`	This option is the list of LDAP servers or host names. If you use Microsoft Active Directory LDAP, use `-ad-domain` instead.
`-servers (deprecated)`	Use `–ldap-servers` instead.
`-ad-domain`	This option defines the Active Directory domain to be used for LDAP server lookups and name resolution. This option causes ONTAP to use DNS SRV record lookups for Active Directory LDAP servers. If you use Linux/UNIX LDAP servers, use `–ldap-servers`. If you want to specify LDAP servers to use in Active Directory, use `–preferred-ad-servers` in addition to `–ad-domain`.
`-bind-as-cifs-server`	Use this option only if a CIFS/SMB server is present in the SVM. Binding as a CIFS server means that the LDAP searches use the credentials of the CIFS/SMB machine account to log in to Active Directory for LDAP queries.
`-schema`	This option defines the LDAP schema that you want to use.
`-port`	This option allows the LDAP port to be changed. The default for LDAP is 389; for LDAPS, the port is 636. If you want global catalog searches in Active Directory LDAP, use port 3268.
`-query-timeout`	This option defines how long a query runs before it times out. The default is 3 seconds.
`-min-bind-level`	This option defines the minimum bind security that is allowed for LDAP binds.
`-bind-dn`	This option defines the user that is used for LDAP binds/logins. The format can be: • `Username` • `Username@domain.com` (Active Directory) • `DOMAIN\username` (Active Directory) • `DN=username,DN=domain,DN=com`

Configuration option	What it means
`-base-dn`	This option defines the base search DN for LDAP queries. If you use `-ad-domain`, it is automatically set to the Active Directory domain DN. For example, `domain.com` becomes the base `DN DC=domain,DC=com`.
`-base-scope`	This option defines the base search scope. It defaults to `subtree`.
`-user-dn`	This option defines the search DN for the `User` object class. Use this option if filtering is needed to speed up queries. If you leave this option blank, ONTAP uses the base search DN.
`-user-scope`	This option defines the search scope for the `User` object class. The default is `subtree`.
`-group-dn`	This option defines the search DN for the `Group` object class. Use this option if filtering is needed to speed up queries. If you leave this option blank, ONTAP uses the base search DN.
`-group-scope`	This option defines the search scope for the `Group` object class. The default is `subtree`.
`-netgroup-dn`	This option defines the search DN for the `Netgroup` object class. Use this option if filtering is needed to speed up queries. If you leave this option blank, ONTAP uses the base search DN.
`-netgroup-scope`	This option defines the search scope for the `Netgroup` object class. The default is `subtree`.
`-use-start-tls`	This option defines whether `start-tls` is used to secure LDAP. StartTLS uses port 389 and is **not** LDAP over SSL (LDAPS). For LDAPS, change the LDAP port to 636.
`-is-netgroup-byhost-enabled`	This option defines whether netgroups are queried by netgroup name (set to `false`) or by host name (set to `true`). For further guidance, see the “Use of LDAP to host netgroups” section in this document.
`-netgroup-byhost-dn`	This option defines the search DN for the `Netgroup-by-host` object class. Use this option if filtering is needed to speed up queries. If you leave this option blank, ONTAP uses the base search DN.
`-netgroup-byhost-scope`	This option defines the search scope for the `Netgroup-by-host` object class. The default is `subtree`.
`-session-security`	This option defines the level of session security. `Sign`, `seal`, `sign and seal`, and `none` are valid options.
`-skip-config-validation`	Config validation attempts to connect and test LDAP servers before configurations are applied. This option allows you to skip those steps. The default is set to `true`.
`-referral-enabled`	This option defines whether ONTAP uses the chase referrals functionality with LDAP servers, which allow LDAP queries to connect to other LDAP servers if a requested object does not exist in the first LDAP server specified.
`-group-membership-filter`	This parameter specifies the custom LDAP search filter to be used when looking up group membership from an LDAP server. Examples of valid filters are `(cn=*99)`, `(cn=1*)`, `(|(cn=*22)(cn=*33))`.

You can find an example in the appendix section, “Sample LDAP Client Configuration,” later in this document.

LDAP client configuration—SVM scopes

When you create an LDAP client configuration in LDAP, you have one of two choices:

- **Explicitly set the `-vserver` option**. This option makes the client configuration available only to the specified SVM, which can provide secure multitenancy functionality in environments that are shared by many different customer bases.
- **Leave the `-vserver` option blank**. This option creates the client configuration and makes it available to **all** SVMs in the cluster. This option is useful when you need to share LDAP client configurations across multiple SVMs in your environment.

Enable LDAP

Now that you have an LDAP client configuration, you must run the `ldap create` command on the SVM to enable LDAP.

```
cluster::> ldap create ?
   [-vserver] <vserver name>          Vserver
   [-client-config] <text>            LDAP Client Configuration
  [[-skip-config-validation] [true|false]]  Skip Configuration Validation
```

This setting simply allows the SVM to use LDAP; it does not participate in authentication requests until the SVM's `ns-switch` settings are modified.

Skip LDAP configuration validation

To allow a check to occur on the configuration, NetApp recommends that you set `-skip-config-validation` to `false`. This is the default value, so if you do not specify the option, a configuration check will be performed. This uses the same checks you would see when you run the `ldap check` command.

Sometimes, LDAP configuration might fail due to the LDAP server's configuration. For example, the configuration validation performs an unindexed baseObject global query. Some LDAP servers (such as openDJ) require that step in order to be disabled, so if you use ONTAP to connect to a server that blocks that query, the check will fail. LDAP should still work with these servers, but you need to work around the issue by setting `-skip-config-validation` to `true`. For more information, see bug 1328101.

Modify the SVM name service switch (ns-switch)

ONTAP does not start using LDAP for name lookups until LDAP is specified in the SVM `ns-switch` configuration, and it uses LDAP only for the databases that are specified by the `ns-switch` commands. You can specify LDAP as a valid name service for:

- `Passwd`
- `Group`
- `Namemap`
- `Netgroup`

The following covers which name service databases are available for use. If you do not plan to use LDAP for certain services, do not enable it. For example, name mapping can incur delays if LDAP is specified as a valid name service source for name mapping rule but is not configured to do name mappings. For more information, review the section, "Use of LDAP for name mapping."

```
cluster::> ns-switch modify ?
  (vserver services name-service ns-switch modify)
    -vserver <vserver name>                    Vserver
   [-database] {hosts|group|passwd|netgroup|namemap}  Name Service Switch Database
   [-sources] {files|dns|ldap|nis}, ...               Name Service Source Order
```

Test LDAP functionality

Now that the configuration is complete and the ONTAP SVM is set up to use LDAP for name service and identity requests, you must test functionality. To do this testing, operate out of diag privilege. To enter diag privilege, use:

```
cluster::> set diag
```

This setting makes all diagnostic and troubleshooting commands available.

LDAP connectivity

These commands help you troubleshoot whether LDAP servers can be reached and whether you can connect to them. However, in ONTAP 9.5 and later, if there is a connectivity or configuration issue, LDAP and DNS configuration commands fail because ONTAP automatically runs checks before it applies configuration changes. For example, if you change something on the LDAP client, ONTAP checks network connectivity, LDAP bind, and searching for the configured DNs in the client configuration. If any of those checks fail, the command to change the configuration fails. You can bypass this check with the -`skip-config-validation` true option.

DNS lookups

To look up LDAP servers by host name or IP addresses by using DNS calls, use the following commands:

```
getxxbyyy gethostbyname -node [node1] -vserver [SVM] -hostname [ldap.ntap.local]
getxxbyyy gethostbyaddr -node [node1] -vserver [SVM] -ipaddress [10.10.10.10]
```

You can also use the following for forward lookups:

```
diag secd dns forward-lookup -node [node1] -vserver [SVM] -hostname [hostname]
```

To look up SRV records, use:

```
diag secd dns srv-lookup -node [node1] -vserver [SVM] -lookup-string [_ldap._tcp.ntap.local]
```

Network pings

Pinging the LDAP servers can be a way to see whether the SVM LIFs can reach LDAP. However, remember that some networks block Internet Control Message Protocol (ICMP) traffic, so pings might not work properly. When pinging, be sure to define the SVM name and data LIF name so that the ping uses the LIFs that are participating in the LDAP traffic.

```
cluster::*> ping ?
   {  -node <nodename>                   Node
   |  -lif <lif-name>  }                 Logical Interface
    -vserver <vserver>                   Vserver
  [ -use-source-port {true|false} ]      *(DEPRECATED)-Use Source Port of Logical Interface
   [-destination] <Remote InetAddress>   Destination
  [ -show-detail|-s [true] ]             Show Detail Output
  [ -record-route|-R [true] ]            Record Route
  [ -verbose|-v [true] ]                 Show All ICMP Packets
  [ -packet-size <integer> ]             Packet Size
  [ -count <integer> ]                   Count
  [ -wait <integer> ]                    Packet Send Wait Time (secs)
  [ -flood [true] ]                      *Flood Ping
  [ -disallow-fragmentation|-D [true] ]  Disallow Packet Fragmentation (default: false)
  [ -wait-response <integer> ]           Packet Response Wait Time (ms) (default: 10000)
```

LDAP connection test

To test LDAP (and other name service server) connections, use `diag secd connections test`.

```
cluster::*> diag secd connections test -node [node1]-vserver [SVM]
```

To view the connections, use:

```
cluster::*> diag secd connections show ?
   [-node] <nodename>         *Node
   [-vserver] <vserver>       *Vserver
  [[-type] <text>]            *Cache type (lsa,netlogon,ldap-ad,ldap-nis-namemap)
  [ -key <text> ]             *Connection key
```

To clear the connections cache, use:

```
cluster::*> diag secd connections clear ?
   [-node] <nodename>         *Node
   [-vserver] <vserver>       *Vserver
  [[-type] <text>]            *Cache type (lsa,netlogon,ldap-ad,ldap-nis-namemap)
  [ -key <text> ]             *Connection key
```

Alternatively, you can use the `ldap check` command.

```
cluster::*> ldap check -vserver DEMO

                  Vserver: DEMO
Client Configuration Name: DEMO
              LDAP Status: up
      LDAP Status Details: Successfully connected to LDAP server "10.x.x.x".
   LDAP DN Status Details: All the configured DNs are available.
```

LDAP name lookup and group membership

Because of changes in how name services operate, LDAP name lookups occur at the SVM level in ONTAP 9.3 and later. Therefore, you should perform LDAP tests by using getxxbyyy commands; see the section, "GetXXbyYY."

Following is an example of group membership for a user:

```
cluster::*> getxxbyyy getgrlist -node node1 -vserver DEMO -username prof1 -show-granular-err true
-use-cache false -show-source true
  (vserver services name-service getxxbyyy getgrlist)
Source used for lookup: LDAP
pw_name: prof1
Groups: 1101 1201 1202 1203 1220
NIS:
Error code:    NS_ERROR_NONE
Error message: No error
LDAP:
Error code:    NS_FOUND
Error message: Entry found
DNS:
Error code:    NS_ERROR_NONE
Error message: No error
FILES:
Error code:    NS_ERROR_NOT_FOUND
Error message: Entry not found
Deterministic Result: Success
```

You can also carry out name lookups and translations through `secd`.

```
cluster::*> diag secd authentication show-ontap-admin-unix-creds ?
  [ -node <nodename> ]         *Node (default: ontap9-tme-8040-01)
   [-vserver] <vserver>        *Vserver
   { [-unix-user-name] <text>  *Unix User Name
   | [-uid] <integer> }        *Unix User ID

cluster::*> diag secd authentication translate ?
  [ -node <nodename> ]          *Node Name (default: ontap9-tme-8040-01)
   [-vserver] <vserver>         *Vserver Name
   { [-uid] <integer>           *UNIX User ID
   | [-gid] <integer>           *UNIX Group ID
   | [-sid] <text>              *Windows SID
   | [-unix-user-name] <text>   *UNIX User Name
   | [-unix-group-name] <text>  *UNIX Group Name
   | [-win-name] <text> }       *Windows Name
```

In ONTAP 9.6 and later, you can use the advanced privilege `vserver services access-check` commands found in the “ONTAP CLI commands for LDAP troubleshooting” section.

```
cluster::*> vserver services access-check ?
  authentication>             *Check Authentication Information
  dns>                        *Check DNS Lookups
  name-mapping>               *Check Name Mapping Operations
  server-discovery>           *Check Server Discovery Information

cluster::*> vserver services access-check authentication show-ontap-admin-unix-creds -vserver
DEMO -unix-user-name prof1
       User Id: 1100
      Group Id: 1101
Home Directory: /home/prof1
   Login Shell: /bin/sh
```

Name mapping in multiprotocol NAS environments

When you use NFS and CIFS/SMB on the same sets of data, accessing those files and folders require name mapping between UNIX and Windows users (and conversely). The name mapping methodology depends on the security styles of the volumes and qtrees that are used in the environment. For example, if a volume uses NTFS security and a user accesses the volume through NFS, then the user must map to a Windows user to ascertain the appropriate permission levels because NFS does not understand NTFS ACLs.

To see what UNIX user maps to a specific Windows user, run the following command:

```
cluster::*> diag secd name-mapping show -node [node] -vserver [SVM] -direction win-unix -name
[username or DOMAIN\username]
```

In ONTAP 9.6 and later, use `access-check.`

```
cluster::*> access-check name-mapping show -vserver [SVM] -direction win-unix -name [username]
```

For UNIX-to-Windows name mapping, run the following commands:

```
cluster::*> diag secd name-mapping show -node [node] -vserver [SVM] -direction unix-win -name
[username]

cluster::*> access-check name-mapping show -vserver [SVM] -direction unix-win -name [username]
```

For Kerberos service principal name (SPN)-to-UNIX users (for Kerberized NFS), run the following commands:

```
cluster::*> diag secd name-mapping show -node [node] -vserver [SVM] -direction krb-unix -name
[SPN]

cluster::*> access-check name-mapping show -vserver [SVM] -direction krb-unix -name [SPN]
```

Name mapping values gather information from one the following places:

- 1:1 default name mappings in ONTAP (`user` always maps to `user`, if both names can be found in name services)
- Name mapping rules (either locally or in LDAP)
- Default Windows or UNIX users (set at the CIFS and NFS server options `–default-unix-user` and `–default-win-user`, respectively)

Name mapping is only part of the equation, however. When you use a multiprotocol environment, you must ensure that all the appropriate group memberships are being populated in these requests. To query all the information about a user, run the following command:

```
cluster::*> diag secd authentication show-creds ?
  [ -node <nodename> ]                 *Node (default: ontap9-tme-8040-01)
   [-vserver] <vserver>                *Vserver
   { [-uid] <integer>                  *UID
   | [-sid] <text>                     *SID
   | [-unix-user-name] <text>          *Unix User Name
   | [-win-name] <text> }              *Windows Name
  [[-list-name] {true|false}]          *Display Translated Names (default: true)
  [ -list-id {true|false} ]            *Display IDs (default: false)
  [ -clientIp <IP Address> ]           *Client IP Address
  [ -skip-domain-group {true|false} ]  *Skip Domain Groups (default: false)
```

In ONTAP 9.6 and later, run the following commands:

```
cluster::*> access-check authentication show-creds ?
  (vserver services access-check authentication show-creds)
  [ -node <nodename> ]                 *Node (default: ontap9-tme-8040-01)
   [-vserver] <vserver>                *Vserver
   { [-uid] <integer>                  *UID
   | [-sid] <text>                     *SID
   | [-unix-user-name] <text>          *Unix User Name
   | [-win-name] <text> }              *Windows Name
  [[-list-name] {true|false}]          *Display Translated Names (default: true)
  [ -list-id {true|false} ]            *Display IDs (default: false)
  [ -clientIp <IP Address> ]           *Client IP Address
  [ -skip-domain-group {true|false} ]  *Skip Domain Groups (default: false)
```

The preceding command fetches all the user information in multiprotocol environments: name mapping, UNIX group memberships, Windows group memberships, numeric IDs, and so on. This command works only when both NFS and CIFS/SMB are configured and in use. For sample output of this command, see the Appendix A: Command examples and other information.

LDAP that uses Active Directory for UNIX identity management

The use of Microsoft Active Directory for UNIX identity management offers several benefits, including:

- Native Kerberos (Key Distribution Center [KDC]) integration
- Native LDAP replication and redundancy
- Forest-level replication through global catalog searches
- Support for trusted domains with LDAP operations

The following sections cover some of these concepts in deeper detail.

Domain controller redundancy and replication

Active Directory, by default, replicates its databases to domain controllers every 15 minutes. All objects in the domain are copied across multiple locations, including user and computer objects and their attributes. Therefore, by having more than one domain controller in a domain, it is possible to eliminate single points of failure in LDAP and Kerberos.

If an LDAP server fails, ONTAP moves on to additional LDAP servers when the primary LDAP server fails connectivity tests. The next server in line depends on how the LDAP client is configured:

- If a server list is specified, the next server in the list is used.
- If a load-balanced host name is used, the next server in the load balancer is used.
- If the Active Directory domain is used, then the next server that is provided in DNS service record (SRV) lookups is used.

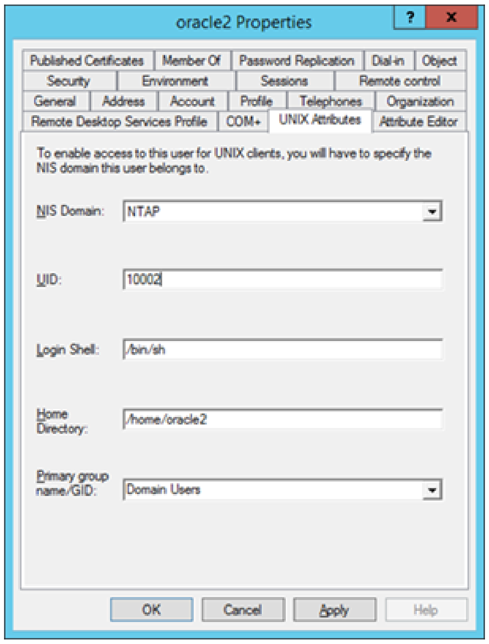
Use of the domain controller as an identity management server for UNIX

Microsoft Active Directory does not act as an LDAP UNIX identity management server natively. In newer Windows versions (Windows 2012 and later), the UNIX attributes exist in the schema but are not populated. Therefore, you no longer have to “extend the schema” as you had to do in Windows 2008 and earlier versions.

To leverage UNIX users, groups, and netgroups, you must populate UNIX attributes with UNIX information. Windows 2012 and earlier versions offered a UNIX Attributes tab as seen in Figure 6 that could populate these entries through GUI interaction.

UNIX Attributes

Figure 6) UNIX Attributes tab in Windows 2012.



To enable access to this user for UNIX clients, you will have to specify the NIS domain this user belongs to.

NIS Domain: NTAP

UID: 10002

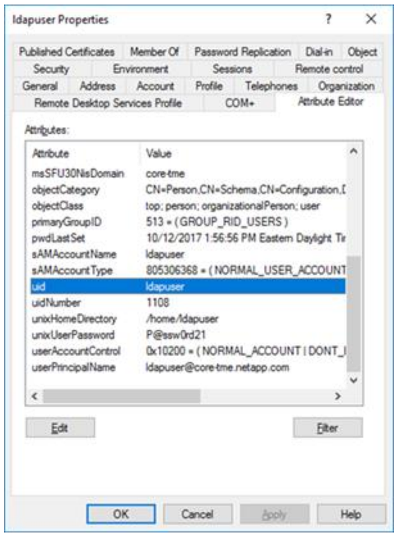
Login Shell: /bin/sh

Home Directory: /home/oracle2

Primary group name/GID: Domain Users

Windows 2016 and later versions have deprecated support for the UNIX Attributes tab. To manage UNIX attributes in Windows 2016 and later, you can use PowerShell or the Attribute Editor tab (see **Error! Not a valid bookmark self-reference.** and the section, “Modification of UNIX attributes in Active Directory”). The Attribute Editor tab is also available in Windows 2012.

Figure 7) Attribute Editor tab in Windows 2016.



Attribute	Value
msSFU30NisDomain	core-tme
objectCategory	CN=Person,CN=Schema,CN=Configuration,[
objectClass	top; person; organizationalPerson; user
primaryGroupID	513 = (GROUP_RID_USERS)
pwdLastSet	10/12/2017 1:56:56 PM Eastern Daylight Ti
sAMAccountName	ldapuser
sAMAccountType	805306368 = (NORMAL_USER_ACCOUNT
uid	ldapuser
uidNumber	1108
unixHomeDirectory	/home/ldapuser
unixUserPassword	P@ssw0rd21
userAccountControl	0x10200 = (NORMAL_ACCOUNT | DONT_I
userPrincipalName	ldapuser@core-tme.netapp.com

UNIX Attributes that are used by ONTAP for LDAP queries

When ONTAP looks up a user, it uses standard LDAP search functionality.

Note: For more information, see this ldapsearch page.

The queries are constructed based on the user or group that comes into the NAS share. ONTAP collects this information and then creates the `ldapsearch` query.

For example, if an NFS user ID of `1234` tries to access an export with NFSv4.x or NTFS ACLs, ONTAP must translate that user ID to a UNIX name that can be resolved in the ACL. LDAP is used if it is specified in the `ns-switch` database.

ONTAP uses the attributes that are assigned in the configured LDAP schema (see “LDAP schemas”) on the SVM’s LDAP client for the search. In the MS-AD-BIS schema, `uid-number-attribute` uses the value `uidNumber`, and the `posix-account-object-class` value is `User`.

```
cluster::*> ldap client schema show -schema MS-AD-BIS -fields posix-account-object-class,uid-
number-attribute
vserver       schema    posix-account-object-class uid-number-attribute
------------- --------- -------------------------- --------------------
DEMO          MS-AD-BIS User                       uidNumber
```

So, for numeric ID `1234`, the LDAP search syntax is:

```
(&(objectClass=User)(uidNumber=1234))
```

This query can be simulated from ONTAP by using the `GetXXbyYY` commands that are listed in the “Troubleshooting tools” section of this document.

Table 6) and Table 7, and Table 8 list the standard or most common attributes that are used with Windows Active Directory UNIX identity management for users and groups, as based on the MS-AD-BIS schema. The MS-AD-BIS schema is the preferred LDAP schema for most standard Windows 2012 and later LDAP deployments. For information about custom schemas, see the “LDAP schemas” section.

UNIX user attributes used by ONTAP for LDAP queries

Table 6) Standard UNIX user attributes (MS-AD-BIS schema).

LDAP client schema attribute (ONTAP LDAP client)	LDAP attribute value (LDAP server)
`-posix-account-object-class`	`User`
`-uid-attribute`	`uid`
`-uid-number-attribute`	`uidNumber`
`-gid-number-attribute`	`gidNumber`
`-gecos-attribute name`	`unixHomeDirectory`
`-home-directory-attribute`	`name`
`-user-password-attribute`	`unixUserPassword`
`-login-shell-attribute`	`LoginShell`
`-windows-to-unix-attribute`	`sAMAccountName`

Group attributes

Table 7) Standard UNIX group attributes (MS-AD-BIS schema).

LDAP client schema attribute (ONTAP LDAP client)	LDAP attribute value (LDAP server)
`-posix-group-object-class`	`Group`
`-cn-group-attribute`	`cn`
`-gid-number-attribute`	`gidNumber`
`-member-uid-attribute`	`memberUid`
`-group-of-unique-names-object-class`	`Group`
`-unique-member-attribute`	`Member`

Note: For information about `memberUid` versus `Member` attributes/secondary groups, see the section, "Secondary, supplemental, and auxiliary GIDs."

NetApp attributes

Table 8) Standard UNIX netgroup attributes (MS-AD-BIS schema).

LDAP client schema attribute (ONTAP LDAP client)	LDAP attribute value (LDAP server)
`-nis-netgroup-object-class`	`nisNetgroup`
`-cn-netgroup-attribute`	`Name`
`-member-nis-netgroup-attribute`	`memberNisNetgroup`
`-nis-netgroup-triple-attribute`	`nisNetgroupTriple`
`-nis-object-class`	`nisObject*`
`-nis-mapname-attribute`	`nisMapName*`

LDAP client schema attribute (ONTAP LDAP client)	LDAP attribute value (LDAP server)
`-nis-mapentry-attribute`	`nisMapEntry*`

Note: Entries with * are used for `netgroup.byhost`.

Modification of UNIX attributes in Active Directory

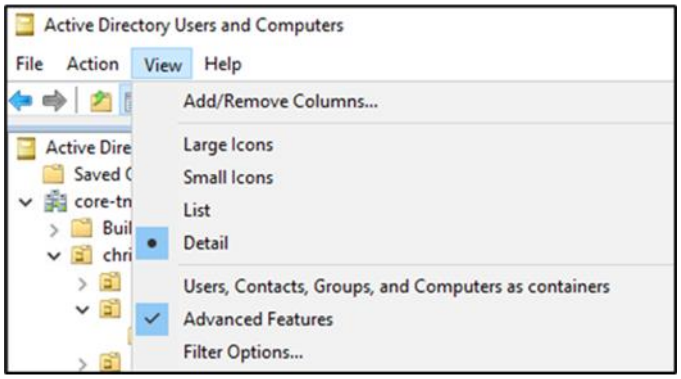
When you create a Windows user name or group, you can also associate UNIX attributes to that object in Active Directory. In modern Windows operating systems, you have two options to create and modify UNIX objects: with the GUI or with PowerShell.

Create and modify UNIX objects with the GUI

The most common way that administrators have managed Active Directory is through the Active Directory Users and Computers (ADUC) Microsoft Management Console (MMC).

With the MMC, you can create users and groups and then modify them afterward to populate UNIX attributes for use with LDAP clients. When you create a user or group through ADUC, there is no way to populate UNIX attributes. Therefore, you must double-click the object afterward and use the Attribute Editor tab in Windows 2012 and later versions. The Attributes Editor tab is not visible by default; you must enable the Advanced Features view in the MMC. See Figure 8.

Figure 8) Enable Advanced Features in MMC to see the Attributes Editor tab.



When you have enabled the advanced features and have opened the user properties, you can then modify the UNIX attributes in Attributes Editor. For details on what attributes need to be edited, see the list of user and group attributes in Table 6) and Table 7) , respectively.

For information about creating and editing netgroups in Active Directory LDAP, see the section, “ONTAP interaction with Active Directory LDAP for netgroups.”

Create and modify UNIX objects with PowerShell

PowerShell also has native user and group cmdlets (`New-ADUser`, `New-ADGroup`) that enable you to create and manage users and groups through the CLI or automation. With PowerShell, you can use the –`OtherAttributes` option to set the UNIX attributes when the object is created.

For example, if you want to create a user named `user1` with a `uidNumber` of `5555` and a `gidNumber` of `1101`, you use the following PowerShell command:

```
PS C:\> New-ADUser -SamAccountName user1 -UserPrincipalName user1@NTAP.LOCAL -Name user1 -
OtherAttributes @{'uid'="user1";'uidNumber'="5555";'gidNumber'="1101"} -Enabled 1 -
PasswordNeverExpires 1 -AccountPassword (Read-Host -AsSecureString "password" -Force)
Password -Force: **********
```

From ONTAP, you can now query this user.

```
cluster::*> getxxbyyy getpwbyname -node ontap9-tme-8040-02 -vserver DEMO -username user1 -show-
source true -use-cache false
  (vserver services name-service getxxbyyy getpwbyname)
Source used for lookup: LDAP
pw_name: user1
pw_passwd:
pw_uid: 5555
pw_gid: 1101
pw_gecos:
pw_dir:
pw_shell:
```

You can modify existing users and groups through `Set-ADUser` and `Set-ADGroup`, respectively. With these commands, you can use the `–Add` or `–Replace` options to add or to replace UNIX entries. In the following example, you can add a second UID or user name to `user1`:

```
PS C:\> Set-ADUser -Identity user1 -Add @{'uid'="user1alt"}
```

Now your UNIX user can use `user1` or `user1alt` to query for UID `5555`.

```
cluster::*> getxxbyyy getpwbyname -node node2 -vserver DEMO -username user1 -show-source true
  (vserver services name-service getxxbyyy getpwbyname)
Source used for lookup: LDAP
pw_name: user1alt
pw_passwd:
pw_uid: 5555
pw_gid: 1101
pw_gecos:
pw_dir:
pw_shell:

cluster::*> getxxbyyy getpwbyname -node node2 -vserver DEMO -username user1alt -show-source true
  (vserver services name-service getxxbyyy getpwbyname)
Source used for lookup: LDAP
pw_name: user1alt
pw_passwd:
pw_uid: 5555
pw_gid: 1101
pw_gecos:
pw_dir:
pw_shell:
```

Secondary and auxiliary Groups

Often, UNIX users are members of multiple groups outside of their primary group. LDAP can query for these groups, but Active Directory LDAP has two different ways to search for group membership: through `memberUid` or through `Member`.

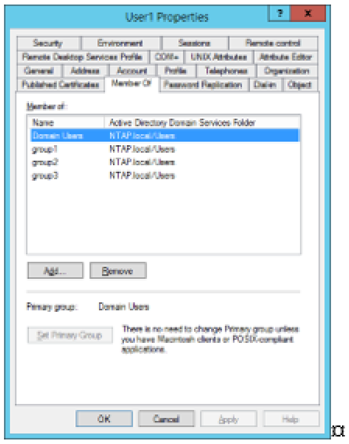
Note: When creating a group, the GID number should not be a negative value (such as -1). If a negative value is used, ONTAP queries for that numeric fail with “Value too large to be stored in data type.”

RFC 2307—Standard method (memberUid)

One way that Active Directory LDAP can show secondary groups for a user is by leveraging the `memberUid` attribute that exists on group objects in Active Directory. When a user is added to the `memberUid` list, then LDAP can return those groups during LDAP queries. The downside is that in Active Directory, that attribute does not automatically populate when a user is added to a Windows group. Manual intervention is required.

For example, if a Windows administrator adds `user1` to Windows groups named `group1`, `group2`, and `group3`, then only the `Member` attribute is populated in Active Directory. Note in Figure 9 that `group2` has no entries in the `memberUid` field, despite having entries in `Member`.

Figure 9) Addition of users to Windows groups.

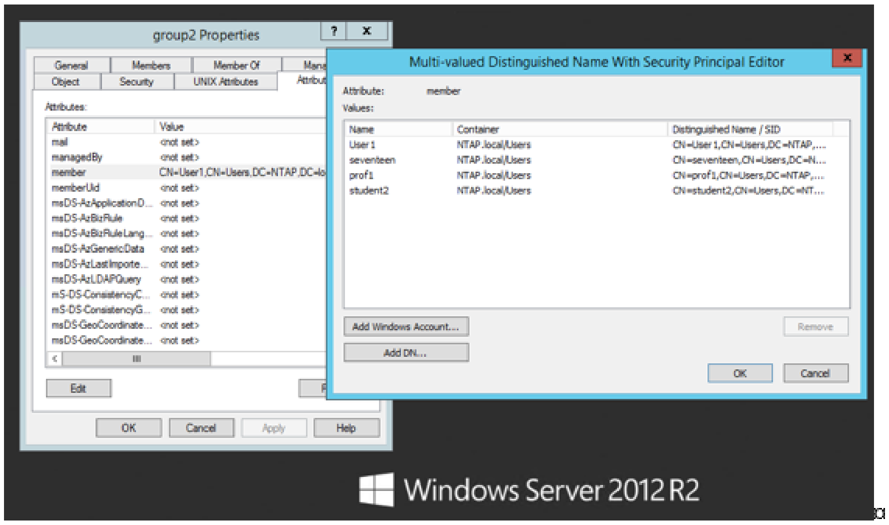

User1 Properties

Member of:

Name	Active Directory Domain Services Folder
Domain Users	NTAP.local/Users
group1	NTAP.local/Users
group2	NTAP.local/Users
group3	NTAP.local/Users

Primary group: Domain Users

There is no need to change Primary group unless you have Macintosh clients or POSIX-compliant applications.


group2 Properties

Attributes:

Attribute	Value
mail	<not set>
managedBy	<not set>
member	CN=User1,CN=Users,DC=NTAP,DC=lo
memberUid	<not set>
msDS-AzApplicationD...	<not set>
msDS-AzBizRule	<not set>
msDS-AzBizRuleLang...	<not set>
msDS-AzGenericData	<not set>
msDS-AzLastImporte...	<not set>
msDS-AzLDAPQuery	<not set>
mS-DS-ConsistencyC...	<not set>
mS-DS-ConsistencyG...	<not set>
msDS-GeoCoordinate...	<not set>
msDS-GeoCoordinate...	<not set>

Multi-valued Distinguished Name With Security Principal Editor

Attribute: member

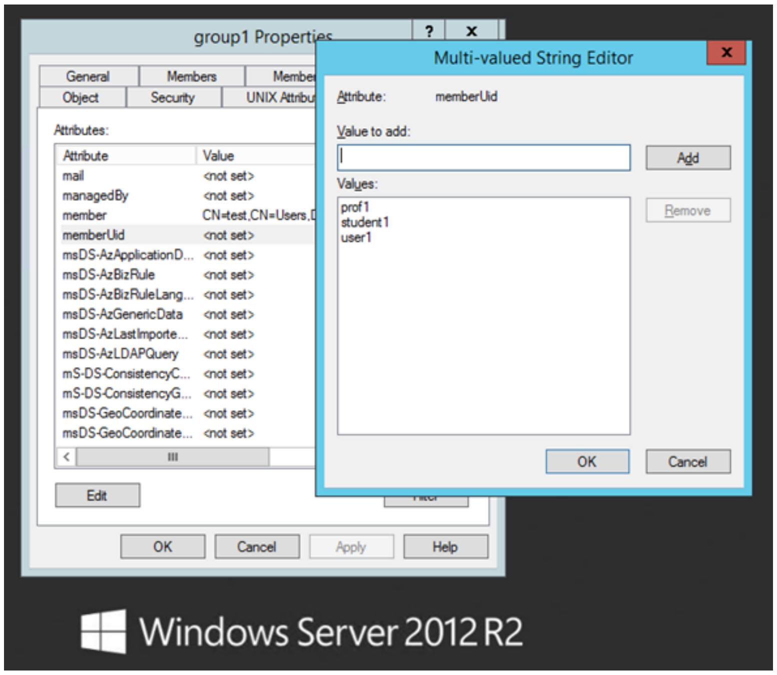
Values:

Name	Container	Distinguished Name / SID
User 1	NTAP.local/Users	CN=User 1,CN=Users,DC=NTAP,...
seventeen	NTAP.local/Users	CN=seventeen,CN=Users,DC=N...
prof1	NTAP.local/Users	CN=prof1,CN=Users,DC=NTAP,...
student2	NTAP.local/Users	CN=student2,CN=Users,DC=NT...

Unless the `memberUid` for each of those groups is modified to add `user1`, a check for UNIX group membership for that user does not show those groups properly. The `memberUid` attribute is a multivalued string, meaning that more than one user can be added to the list.

In the following example in Figure 10, users are added to `group1`.

Figure 10) memberUid attribute Example.


group1 Properties

Attributes:

Attribute	Value
mail	<not set>
managedBy	<not set>
member	CN=test,CN=Users,D
memberUid	<not set>
msDS-AzApplicationD...	<not set>
msDS-AzBizRule	<not set>
msDS-AzBizRuleLang...	<not set>
msDS-AzGenericData	<not set>
msDS-AzLastImporte...	<not set>
msDS-AzLDAPQuery	<not set>
mS-DS-ConsistencyC...	<not set>
mS-DS-ConsistencyG...	<not set>
msDS-GeoCoordinate...	<not set>
msDS-GeoCoordinate...	<not set>

Multi-valued String Editor

Attribute: memberUid

Value to add:

Values:

prof1
student1
user1

In ONTAP, you check which UNIX group memberships `user1` has. `Group1` (`gidNumber 1201`) has `memberUid` populated and is seen in the list, whereas `group2` (`gidNumber 1202`) has no `memberUid` populated and does not appear in the list. RFC 2307bis functionality is disabled.

```
cluster::*> ldap client schema modify -schema DEMO -enable-rfc2307bis false
```

```
cluster::*> getxxbyyy getgrlist -node ontap9-tme-8040-01 -vserver DEMO -username user1 -use-cache
false
  (vserver services name-service getxxbyyy getgrlist)
pw_name: user1
Groups: 1101 1201
```

RFC 2307bis (member)

RFC 2307bis is another way to query for group memberships with users, and it happens to be the perfect fit for Windows Active Directory environments. Recall that in the preceding section, when you add users to Windows groups, Active Directory populates the `Member` attribute (see Figure 9) but does not populate the `memberUid` attribute (Figure 10). As a result, secondary group membership for UNIX users does not populate properly.

When RFC 2307bis is enabled, ONTAP queries for the `-unique-member-attribute` that is configured in the LDAP client schema. By default, the MS-AD-BIS schema uses `Member` for that attribute.

On the same SVM with the same configuration that is exemplified in the previous section, you enable RFC 2307bis support and make no other changes to the user or group membership. Then you run the same group list command and see the proper group membership.

```
cluster::*> ldap client schema modify -schema DEMO -enable-rfc2307bis true

cluster::*> getxxbyyy getgrlist -node ontap9-tme-8040-01 -vserver DEMO -username user1 -use-cache
false
  (vserver services name-service getxxbyyy getgrlist)
pw_name: user1
Groups: 1101 1201 1202 1203
```

For more information, see the section, “RFC 2307bis.”

Use of trusted domains in a forest for UNIX identity management

With Active Directory, you can set up a trust between two domains in a forest and have child domains below those parent domains. The default behavior of these environments is to use LDAP referrals to query additional LDAP servers when the first LDAP server does not have the user or group. ONTAP 9.5 and later versions support referrals. For more information about referrals, see the section, “LDAP referrals (chase referrals).”

For troubleshooting commands for domain trusts, see the section, “Troubleshooting tools.”

Active Directory global catalog searches

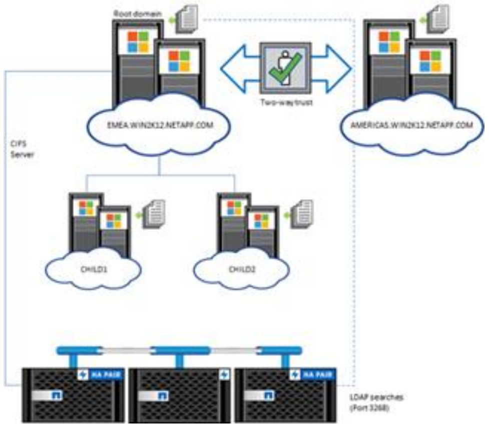
If you are using Windows Active Directory for UNIX identity management, you can leverage the global catalog to populate UNIX attributes, to replicate across the domain forest, and to query in ONTAP over port 3268. In this setup, you can have multiple trusted domains in the same forest, all with unique UNIX users and groups, that replicate up to the top level of the forest. This approach enables ONTAP to search at a forest level and bypasses the need for LDAP referrals.

Replicate new attributes to the global catalog

UNIX attributes are not replicated to the global catalog by default; therefore, they cannot be searched in the global catalog until you tell Active Directory to replicate them. Figure 11 shows an example of a trusted domain setup that you can use for LDAP lookups with global catalog searches.

UNIX attributes are not replicated to the global catalog by default; therefore, they cannot be searched in the global catalog until you tell Active Directory to replicate them. Figure 11 shows an example of a trusted domain setup that you can use for LDAP lookups with global catalog searches.

Figure 11) Trusted domain that uses global catalog searches.



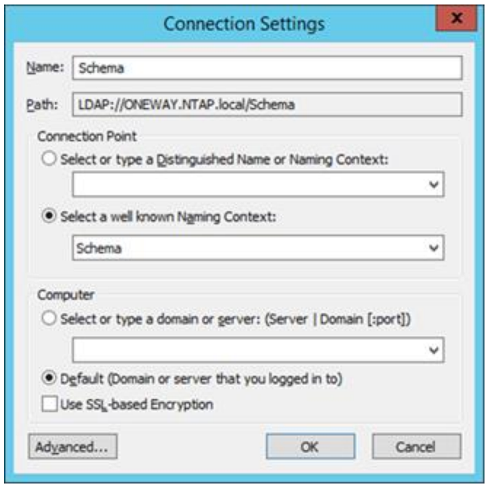
How to configure attributes to replicate to the global catalog

Active Directory uses a back-end schema to control how objects operate. This schema can be modified, but modification requires special steps.

It is best to contact Microsoft when you modify the schema, but you can use the following steps to modify the schema attributes. This example was performed on a Windows 2012 R2 Active Directory Domain Controller, so be sure to verify that these steps work with your version of Windows.

You can modify schema attributes by using ADSI Edit and by connecting to the Schema Naming Context (Figure 12).

Figure 12) Connecting to the Schema Naming Context.


Connection Settings

Name: Schema

Path: LDAP://ONEWAY.NTAP.local/Schema

Connection Point

○ Select or type a Distinguished Name or Naming Context:

◉ Select a well known Naming Context: Schema

Computer

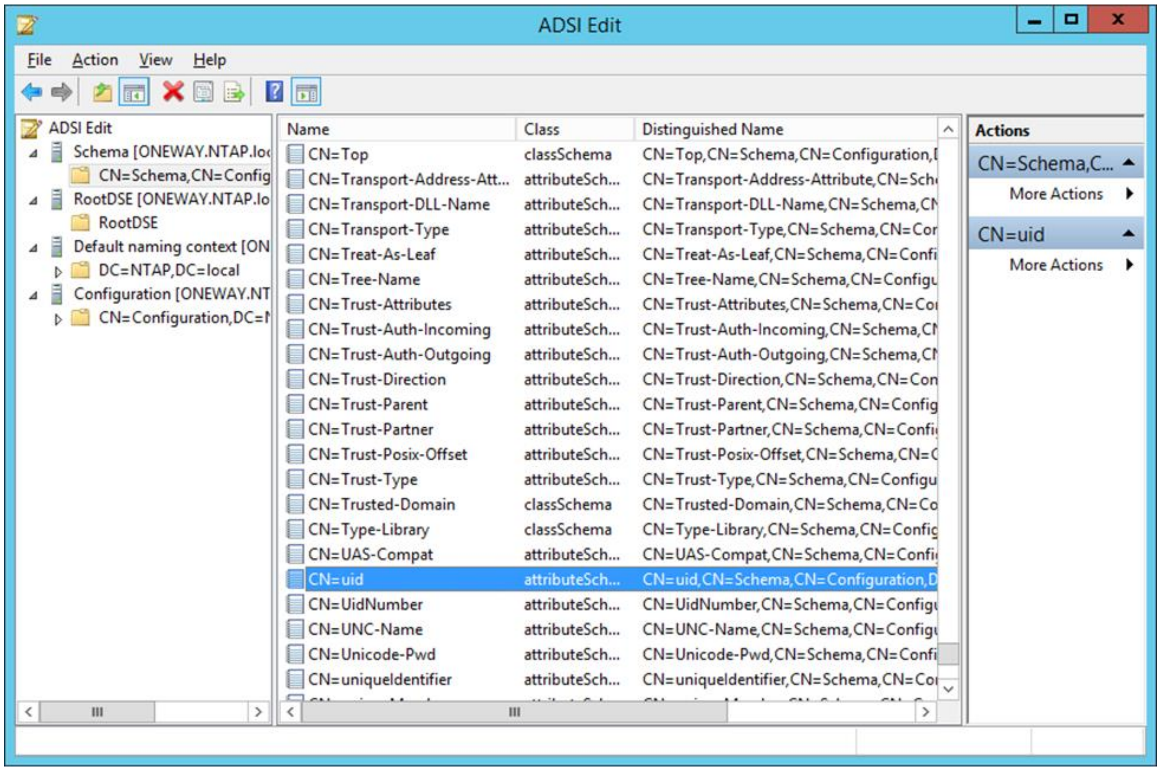
○ Select or type a domain or server: (Server | Domain [:port])

◉ Default (Domain or server that you logged in to)

☐ Use SSL-based Encryption

After you have connected to the Schema Naming Context, you can navigate down through the CN=Schema, CN=Configuration, DC=NTAP, DC=local folder to the attributes. Attributes appear as CN=attributename, such as CN=uid. See Figure 13.

Figure 13) Schema Naming Context format.



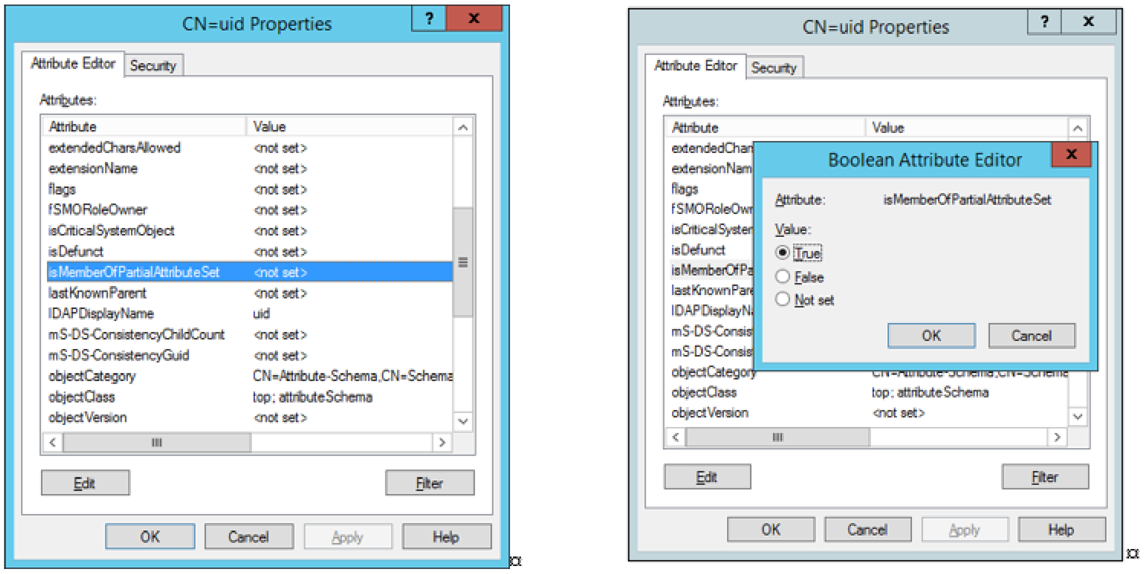
ADSI Edit
- Schema [ONEWAY.NTAP.lo
  - CN=Schema,CN=Config
- RootDSE [ONEWAY.NTAP.lo
  - RootDSE
- Default naming context [ON
  - DC=NTAP,DC=local
- Configuration [ONEWAY.NT
  - CN=Configuration,DC=

Name	Class	Distinguished Name
CN=Top	classSchema	CN=Top,CN=Schema,CN=Configuration,I
CN=Transport-Address-Att...	attributeSch...	CN=Transport-Address-Attribute,CN=Sch
CN=Transport-DLL-Name	attributeSch...	CN=Transport-DLL-Name,CN=Schema,CN
CN=Transport-Type	attributeSch...	CN=Transport-Type,CN=Schema,CN=Cor
CN=Treat-As-Leaf	attributeSch...	CN=Treat-As-Leaf,CN=Schema,CN=Confi
CN=Tree-Name	attributeSch...	CN=Tree-Name,CN=Schema,CN=Configu
CN=Trust-Attributes	attributeSch...	CN=Trust-Attributes,CN=Schema,CN=Co
CN=Trust-Auth-Incoming	attributeSch...	CN=Trust-Auth-Incoming,CN=Schema,CN
CN=Trust-Auth-Outgoing	attributeSch...	CN=Trust-Auth-Outgoing,CN=Schema,CN
CN=Trust-Direction	attributeSch...	CN=Trust-Direction,CN=Schema,CN=Con
CN=Trust-Parent	attributeSch...	CN=Trust-Parent,CN=Schema,CN=Config
CN=Trust-Partner	attributeSch...	CN=Trust-Partner,CN=Schema,CN=Confi
CN=Trust-Posix-Offset	attributeSch...	CN=Trust-Posix-Offset,CN=Schema,CN=C
CN=Trust-Type	attributeSch...	CN=Trust-Type,CN=Schema,CN=Configu
CN=Trusted-Domain	classSchema	CN=Trusted-Domain,CN=Schema,CN=Co
CN=Type-Library	classSchema	CN=Type-Library,CN=Schema,CN=Config
CN=UAS-Compat	attributeSch...	CN=UAS-Compat,CN=Schema,CN=Confi
CN=uid	attributeSch...	CN=uid,CN=Schema,CN=Configuration,D
CN=UidNumber	attributeSch...	CN=UidNumber,CN=Schema,CN=Configu
CN=UNC-Name	attributeSch...	CN=UNC-Name,CN=Schema,CN=Configu
CN=Unicode-Pwd	attributeSch...	CN=Unicode-Pwd,CN=Schema,CN=Confi
CN=uniqueIdentifier	attributeSch...	CN=uniqueIdentifier,CN=Schema,CN=Co

Actions: CN=Schema,C... / CN=uid

After you find the attribute that you want to replicate to the global catalog, double-click it or right-click and select Properties. Then navigate to the i`sMemberOfPartialAttributeSet` value. Double-click that value and toggle the option to True and then click OK and then Apply. See Figure 14.

Figure 14) isMemberOfPartialAttributeSet attribute.



Attributes:

Attribute	Value
extendedCharsAllowed	<not set>
extensionName	<not set>
flags	<not set>
fSMORoleOwner	<not set>
isCriticalSystemObject	<not set>
isDefunct	<not set>
isMemberOfPartialAttributeSet	<not set>
lastKnownParent	<not set>
lDAPDisplayName	uid
mS-DS-ConsistencyChildCount	<not set>
mS-DS-ConsistencyGuid	<not set>
objectCategory	CN=Attribute-Schema,CN=Schema
objectClass	top; attributeSchema
objectVersion	<not set>

Boolean Attribute Editor

Attribute: isMemberOfPartialAttributeSet

Value:

(● True) ○ False ○ Not set

OK Cancel

You can also modify the attributes by using PowerShell and the following command:

```
PS C:\> Set-ADObject 'CN=uidNumber,CN=Schema,CN=Configuration,DC=NTAP,DC=local' -Replace
@{isMemberOfPartialAttributeSet="TRUE"}
```

To enable global catalog LDAP searches to work with ONTAP for Windows 2008 R2 and later, you should modify the following UNIX attributes to replicate across the Global Catalog servers

```
gecos
gidNumber
memberUid
nisMapName (if using netgroups)
nisMapEntry (if using netgroups)
nisNetgroupTriple (if using netgroups)
uid
uidNumber
unixHomeDirectory
unixUserPassword
```

You can verify which UNIX LDAP attributes have the value set to `TRUE` with this PowerShell command:

```
PS C:\> Get-ADObject -SearchBase "cn=Schema,cn=Configuration,dc=ntap,dc=local" -LDAPFilter
"(isMemberOfPartialAttributeSet=TRUE)" -Properties lDAPDisplayName | Select lDAPDisplayName |
findstr -i "member uid gid unix"
fRSMemberReference
netbootGUID
netbootDUID
objectGUID
msFVE-VolumeGuid
msFVE-RecoveryGuid
uid
member
unixUserPassword
uidNumber
gidNumber
unixHomeDirectory
memberUid
```

Keep in mind the following caveats:

- The use of global catalog servers for searches can add significant load and traffic to those servers. If you use the global catalog for LDAP searches, be sure that enough servers are available to handle the load.
- Modifying the Active Directory schema can be extremely dangerous. Modify it with caution and document all changes in extreme detail. If possible, engage Microsoft support for assistance.

After you make changes to replicate attributes to the global catalog, you can either wait for the 15-minute replication window or force replication by using Active Directory Sites and Services.

Enabling global catalog searches in ONTAP LDAP clients is as simple as changing the LDAP port (`–port`) to 3268.

For example:

```
cluster::*> ldap client modify -vserver DEMO -client-config DEMO -port 3268
cluster::*> ldap client show -vserver DEMO -fields port
vserver client-config port
------- ------------- ----
DEMO    DEMO          3268
```

In this example, before the Active Directory global catalog was modified to replicate UNIX attributes, lookups failed.

```
cluster::*> getxxbyyy getpwbyname -node node1 -vserver DEMO -username prof1
  (vserver services name-service getxxbyyy getpwbyname)

Error: command failed: Failed to resolve prof1. Reason: Entry not found for "username: prof1".
```

After the changes, lookups were successful.

```
cluster::*> getxxbyyy getpwbyname -node node1 -vserver DEMO -username prof1
  (vserver services name-service getxxbyyy getpwbyname)
pw_name: prof1
pw_passwd:
pw_uid: 1100
pw_gid: 1101
pw_gecos: Professor
pw_dir: /home/prof1
pw_shell: /bin/sh
```

Use of LDAP to serve name mapping rules

In addition to UNIX users, groups, and netgroups, you can also use LDAP to query for name mappings in lieu of creating static name mapping entries on the ONTAP SVM. For consistency across UNIX and Windows users as they read, write, and navigate permissions, name mappings are necessary in multiprotocol NAS environments.

There are two main name mapping rule concepts:

- Symmetric name mapping is implicit name mapping between UNIX and Windows users who leverage the same user name; for example, Windows user `DOMAIN\justin` maps to UNIX user `justin`.
- Asymmetric name mapping is name mapping between UNIX and Windows users who leverage different user names; for example, Windows user `DOMAIN\justin` maps to UNIX user `nfsdudeabides`.

ONTAP natively supports symmetric name mappings with no need for name mapping rules and can support asymmetric name mappings with the name map `ns-switch` database.

Order of operations for name mappings in ONTAP

When a user attempts to authenticate to a NAS mount or share, ONTAP uses a specific order of name mapping mechanisms to look for valid users or name map entries. This order ultimately depends on the first name service database value that is specified for the name map value in `vserver services name-service ns-switch`. In the following example, ONTAP tries local files first and then LDAP. `Local files` for name map values means the entries in the SVM's name mapping table in `vserver name-mapping`.

```
cluster::> vserver services name-service ns-switch show -vserver DEMO -database namemap

                     Vserver: DEMO
Name Service Switch Database: namemap
   Name Service Source Order: files, ldap
```

When you use LDAP for name mapping, ONTAP uses whatever the LDAP server is configured to use. Usually, it is a symmetric name mapping, but it is also possible to use asymmetric values.

Note: Specify an external service in the name map database only if one is actually being used for asymmetric name mappings. If you specify a server that does not have any name mapping rules configured, it adds latency to requests and creates slow authentication or failures.

If no name mapping can be found in the name services entries for the user, then ONTAP tries to fall back on the default values that are set for the NFS or CIFS/SMB server. The use of this value depends on the protocol that is attempting access, the volume security style, and the name mapping direction that is requested. Table 9 shows the differences.

Table 9) Name mapping and default user considerations for multiprotocol NAS access.

Protocol	Security style	Name mapping direction	Default user
NFS	UNIX	n/a (UID lookup only)	n/a

Protocol	Security style	Name mapping direction	Default user
NFS	NTFS	UNIX > Windows	Default Windows user (NFS option `default-win-user`)
CIFS/SMB	UNIX	Windows > UNIX	Default UNIX user (CIFS option default-`unix-user; pcuse`r by default)
CIFS/SMB	NTFS	Windows > UNIX (initial authentication) NTFS ACLs are used after initial entry.	Default UNIX user (CIFS option `default-unix-user; pcuser` by default)

Asymmetric name mapping from Windows to UNIX users in LDAP

If your environment relies on bidirectional asymmetric name mapping from LDAP in ONTAP, create name mapping rules per SVM for the Windows-UNIX name mappings. However, there is a limit of 1,024 rules per SVM. If you need more rules than are allowed by the cluster, then you must modify the LDAP server attributes to include a UNIX user name with the same value as the Windows user name. Clients still pick up the desired UID/GID in this case.

You can use the LDAP client schema options in Table 10 to configure LDAP to serve name mappings.

Table 10) LDAP client schema options.

New LDAP schema attribute	What it does
`-windows-to-unix-object-class`	Provides the LDAP attribute to define the Windows-to-UNIX name mapping object class. Object classes are used to group multiple LDAP objects to enable faster searches. The default value in AD-IDMU is `User`. For RFC 2037 schemas, the value is set to `posixAccount`.
`-windows-to-unix-attribute`	Provides the LDAP attribute for the value that is used for mapping a Windows user to a UNIX user. The default value for AD-IDMU schemas in ONTAP is `sAMAccountName`. For RFC 2307 schemas, the value defaults to `windowsAccount`.
`-windows-to-unix-no-domain-prefix`	This option controls whether the attribute value in `–windows-to-unix-attribute` has the domain prefix added to it. (The default is `false`.) Because `sAMAccountName` is represented by a single user name (rather than `DOMAIN\username`) and because `msDS-PrincipalName` is not a value that can be used in LDAP search, domain prefixes might be necessary to enable functional asymmetric name mapping. The need for this value depends on the LDAP schema and attributes that are being used, as well as whether multiple domain name mappings are present for multiple unique Windows domains.

These options allow bidirectional asymmetric name mappings from both Windows to UNIX and UNIX to Windows from LDAP servers. The attribute values for these options depend on what your environment looks like.

For most Active Directory LDAP servers, the values for asymmetric name mappings are as follows:

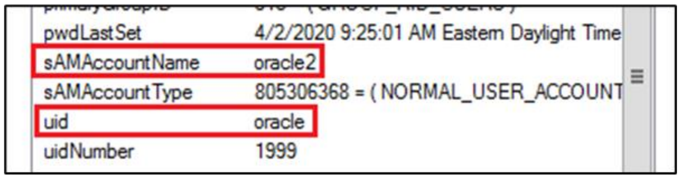
```
-windows-to-unix-object-class User
-windows-account-attribute sAMAccountName
```

```
-windows-to-unix-attribute sAMAccountName
-windows-to-unix-no-domain-prefix true
```

With the preceding values, Active Directory LDAP works with name mappings out of the box. Any variations on the default schemas must be accounted for.

To set a user name mapping in LDAP on a user, simply populate the `uid` field in the attributes with the alternately named user. Note the difference in Figure 15 in user names for `uid` and for `sAMAccountName`.

Figure 15) Use of LDAP for asymmetric name mapping.



```
pwdLastSet        4/2/2020 9:25:01 AM Eastern Daylight Time
sAMAccountName    oracle2
sAMAccountType    805306368 = ( NORMAL_USER_ACCOUNT
uid               oracle
uidNumber         1999
```

The following example shows a UNIX user named oracle mapping to a Windows user named oracle2 and vice versa.

Example of working UNIX > Windows and Windows > UNIX name mappings

```
cluster::*> access-check name-mapping show -vserver DEMO -direction win-unix -name oracle

'oracle2' maps to 'oracle'

cluster::*> access-check name-mapping show -vserver DEMO -direction unix-win -name oracle2

'oracle2' maps to 'NTAP\oracle2'
```

Asymmetric name mapping of UNIX users to Windows users

The LDAP schema that is defined in ONTAP contains an attribute called "ONTAP Name Mapping windowsAccount Attribute" (`-windows-account-attribute`) that defines which LDAP schema attribute to use when mapping UNIX names to Windows names. The default value of this attribute is sAMAccountName, which is the standard field that is used for Windows accounts when new users are created.

This value can be modified if necessary, by creating a custom LDAP client schema, as covered in the section, "Create custom LDAP schemas."

UNIX-to-Windows name mapping across multiple domains

In some scenarios, UNIX-to-Windows name mapping might need to consider multiple users in different domains.

For example:

- The `DEMO` SVM has a CIFS/SMB server in `NTAP.LOCAL`, which is also using LDAP for UNIX users.
- `DEMO`'s LDAP client points to `NTAP.LOCAL` for UNIX user lookup.
- `DEMO` acquires a new company, Company B, and creates a new SVM called `COMPANYB`.
- Company B's Active Directory domain `CORE-TME.NETAPP.COM` also has UNIX users.
- `NTAP.LOCAL` and `CORE-TME.NETAPP.COM` have a bidirectional trust created.
- This trust means that both domains can query Windows users in the other's domain.

The goal here is to allow ONTAP to perform name mappings from UNIX users to Windows users, regardless of which domain they reside in. Because the domains are trusted, both SVMs can find the other domain's Windows users with no issue.

```
cluster::*> access-check authentication translate -vserver DEMO -win-name CORE-TME\ldapuser
S-1-5-21-1426196048-1826357187-2923433760-3643

cluster::*> access-check authentication translate -vserver COMPANYB -win-name NTAP\student2
S-1-5-21-3552729481-4032800560-2279794651-1109
```

But what must happen first is that both SVMs must be able to find the UNIX users in LDAP, regardless of where they live. With the initial configuration of LDAP clients, each SVM can find its own UNIX users, but they can't find the trusted domain's UNIX users.

```
cluster::*> access-check authentication translate -vserver COMPANYB -unix-user-name ldapuser
1108
cluster::*> access-check authentication translate -vserver COMPANYB -unix-user-name prof1
  (vserver services access-check authentication translate)

Vserver: COMPANYB (internal ID: 3)

Error: Acquire UNIX credentials procedure failed
  [  6 ms] Hostname found in Name Service Cache
  [     7] Hostname found in Name Service Cache
  [    16] Successfully connected to ip 10.193.67.93, port 389 using
           TCP
**[    24] FAILURE: User 'prof1' not found in UNIX authorization
**         source LDAP.
  [    24] Entry for user-name: prof1 not found in the current
           source: LDAP. Ignoring and trying next available source
  [    25] Entry for user-name: prof1 not found in the current
           source: FILES. Entry for user-name: prof1 not found in
           any of the available sources
  [    25] Unable to retrieve UID for UNIX user prof1

Error: command failed: Failed to resolve user name to a UNIX ID. Reason: "SecD Error: object not
found".
```

To get multiple domains to map properly in both directions, you must perform a few steps:

1. Configure the LDAP clients to search multiple unique LDAP servers.
2. Configure UNIX-to-Windows mappings across multiple domains.

Step 1: Configure the LDAP clients to search multiple unique LDAP servers

For both SVMs to be able to find users in LDAP, you have two options with Active Directory:

- Configure Active Directory to replicate UNIX attributes to the global catalog (as per the "Active Directory global catalog searches" section).
- Leverage LDAP referrals (as per the section, "LDAP referrals (chase referrals)").

Each option has a few requirements involved.

Global catalog LDAP searches for UNIX identities

For LDAP searches that use the global catalog to work across multiple domains, you need the following:

- Multiple domains in the same forest:
  - Multiple domains in different forests cannot access the global catalog.
- Domain trusts that work properly.
- UNIX attributes replicated to the forest level of the global catalog.
- The ONTAP SVM LDAP client configured for the Active Directory domain of the forest.
- DNS that functions properly.

- Time synchronized across the domains.
- The LDAP client set to port 3268 (port 3269 is not supported by ONTAP).
- Bind user that can view objects in both domains.

LDAP referrals for UNIX identities

You can use LDAP referrals when domains are in different forests or when the global catalog cannot be used. You can also use LDAP referrals for LDAP servers that are not Windows Active Directory based. For LDAP referrals to work properly, the following must be true:

- LDAP referrals are enabled on the SVM LDAP client (`-referrals-enabled`).
- LDAP port 389 is used (port 636 is not supported for use with LDAP referrals).
- The LDAP server can support referrals (also known as chase referrals).
- The LDAP server list (`-servers`) is either multiple LDAP servers (IP addresses or hosts) or a fully qualified domain name (FQDN) with load-balanced IP addresses, or the Active Directory domain (-ad-domain) is set and DNS is configured with multiple SRV records for the LDAP servers.
- Multiple DNs are configured in base DN (`-base-dn`) and optionally in user, group, and netgroup DNs (`-user-dn`, `-group-dn`, `-netgroup-dn`).
- The bind level (`-min-bind-level`) and bind DN (`-bind-dn`) can bind to all LDAP servers listed.

In the following example, the LDAP client was set to use LDAP referrals to query LDAP servers in both the `NTAP.LOCAL` domain and the `CORE-TME.NETAPP.LOCAL` domain, which are trusted domains that are not in the same forest.

LDAP client configuration example for multiple domains with LDAP referrals

In this example, the fields that are needed for LDAP referral chasing to work are highlighted in yellow.

```
cluster::> ldap client show -client-config LDAP

                                  Vserver: COMPANYB
                Client Configuration Name: LDAP
                         LDAP Server List: -
             (DEPRECATED)-LDAP Server List: -
                  Active Directory Domain: ntap.local
       Preferred Active Directory Servers: -
Bind Using the Vserver's CIFS Credentials: true
                          Schema Template: DEMO2
                         LDAP Server Port: 389
                      Query Timeout (sec): 3
        Minimum Bind Authentication Level: sasl
                           Bind DN (User): -
                                  Base DN: DC=CORE-TME,DC=NETAPP,DC=COM;DC=NTAP,DC=LOCAL
                        Base Search Scope: subtree
               Vserver Owns Configuration: true
      Use start-tls Over LDAP Connections: false
                  Client Session Security: none
                    LDAP Referral Chasing: true
```

In the preceding example, the Active Directory domain is `NTAP.LOCAL`. `DNS SRV LDAP` records have been added to the DNS server for the `CORE-TME` domain, the `CORE-TME` zone has been added as a secondary zone to the DNS server, and ONTAP can query both from the SVM.

```
cluster::*> access-check dns srv-lookup -vserver COMPANYB -lookup-string _ldap._tcp.core-
tme.netapp.com
Got 4 Ip Addresses
10.193.67.200
2001:db8::1
10.193.67.181
10.193.67.93

cluster::*> access-check dns srv-lookup -vserver COMPANYB -lookup-string _ldap._tcp.ntap.local
```

```
Got 4 Ip Addresses
10.193.67.236
10.193.67.200
2001:db8::1
10.193.67.181
```

With the preceding settings, the UNIX users in both domains can now be queried.

```
cluster::*> access-check authentication translate -vserver COMPANYB -unix-user-name ldapuser
  (vserver services access-check authentication translate)
1108

ontap9-tme-8040::*> access-check authentication translate -vserver COMPANYB -unix-user-name prof1
  (vserver services access-check authentication translate)
1100
```

UNIX user and group ID collisions

Sometimes, identical user names or numeric IDs might be in multiple domains. This situation can create problems for ONTAP, because it does not know which UID, user name, or GID is the correct one. Instead, it simply returns the first one that it finds. If you plan to use multiple domains for LDAP lookups, to avoid inconsistency in user and group lookups, make sure that there are no duplicate users or groups across the domains.

Step 2: Configure UNIX-to-Windows mappings across multiple domains

In some cases, a user might exist only as a UNIX user in one LDAP client configuration (such as UNIX LDAP or Centrify) and must be able to map to a valid Windows user in another domain.

In the following example, a user was created in `CORE-TME` named `user`, and the UNIX user name was set to `username`. There are no asymmetric name mapping rules, so `username` tries to find a Windows user named `CORE-TME\username` by default. It finds the UNIX UID but fails to map to a valid Windows user, even though a valid Windows user named `NTAP\username` is in the `NTAP.LOCAL` domain that the SVM can see properly—and that maps Windows to UNIX properly.

```
cluster::*> access-check authentication show-creds -vserver COMPANYB -unix-user-name username
-list-name true -list-id true
  (vserver services access-check authentication show-creds)

Vserver: COMPANYB (internal ID: 3)

Error: Get user credentials procedure failed
  [  0 ms] Determined UNIX id 1998 is UNIX user 'username'
  [     0] Trying to map 'username' to Windows user 'username' using
           implicit mapping
  [     1] Using a cached connection to
           stme-infra02.core-tme.netapp.com
  [     2] Could not find Windows name 'username'
  [     2] Unable to map 'username'. No default Windows user defined.
**[     2] FAILURE: Name mapping for UNIX user 'username' failed. No
**         mapping found

Error: command failed: Failed to get user credentials. Reason: "SecD Error: Name mapping does not
exist".


cluster::*> access-check authentication show-creds -vserver COMPANYB -win-name NTAP\username -
list-name true -list-id true
  (vserver services access-check authentication show-creds)

 UNIX UID: 1998 (username) <> Windows User: S-1-5-21-3552729481-4032800560-2279794651-1242
(NTAP\username (Windows Domain User))

 GID: 513 (Domain Users)
 Supplementary GIDs:
  513  (Domain Users)
 Primary Group SID: S-1-5-21-3552729481-4032800560-2279794651-513   NTAP\DomainUsers (Windows
Domain group)

 Windows Membership:
  S-1-5-21-3552729481-4032800560-2279794651-513   NTAP\DomainUsers (Windows Domain group)
  S-1-18-2   Service asserted identity (Windows Well known group)
  S-1-5-21-0-0-0-497   NT AUTHORITY\Claims Valid (Windows Well known group)
 User is also a member of Everyone, Authenticated Users, and Network Users
```

When a UNIX user lives in the **same** trusted domain as the Windows user, the UNIX-to-Windows name mapping works without the need to configure anything. For example, if the LDAP configuration points to `CORE-TME` and a user named `prof1` lives in `NTAP.LOCAL` with its corresponding Windows user, things work as expected.

```
cluster::*> access-check authentication show-creds -vserver COMPANYB -unix-user-name prof1 -list-
name true -list-id true
  (vserver services access-check authentication show-creds)

 UNIX UID: 1100 (prof1) <> Windows User: S-1-5-21-3552729481-4032800560-2279794651-1110
(NTAP\prof1 (Windows Domain User))

 GID: 1101 (ProfGroup)
 Supplementary GIDs:
  1101  (ProfGroup)
  10000  (Domain Users)
  1201  (group1)
  1202  (group2)
  1203  (group3)
  1220  (sharedgroup)

 Primary Group SID: S-1-5-21-3552729481-4032800560-2279794651-1111   NTAP\ProfGroup (Windows
Domain group)

 Windows Membership:
  S-1-5-21-3552729481-4032800560-2279794651-1106   NTAP\group2 (Windows Domain group)
  S-1-5-21-3552729481-4032800560-2279794651-513   NTAP\DomainUsers (Windows Domain group)
 User is also a member of Everyone, Authenticated Users, and Network Users
```

To get the UNIX-to-Windows mappings to work properly across domains in this scenario, you must perform two steps:

- Create a UNIX-to-Windows name mapping rule that maps all UNIX users to wildcards for the domain and user.
- Add a `name-mapping-search` entry to the SVM to tell ONTAP to look in other trusted domains for UNIX-to-Windows name mappings.

This example does the following:

```
cluster::*> vserver name-mapping create -vserver COMPANYB -direction unix-win -pattern * -
replacement *\\* -position 1

cluster::*> name-mapping-search add -vserver COMPANYB -trusted-domains NTAP.LOCAL
```

When that step is done, the previously nonworking `username` UNIX user now maps to the Windows user `NTAP\username`.

```
cluster::*> access-check authentication show-creds -vserver COMPANYB -unix-user-name username -
list-name true -list-id true
  (vserver services access-check authentication show-creds)

 UNIX UID: 1998 (username) <> Windows User: S-1-5-21-3552729481-4032800560-2279794651-1242
(NTAP\username (Windows Domain User))

 GID: 513 (Domain Users)
 Supplementary GIDs:
  513  (Domain Users)
 Primary Group SID: S-1-5-21-3552729481-4032800560-2279794651-513   NTAP\DomainUsers (Windows
Domain group)

 Windows Membership:
  S-1-5-21-3552729481-4032800560-2279794651-513   NTAP\DomainUsers (Windows Domain group)
  S-1-18-2   Service asserted identity (Windows Well known group)
  S-1-5-21-0-0-0-497   NT AUTHORITY\Claims Valid (Windows Well known group)
User is also a member of Everyone, Authenticated Users, and Network Users
```

Active Directory Lightweight Directory Services

Rather than setting up an entire domain controller, you might want to provide LDAP services for UNIX users and groups with a standalone Windows server. For example, if you want a place to serve users and groups but don't need Kerberos authentication, or if you need just LDAP functionality for an application, you can use Lightweight Directory Services (LDS). This directory service is available through the Active Directory LDS feature.

To manage users, groups, and netgroups in LDS, you must use ADSI Edit. Utilities such as Active Directory Users and Computers are intended for domain user management and do not work with standalone LDS instances.

To set up Active Directory LDS for use with UNIX identities, see Active Directory LDS Identity Mapping for Services for NFS.

To use Active Directory LDS with ONTAP, follow the same configuration steps as you would with any other LDAP server. The following example shows a query from an ONTAP SVM to a standalone Active Directory LDS server that is running on Windows 2019.

```
cluster::*> getxxbyyy getpwbyname -node node1 -vserver NFS -username lds -show-source true
  (vserver services name-service getxxbyyy getpwbyname)
Source used for lookup: LDAP
pw_name: lds
pw_passwd:
pw_uid: 1001
pw_gid: 1101
pw_gecos:
pw_dir:
pw_shell:
```

Configure secure LDAP

ONTAP provides several methods to secure LDAP communication over the wire, with end-to-end encryption that uses industry-standard security mechanisms such as TLS 1.2 and AES-256 Kerberos. The following section covers how to configure these methods at a high level. For more detailed steps, consult your LDAP server vendor's documentation.

StartTLS and LDAPS

In this report, the section, "Start Transport Layer Security versus LDAP over SSL," highlights the differences between StartTLS and LDAPS. Configuration for both of these applications is remarkably similar: Both require certificates to be present on the LDAP server and on the ONTAP SVM. This part of the setup is generally the most complicated.

The ONTAP LDAP client configuration is relatively simple. For LDAPS, set the port to 636; ONTAP then knows to use LDAPS for binding and queries. To use StartTLS, set the port to 389 and enable the `-use-start-tls` option. ONTAP takes care of the rest, provided that the certificates have been installed on the SVM.

There are three general steps to configure LDAPS or StartTLS:

1. Configure certificate services on the LDAP server.

2. Install the certificates in the desired SVM by using `security certificate` commands.
3. Configure the LDAP client to use StartTLS or LDAPS.

The following sections cover these steps in further detail.

Manage certificates in FreeIPA

Use the following links to create certificates in FreeIPA for use with LDAP:

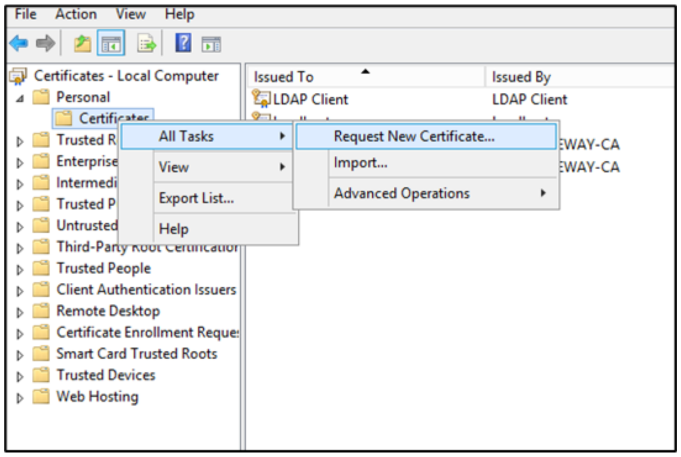
- FreeIPA: Howto/Client Certificate Authentication with LDAP
- Red Hat: Managing Certificates for Users, Hosts, and Services

Manage certificates in Windows Active Directory LDAP

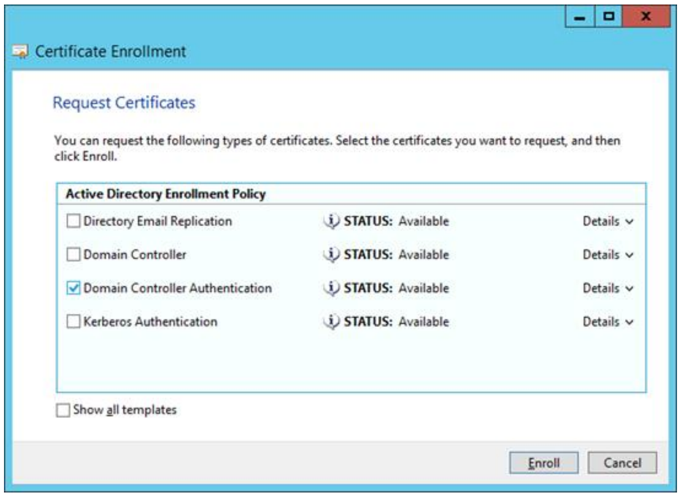
To manage certificates with Windows Active Directory, you must have the Certificates feature installed and configured in your environment. This feature enables you to generate the necessary certificates to use with ONTAP for secure LDAP that uses SSL or StartTLS. Use the Microsoft procedures or contact Microsoft for assistance.

After you have installed the Certificates feature, to manage certificates:

1. Go to the Manage Computer Certificates window. Right-click Personal > Certificates and select All Tasks > Request New Certificate.



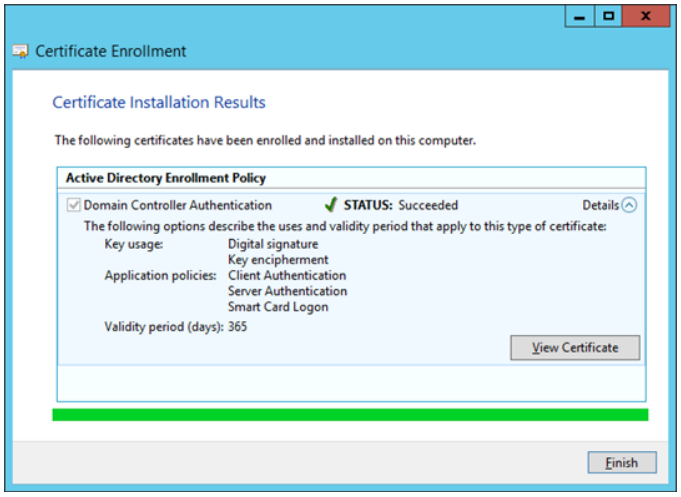
2. Follow the Certificate Enrollment wizard and select Domain Controller Authentication as your enrollment policy.



You can request the following types of certificates. Select the certificates you want to request, and then click Enroll.

Active Directory Enrollment Policy		
☐ Directory Email Replication	STATUS: Available	Details
☐ Domain Controller	STATUS: Available	Details
☑ Domain Controller Authentication	STATUS: Available	Details
☐ Kerberos Authentication	STATUS: Available	Details

3. Click Enroll, and the certificate is ready to be exported.



Certificate Enrollment

Certificate Installation Results

The following certificates have been enrolled and installed on this computer.

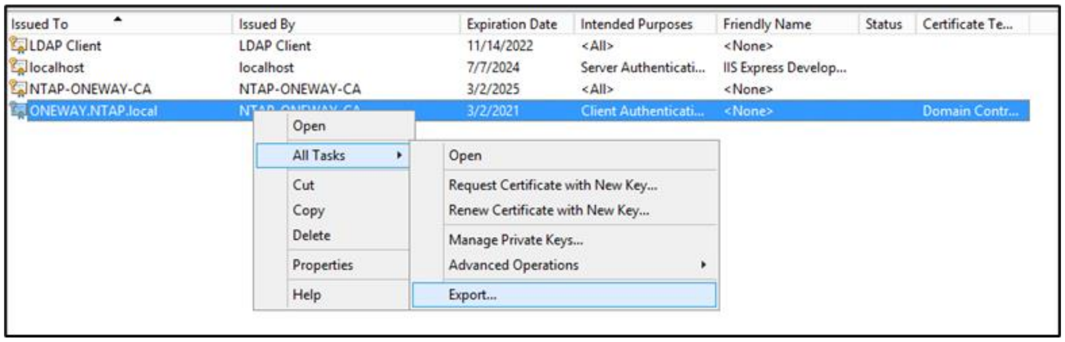
Active Directory Enrollment Policy

Domain Controller Authentication ✓ STATUS: Succeeded Details

The following options describe the uses and validity period that apply to this type of certificate:

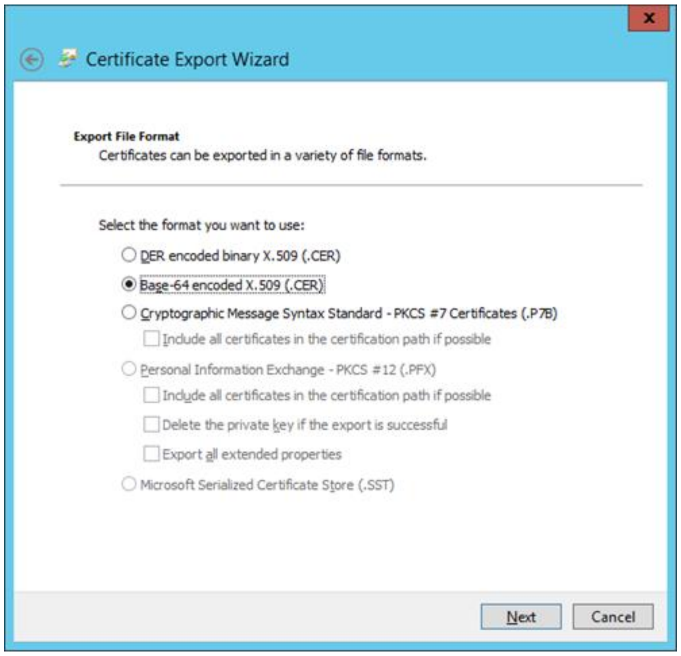
Key usage:	Digital signature Key encipherment
Application policies:	Client Authentication Server Authentication Smart Card Logon
Validity period (days):	365

4. Navigate to the new certificate in the Personal > Certificates folder. It should have the same name as the Active Directory domain. Right-click and select All Tasks > Export.



Issued To	Issued By	Expiration Date	Intended Purposes	Friendly Name	Status	Certificate Te...
LDAP Client	LDAP Client	11/14/2022	<All>	<None>		
localhost	localhost	7/7/2024	Server Authenticati...	IIS Express Develop...		
NTAP-ONEWAY-CA	NTAP-ONEWAY-CA	3/2/2025	<All>	<None>		
ONEWAY.NTAP.local	NTAP-ONEWAY-CA	3/2/2021	Client Authenticati...	<None>		Domain Contr...

5. Use the Certificate Export wizard to create a new `.cer` file. You will use this file to install the certificate into the ONTAP SVM for LDAP over SSL or StartTLS. Base-64 `.cer` gives you a file that you can use immediately; DER encoded binary must be converted by using the `certutil` in Windows.



Export File Format
Certificates can be exported in a variety of file formats.

Select the format you want to use:

- ○ DER encoded binary X.509 (.CER)
- ● Base-64 encoded X.509 (.CER)
- ○ Cryptographic Message Syntax Standard - PKCS #7 Certificates (.P7B)
  - ☐ Include all certificates in the certification path if possible
- ○ Personal Information Exchange - PKCS #12 (.PFX)
  - ☐ Include all certificates in the certification path if possible
  - ☐ Delete the private key if the export is successful
  - ☐ Export all extended properties
- ○ Microsoft Serialized Certificate Store (.SST)

6. When you have completed the wizard, you can open the `.cer` file. You should see a long text string that starts with:

```
-----BEGIN CERTIFICATE-----
```

7. Now you are ready to install the certificate in the ONTAP SVM.

Install certificates in ONTAP

SVMs in ONTAP provide a method to import security certificates from LDAP servers through the `security certificate` commands.

```
cluster::*> security certificate ?
  ca-issued>                    Show Digital Certificates Issued by Self-Signed CA
  config>                       The config directory
  create                        Create and Install a Self-Signed Digital Certificate
  delete                        Delete an Installed Digital Certificate
  file>                         *Show Digital Certificate files
  generate-csr                  Generate a Digital Certificate Signing Request
  install                       Install a Digital Certificate
  print                         Display the contents of a certificate
  remove-precluster-cert        *This command removes the auto-generated precluster certificate
from all nodes
  rename                        Rename a certificate
  show                          Display Installed Digital Certificates
  show-generated                Display ONTAP generated certificates
  show-truststore               Display default truststore certificates
  show-user-installed           Display user installed certificates
  sign                          Sign a Digital Certificate using Self-Signed Root CA
  truststore>                   truststore
```

By default, the admin SVM contains some well-known CA certificates (such as Verisign and Amazon), which you can copy and use in other SVMs if necessary. You can use the `security certificate install` command with any certificate type, whether it is Active Directory LDAP or not.

The previous section showed how to generate a self-signed certificate for use with Active Directory LDAP. To use that certificate, run the following command to install a `server-ca` certificate:

```
cluster::*> security certificate install -type server-ca -vserver DEMO -cert-name MS-LDAP
```

After that command has been run, it asks you to copy and paste the contents of your `.cer` file. When that step is finished, hit Enter and then the certificate is installed.

```
You should keep a copy of the CA-signed digital certificate for future reference.

The installed certificate's CA and serial number for reference:
CA: NTAP-ONEWAY-CA
Serial: 5500000004B5165DB556062E5E000000000004
```

You can view the certificate with the following:

```
cluster::*> security certificate show -vserver DEMO -common-name MS-LDAP
Vserver    Serial Number   Certificate Name                       Type
---------- --------------- -------------------------------------- ------------
DEMO       5500000004B5165DB556062E5E000000000004
                           ONEWAY-DOMAIN-AUTH                     server-ca
    Certificate Authority: NTAP-ONEWAY-CA
          Expiration Date: Tue Mar 02 17:21:13 2021
```

Now you can test it out.

Configure and test LDAPS or StartTLS

After you install your `server-ca` certificate from your LDAP server, you can enable either StartTLS or LDAPS for use with LDAP binds and queries. If something was incorrect in the certificate configuration or installation, ONTAP prevents configuration changes or LDAP client creation if it can't do a basic bind by using the specified security settings. For example, when the proper certificate has not been configured, the following errors result:

```
cluster::*> ldap client modify -client-config DEMO -vserver DEMO -use-start-tls true

Error: Validate the Ldap configuration procedure failed
  [  6 ms] Hostname found in Name Service Cache
  [     7] Successfully connected to ip 10.193.67.236, port 389
           using TCP
  [    13] Unable to start TLS: Server is unavailable
  [    13] Additional info: 00000000: LdapErr: DSID-0C09102C,
           comment: Error initializing SSL/TLS, data 0, v2580
  [    13] Unable to connect to LDAP (NIS & Name Mapping) service on
           oneway.ntap.local
  [    13] No servers available for LDAP_NIS_AND_NAME_MAPPING,
           vserver: 10, domain: .
**[    13] FAILURE: Unable to make a connection (LDAP (NIS & Name
**         Mapping):), result: 6940
Error: command failed: The LDAP client configuration "DEMO" for Vservers "DEMO" is an invalid
configuration.

cluster::*> ldap client modify -client-config DEMO -vserver DEMO -port 636

Error: Validate the Ldap configuration procedure failed
  [  4 ms] Hostname found in Name Service Cache
  [    10] Successfully connected to ip 10.193.67.236, port 636
           using TCP
  [    67] Unable to start LDAPS: Can't contact LDAP server
  [    67] Unable to connect to LDAP (NIS & Name Mapping) service on
           oneway.ntap.local (Error: Can't contact LDAP server)
  [    67] No servers available for LDAP_NIS_AND_NAME_MAPPING,
           vserver: 10, domain: .
**[    67] FAILURE: Unable to make a connection (LDAP (NIS & Name
**         Mapping):), result: 6940
Error: command failed: The LDAP client configuration "DEMO" for Vservers "DEMO" is an invalid
configuration.
```

This approach is a safeguard against outages caused by incorrect LDAP configuration. You can bypass this check with the `-skip-config-validation` option.

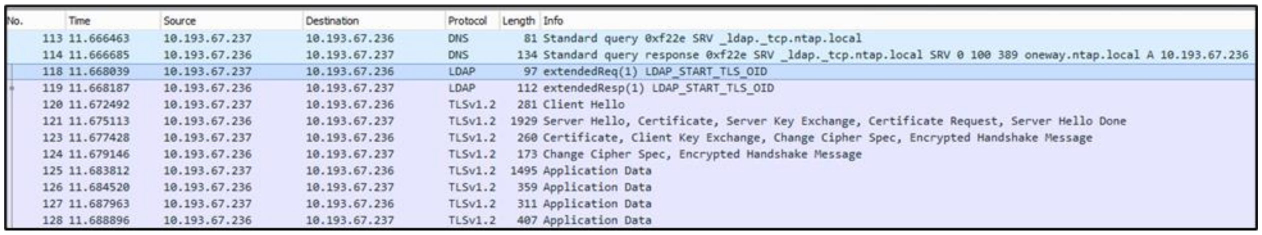
A sign that LDAP over SSL or StartTLS is working is the mere fact that the `create` or `modify` command works without error.

```
cluster::*> ldap client modify -client-config DEMO -vserver DEMO -use-start-tls true

Warning: You may also want to modify "-use-start-tls-for-ad-ldap" option to "true" using "vserver
cifs security modify" command for the following Vserver(s): DEMO.
```

You can perform additional checks with the commands in the section, “ONTAP CLI commands for LDAP troubleshooting.”

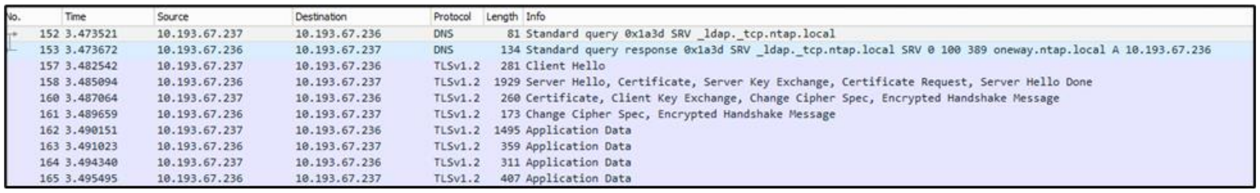
Figure 16 and Figure 17 are examples of packet captures from identical LDAP queries that use StartTLS and LDAPS. The communication is nearly identical, except StartTLS has a TLS handshake and travels over port 389.

Figure 16) Packet capture of LDAP StartTLS.



```
No.     Time         Source          Destination     Protocol  Length Info
    113 11.666463    10.193.67.237   10.193.67.236   DNS           81 Standard query 0xf22e SRV _ldap._tcp.ntap.local
    114 11.666685    10.193.67.236   10.193.67.237   DNS          134 Standard query response 0xf22e SRV _ldap._tcp.ntap.local SRV 0 100 389 oneway.ntap.local A 10.193.67.236
    118 11.668039    10.193.67.237   10.193.67.236   LDAP          97 extendedReq(1) LDAP_START_TLS_OID
    119 11.668187    10.193.67.236   10.193.67.237   LDAP         112 extendedResp(1) LDAP_START_TLS_OID
    120 11.672492    10.193.67.237   10.193.67.236   TLSv1.2      281 Client Hello
    121 11.675113    10.193.67.236   10.193.67.237   TLSv1.2     1929 Server Hello, Certificate, Server Key Exchange, Certificate Request, Server Hello Done
    123 11.677428    10.193.67.237   10.193.67.236   TLSv1.2      260 Certificate, Client Key Exchange, Change Cipher Spec, Encrypted Handshake Message
    124 11.679146    10.193.67.236   10.193.67.237   TLSv1.2      173 Change Cipher Spec, Encrypted Handshake Message
    125 11.683812    10.193.67.237   10.193.67.236   TLSv1.2     1495 Application Data
    126 11.684520    10.193.67.236   10.193.67.237   TLSv1.2      359 Application Data
    127 11.687963    10.193.67.237   10.193.67.236   TLSv1.2      311 Application Data
    128 11.688896    10.193.67.236   10.193.67.237   TLSv1.2      407 Application Data
```

Figure 17) Packet capture of LDAPS.



```
No.     Time        Source          Destination     Protocol  Length Info
    152 3.473521    10.193.67.237   10.193.67.236   DNS           81 Standard query 0x1a3d SRV _ldap._tcp.ntap.local
    153 3.473672    10.193.67.236   10.193.67.237   DNS          134 Standard query response 0x1a3d SRV _ldap._tcp.ntap.local SRV 0 100 389 oneway.ntap.local A 10.193.67.236
    157 3.482542    10.193.67.237   10.193.67.236   TLSv1.2      281 Client Hello
    158 3.485094    10.193.67.236   10.193.67.237   TLSv1.2     1929 Server Hello, Certificate, Server Key Exchange, Certificate Request, Server Hello Done
    160 3.487064    10.193.67.237   10.193.67.236   TLSv1.2      260 Certificate, Client Key Exchange, Change Cipher Spec, Encrypted Handshake Message
    161 3.489659    10.193.67.236   10.193.67.237   TLSv1.2      173 Change Cipher Spec, Encrypted Handshake Message
    162 3.490151    10.193.67.237   10.193.67.236   TLSv1.2     1495 Application Data
    163 3.491023    10.193.67.236   10.193.67.237   TLSv1.2      359 Application Data
    164 3.494340    10.193.67.237   10.193.67.236   TLSv1.2      311 Application Data
    165 3.495495    10.193.67.236   10.193.67.237   TLSv1.2      407 Application Data
```

LDAP signing and sealing (LDAP session security)

Windows Active Directory LDAP provides a way to secure LDAP communication natively, with no need to configure security certificates. The LDAP client option that controls this method is `–session-security`. If you use LDAP signing and sealing, you should also consider configuring the CIFS/SMB security settings as described in the section, “CIFS/SMB server security considerations.”

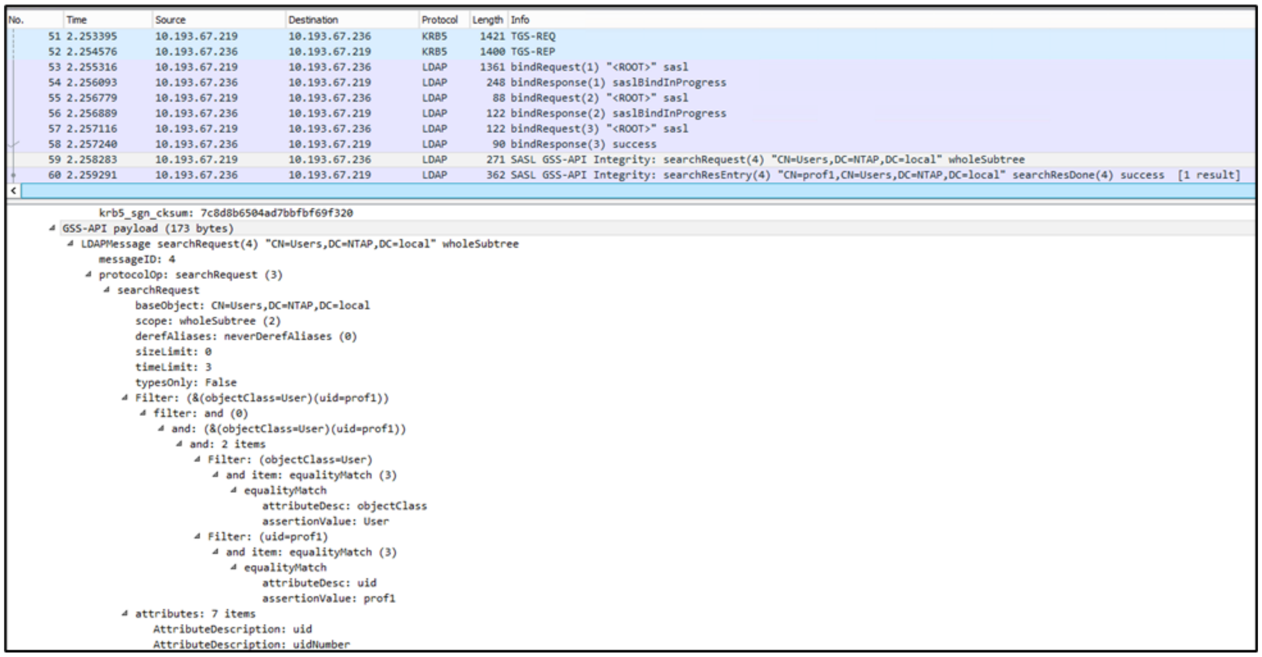
You have three options to configure session security:

- **None.** No session security is enforced.
- **Sign.** Session security is enforced for signing (integrity verification) LDAP sessions only. In this setup, LDAP queries can be seen over the wire in packet captures.
- **Seal.** Session security is enforced for both signing and sealing LDAP sessions. In this configuration, LDAP queries are encrypted and cannot be seen in packet captures.

Naturally, signing and sealing is the most secure, but it also incurs the most overhead for processing and can add some latency to queries. Results depend on the network load, the server load, and the size of queries. NetApp encourages you to carry out testing.

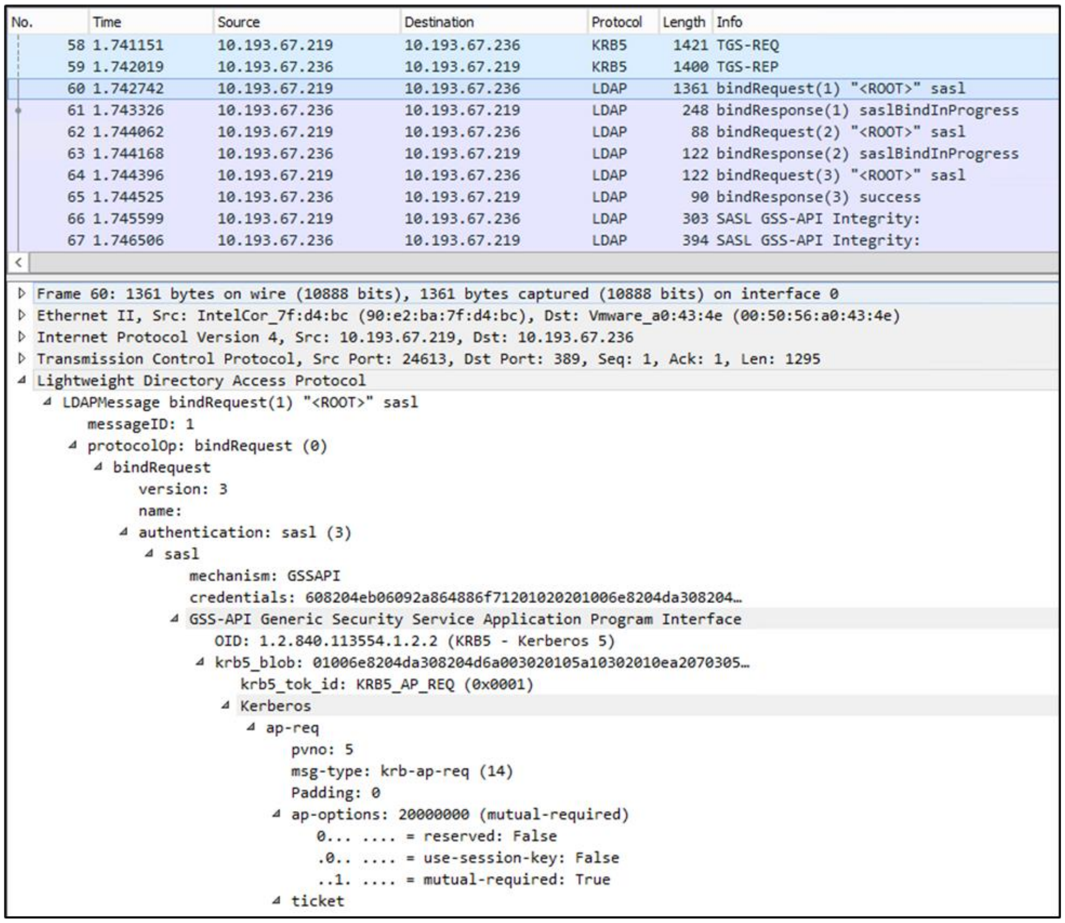
Figure 18 and Figure 19 show packet captures of LDAP signing and sealing, and the differences in what you can and cannot see in packet captures.

Figure 18) Packet capture of LDAP with signing enabled.



```
No.      Time       Source          Destination     Protocol Length Info
    51 2.253395     10.193.67.219   10.193.67.236   KRB5     1421 TGS-REQ
    52 2.254576     10.193.67.236   10.193.67.219   KRB5     1400 TGS-REP
    53 2.255316     10.193.67.219   10.193.67.236   LDAP     1361 bindRequest(1) "<ROOT>" sasl
    54 2.256093     10.193.67.236   10.193.67.219   LDAP      248 bindResponse(1) saslBindInProgress
    55 2.256779     10.193.67.219   10.193.67.236   LDAP       88 bindRequest(2) "<ROOT>" sasl
    56 2.256889     10.193.67.236   10.193.67.219   LDAP      122 bindResponse(2) saslBindInProgress
    57 2.257116     10.193.67.219   10.193.67.236   LDAP      122 bindRequest(3) "<ROOT>" sasl
    58 2.257240     10.193.67.236   10.193.67.219   LDAP       90 bindResponse(3) success
    59 2.258283     10.193.67.219   10.193.67.236   LDAP      271 SASL GSS-API Integrity: searchRequest(4) "CN=Users,DC=NTAP,DC=local" wholeSubtree
    60 2.259291     10.193.67.236   10.193.67.219   LDAP      362 SASL GSS-API Integrity: searchResEntry(4) "CN=prof1,CN=Users,DC=NTAP,DC=local" searchResDone(4) success  [1 result]

            krb5_sgn_cksum: 7c8d8b6504ad7bbfbf69f320
      ◢ GSS-API payload (173 bytes)
        ◢ LDAPMessage searchRequest(4) "CN=Users,DC=NTAP,DC=local" wholeSubtree
            messageID: 4
          ◢ protocolOp: searchRequest (3)
            ◢ searchRequest
                baseObject: CN=Users,DC=NTAP,DC=local
                scope: wholeSubtree (2)
                derefAliases: neverDerefAliases (0)
                sizeLimit: 0
                timeLimit: 3
                typesOnly: False
              ◢ Filter: (&(objectClass=User)(uid=prof1))
                ◢ filter: and (0)
                  ◢ and: (&(objectClass=User)(uid=prof1))
                    ◢ and: 2 items
                      ◢ Filter: (objectClass=User)
                        ◢ and item: equalityMatch (3)
                          ◢ equalityMatch
                              attributeDesc: objectClass
                              assertionValue: User
                      ◢ Filter: (uid=prof1)
                        ◢ and item: equalityMatch (3)
                          ◢ equalityMatch
                              attributeDesc: uid
                              assertionValue: prof1
              ◢ attributes: 7 items
                  AttributeDescription: uid
                  AttributeDescription: uidNumber
```

Figure 19) Packet capture of LDAP with signing and sealing enabled.



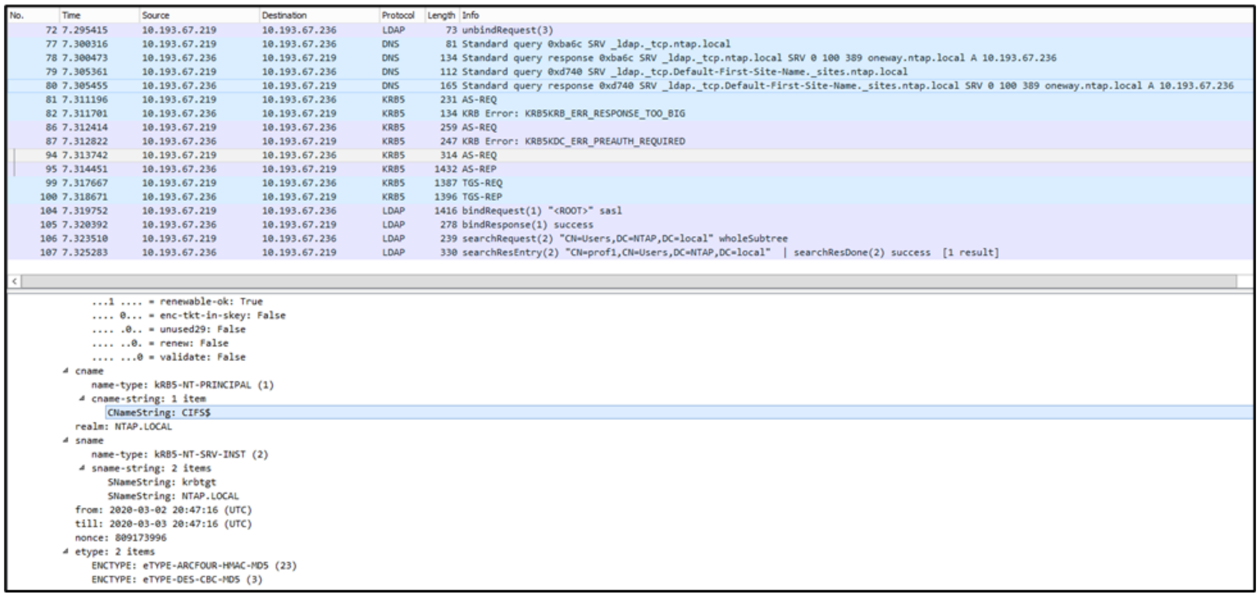
```
No.      Time       Source          Destination     Protocol Length Info
    58 1.741151     10.193.67.219   10.193.67.236   KRB5     1421 TGS-REQ
    59 1.742019     10.193.67.236   10.193.67.219   KRB5     1400 TGS-REP
    60 1.742742     10.193.67.219   10.193.67.236   LDAP     1361 bindRequest(1) "<ROOT>" sasl
    61 1.743326     10.193.67.236   10.193.67.219   LDAP      248 bindResponse(1) saslBindInProgress
    62 1.744062     10.193.67.219   10.193.67.236   LDAP       88 bindRequest(2) "<ROOT>" sasl
    63 1.744168     10.193.67.236   10.193.67.219   LDAP      122 bindResponse(2) saslBindInProgress
    64 1.744396     10.193.67.219   10.193.67.236   LDAP      122 bindRequest(3) "<ROOT>" sasl
    65 1.744525     10.193.67.236   10.193.67.219   LDAP       90 bindResponse(3) success
    66 1.745599     10.193.67.219   10.193.67.236   LDAP      303 SASL GSS-API Integrity:
    67 1.746506     10.193.67.236   10.193.67.219   LDAP      394 SASL GSS-API Integrity:

▷ Frame 60: 1361 bytes on wire (10888 bits), 1361 bytes captured (10888 bits) on interface 0
▷ Ethernet II, Src: IntelCor_7f:d4:bc (90:e2:ba:7f:d4:bc), Dst: Vmware_a0:43:4e (00:50:56:a0:43:4e)
▷ Internet Protocol Version 4, Src: 10.193.67.219, Dst: 10.193.67.236
▷ Transmission Control Protocol, Src Port: 24613, Dst Port: 389, Seq: 1, Ack: 1, Len: 1295
◢ Lightweight Directory Access Protocol
  ◢ LDAPMessage bindRequest(1) "<ROOT>" sasl
      messageID: 1
    ◢ protocolOp: bindRequest (0)
      ◢ bindRequest
          version: 3
          name:
        ◢ authentication: sasl (3)
          ◢ sasl
              mechanism: GSSAPI
              credentials: 608204eb06092a864886f71201020201006e8204da308204…
            ◢ GSS-API Generic Security Service Application Program Interface
                OID: 1.2.840.113554.1.2.2 (KRB5 - Kerberos 5)
              ◢ krb5_blob: 01006e8204da308204d6a003020105a10302010ea2070305…
                  krb5_tok_id: KRB5_AP_REQ (0x0001)
                ◢ Kerberos
                  ◢ ap-req
                      pvno: 5
                      msg-type: krb-ap-req (14)
                      Padding: 0
                    ◢ ap-options: 20000000 (mutual-required)
                        0... .... = reserved: False
                        .0.. .... = use-session-key: False
                        ..1. .... = mutual-required: True
                    ◢ ticket
```

Binding as the CIFS/SMB server

When you use Windows Active Directory LDAP for UNIX user and group lookups and the same SVM also has a CIFS/SMB server configured, you can use the CIFS/SMB server machine account to bind to LDAP, rather than using a user name/password or anonymous binds. Binding as a CIFS/SMB server is simple: Set the option `-bind-as-cifs-server` to `true` in the LDAP client and verify that the configured CIFS/SMB server has the appropriate DNS entries. ONTAP sets the Kerberos SPN for the CIFS/SMB server automatically when the CIFS/SMB server is created.

Binding as the CIFS/SMB machine account uses the same security mechanisms that the Active Directory domain supports. Machine account authentication tries to negotiate through Kerberos (by using `GSS-SPNEGO`) first. If a valid SPN exists on the KDC, then Kerberized binds are used with the strongest supported encryption type available on the KDC. For Windows 2008 and later, that encryption is AES-256. Figure 20 shows a packet capture of an LDAP bind using the CIFS/SMB server.

Figure 20) Packet capture of LDAP binding as a CIFS/SMB server.



```
No.     Time        Source          Destination     Protocol  Length Info
     72 7.295415    10.193.67.219   10.193.67.236   LDAP        73 unbindRequest(3)
     77 7.300316    10.193.67.219   10.193.67.236   DNS         81 Standard query 0xba6c SRV _ldap._tcp.ntap.local
     78 7.300473    10.193.67.236   10.193.67.219   DNS        134 Standard query response 0xba6c SRV _ldap._tcp.ntap.local SRV 0 100 389 oneway.ntap.local A 10.193.67.236
     79 7.305361    10.193.67.219   10.193.67.236   DNS        112 Standard query 0xd740 SRV _ldap._tcp.Default-First-Site-Name._sites.ntap.local
     80 7.305455    10.193.67.236   10.193.67.219   DNS        165 Standard query response 0xd740 SRV _ldap._tcp.Default-First-Site-Name._sites.ntap.local SRV 0 100 389 oneway.ntap.local A 10.193.67.236
     81 7.311196    10.193.67.219   10.193.67.236   KRB5       231 AS-REQ
     82 7.311701    10.193.67.236   10.193.67.219   KRB5       134 KRB Error: KRB5KRB_ERR_RESPONSE_TOO_BIG
     86 7.312414    10.193.67.219   10.193.67.236   KRB5       259 AS-REQ
     87 7.312822    10.193.67.236   10.193.67.219   KRB5       247 KRB Error: KRB5KDC_ERR_PREAUTH_REQUIRED
     94 7.313742    10.193.67.219   10.193.67.236   KRB5       314 AS-REQ
     95 7.314451    10.193.67.236   10.193.67.219   KRB5      1432 AS-REP
     99 7.317667    10.193.67.219   10.193.67.236   KRB5      1387 TGS-REQ
    100 7.318671    10.193.67.236   10.193.67.219   KRB5      1396 TGS-REP
    104 7.319752    10.193.67.219   10.193.67.236   LDAP      1416 bindRequest(1) "<ROOT>" sasl
    105 7.320392    10.193.67.236   10.193.67.219   LDAP       278 bindResponse(1) success
    106 7.323510    10.193.67.219   10.193.67.236   LDAP       239 searchRequest(2) "CN=Users,DC=NTAP,DC=local" wholeSubtree
    107 7.325283    10.193.67.236   10.193.67.219   LDAP       330 searchResEntry(2) "CN=prof1,CN=Users,DC=NTAP,DC=local"  | searchResDone(2) success  [1 result]
```

```
            ...1 .... = renewable-ok: True
            .... 0... = enc-tkt-in-skey: False
            .... .0.. = unused29: False
            .... ..0. = renew: False
            .... ...0 = validate: False
      ◢ cname
            name-type: kRB5-NT-PRINCIPAL (1)
         ◢ cname-string: 1 item
               CNameString: CIFS$
        realm: NTAP.LOCAL
      ◢ sname
            name-type: kRB5-NT-SRV-INST (2)
         ◢ sname-string: 2 items
               SNameString: krbtgt
               SNameString: NTAP.LOCAL
        from: 2020-03-02 20:47:16 (UTC)
        till: 2020-03-03 20:47:16 (UTC)
        nonce: 809173996
      ◢ etype: 2 items
            ENCTYPE: eTYPE-ARCFOUR-HMAC-MD5 (23)
            ENCTYPE: eTYPE-DES-CBC-MD5 (3)
```

If Kerberos SPNs are not available, the machine account authentication falls back to NTLM. If NTLM is blocked in the domain, then the ONTAP LDAP client checks to see whether a username/password is configured. Otherwise, binding fails.

Considerations for binding as a CIFS/SMB server

When you bind as a CIFS/SMB server, consider the following:

- Ensure that CIFS/SMB is licensed and that a CIFS/SMB server is configured.
- Ensure that DNS entries exist for the CIFS server name that is being used.
- Ensure that DNS is configured on the SVM in ONTAP.
- In the LDAP client, ensure that the Active Directory domain is configured with the `-ad-domain` option.
- Set the minimum bind level (`-min-bind-level`) on the LDAP client to SASL.
- If NTLM is disabled in your domain, consider setting a bind user and password for fault tolerance in case Kerberos binds fail.

CIFS/SMB server security considerations

When you use Active Directory for LDAP services, there are also some CIFS/SMB specific options that you can configure to further secure LDAP traffic.

The following options are available in the advanced privilege:

```
cluster::*> cifs security modify -vserver DEMO ?
  [ -kerberos-clock-skew <integer> ]
Maximum Allowed Kerberos Clock Skew
  [ -kerberos-ticket-age <integer> ]
Kerberos Ticket Lifetime
  [ -kerberos-renew-age <integer> ]
Maximum Kerberos Ticket Renewal Days
  [ -kerberos-kdc-timeout {1..23} ]
Timeout for Kerberos KDC Connections (Secs)
  [ -is-signing-required {true|false} ]
Require Signing for Incoming CIFS Traffic
  [ -is-password-complexity-required {true|false} ]
Require Password Complexity for Local User Accounts
  [ -use-start-tls-for-ad-ldap {true|false} ]
Use start_tls for AD LDAP Connections
  [ -is-aes-encryption-enabled {true|false} ]
Is AES-128 and AES-256 Encryption for Kerberos Enabled
  [ -lm-compatibility-level {lm-ntlm-ntlmv2-krb|ntlm-ntlmv2-krb|ntlmv2-krb|krb} ]
LM Compatibility Level
  [ -is-smb-encryption-required {true|false} ]
Require SMB Encryption for Incoming CIFS Traffic
  [ -session-security-for-ad-ldap {none|sign|seal} ]
Client Session Security
  [ -smb1-enabled-for-dc-connections {false|true|system-default} ]
SMB1 Enabled for DC Connections
  [ -smb2-enabled-for-dc-connections {false|true|system-default} ]
SMB2 Enabled for DC Connections
  [ -referral-enabled-for-ad-ldap {true|false} ]
LDAP Referral Chasing Enabled For AD LDAP Connections
  [ -use-ldaps-for-ad-ldap {true|false} ]
```

The CIFS/SMB security options apply to LDAP lookups for CIFS/SMB communication. For UNIX LDAP communication with Active Directory, use the LDAP client settings. To get the best possible security, use both the CIFS/SMB and LDAP client security settings.

Use of LDAP to host netgroups

You can leverage netgroup functionality in LDAP, which is not possible in NIS. Netgroups enable storage administrators to control access to a series of hosts by using a group, rather than having to create several different rules per host. In LDAP, you can use ONTAP to store and to query host names, IP addresses, and netgroup entries. The use of LDAP as a NIS server is covered in RFC 2307. Currently, only host names and IP addresses are supported for use with netgroups in ONTAP.

About NIS objects and attributes in LDAP

NIS object types in LDAP are determined by way of the `objectClass` attribute. The `objectClass` attribute that is set on an object determines how ONTAP and other LDAP clients query LDAP for netgroup-related objects. For netgroups, the `nisNetgroup` object class is used by default in most schemas, including Active Directory and FreeIPA. Table 11 presents a summary.

Table 11) Object class types for netgroups.

objectClass	Used for	Common attributes used
nisMap	NIS maps	nisMapName
nisNetgroup	Netgroups	nisMapName nisNetgroupTriple

objectClass	Used for	Common attributes used
`nisObject`	Netgroups `netgroup.byhost` entries	`nisMapEntry` `nisMapName`

NIS object terminology

Table 12 defines terminology for specific aspects of NIS objects.

Table 12) NIS object terminology.

Term	Definition

NIS map	NIS maps are designed to centralize and to replace commonly found files in the `/etc` directory of Linux and UNIX clients.
	
	ONTAP currently supports the following NIS map types:
	`Passwd.byname` and `passwd.byuid`
	`Group.byname` and `group.bygid`
	Netgroup
	`netgroup.byhost` (as of ONTAP 8.3)
	
	ONTAP does not currently support host name resolution in NIS.
	For more information about NIS maps, see Oracle NIS Maps.

Netgroup	A netgroup is a set of (host,user,domain) triples that are used for permission and export access checking. ONTAP currently supports only hosts in netgroup entries. The netgroup must use only a comma (,) as the delimiter. For more information about netgroups, see the Linux manual pages and the FreeBSD Manual Pages.
Triple	A netgroup triple refers to the series of entries in a netgroup file, consisting of (host,user,domain). A valid triple in ONTAP consists of (`host,,`). When you designate a blank field, be sure to follow the netgroup file standard guidance for your operating system. Special characters, such as dashes, can cause lookups to fail and access to be denied. Host names that are used in netgroup triples require DNS resolution in ONTAP. For best results in netgroup translation, see the name services best practices in TR-4067 and TR-4668.
`netgroup.byhost`	`netgroup.byhost` entries are used to accelerate netgroup lookups by querying the name service for the group membership by host rather than querying the entire netgroup. For netgroups with many entries, this process can reduce lookup time drastically and improve performance. For more information about `netgroup.byhost` support, see the section, “netgroup.byhost Support.”

ONTAP interaction with Active Directory LDAP for netgroups

In the schemas that ONTAP provides, the following attributes control lookups for netgroups and their members:

```
-nis-netgroup-object-class
-nis-netgroup-triple-attribute
-member-nis-netgroup-attribute
-cn-netgroup-attribute
```

In ONTAP 8.3 and later, the following attributes are provided to support `netgroup.byhost`; for more information, see the “netgroup.byhost Support” section:

```
-nis-object-class
-nis-mapname-attribute
```

```
-nis-mapentry-attribute
```

You can modify LDAP client schemas to change the default attributes for netgroups. In most cases, the provided read-only templates work, but in some cases, you might have to copy a schema template to a new template and modify it. For more information about schemas, see the section in this document titled "LDAP schemas."

The Active Directory schema has the following schema attributes added by default in Windows 2012 and later (the default attributes that ONTAP uses are in bold):

```
memberNisNetgroup
msSFU30Name
msSFU30NetgroupHostAtDomain
msSFU30NetgroupUserAtDomain
msSFU30NisDomain
NisMap
nisMapEntry
nisMapName
nisNetgroup
nisNetgroupTriple
nisObject
```

Creating netgroups With Active Directory LDAP

Active Directory netgroups can be controlled by using the utilities `nis2ad` and `nismap`, PowerShell, or GUI tools such as ADSI Edit.

Use of nismap to create NIS objects

With `nis2ad`, you can migrate existing maps from NIS to Active Directory, or you can create NIS maps from a local file. This utility is included in the Identity Management for UNIX feature in Windows 2008 and later. However, you generally do not need it unless you create new NIS maps outside of the default `netgroup` NIS map that AD-IDMU creates.

The `nismap` command enables granular management of NIS maps in addition to what `nis2ad` provides.

The `-e` flag lists the netgroup/nismap entry. The format follows the same formats that are used in NIS netgroup files and that are covered in the Linux manual pages.

Note: The `ipHostNumber` attribute is used for lookups of the NIS host IP information for most LDAP servers and clients. ONTAP does not support this attribute.

Following is a sample `nismap` command:

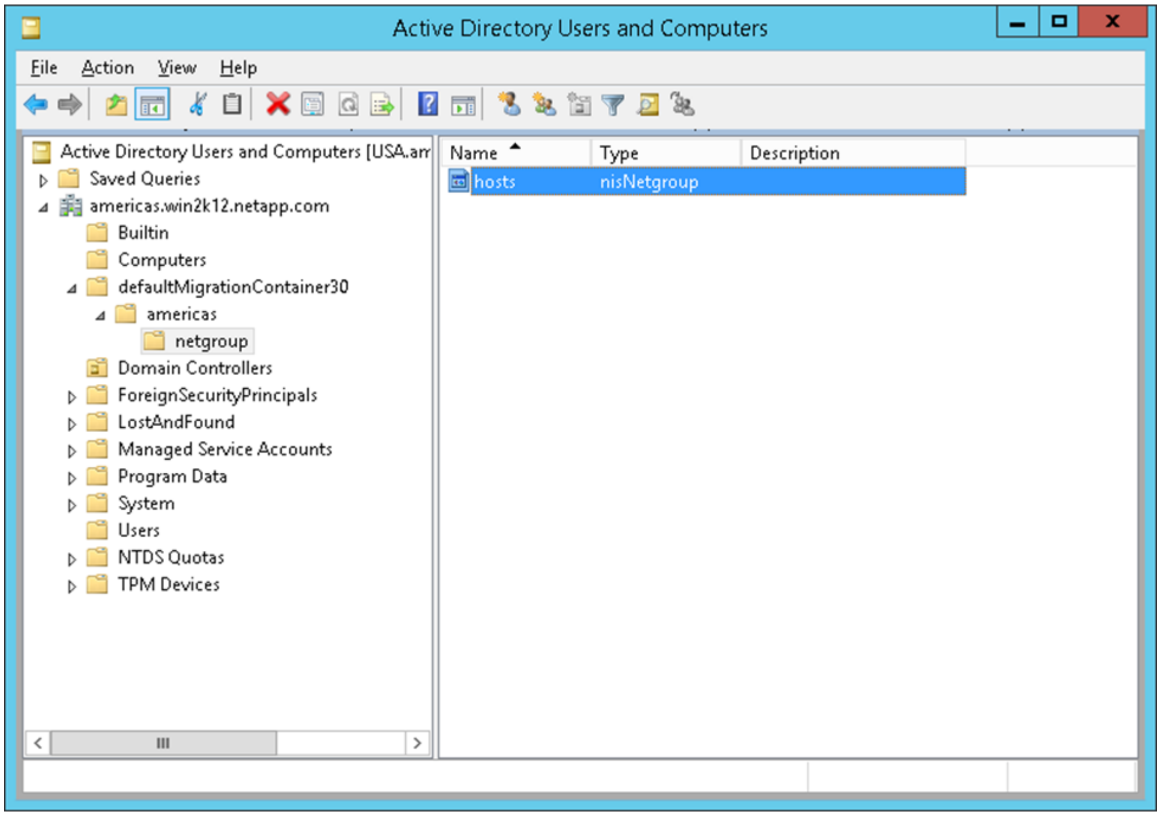
```
C:\>nismap add -a americas -s USA -c C:\nisadd.txt -e "hosts
(host1,,) (host2,,)" netgroup
Activity = Adding  map = 'netgroup'...
SUCCESS
Adding the object in Active Directory Domain Services.
Object = 'hosts'
Object class = 'NisNetgroup'
container =
'CN=netgroup,CN=americas,CN=DefaultMigrationContainer30,DC=americas,DC=win2k12,DC=netapp,DC=com'.

SUCCESS
adding NIS entries to AD
```

In the preceding example, the following occurred (see Figure 21):

- An object called `hosts` was created.
- The object class of `NisNetgroup` was applied to the object.
- The default container was `'CN=netgroup,CN=americas,CN=DefaultMigrationContainer30,DC=americas,DC=win2k12,DC=netapp,DC=com'`.

The netgroup DN will be used when configuring the LDAP client in ONTAP using the `-netgroup-dn` field to provide DN filtering for netgroup LDAP queries.

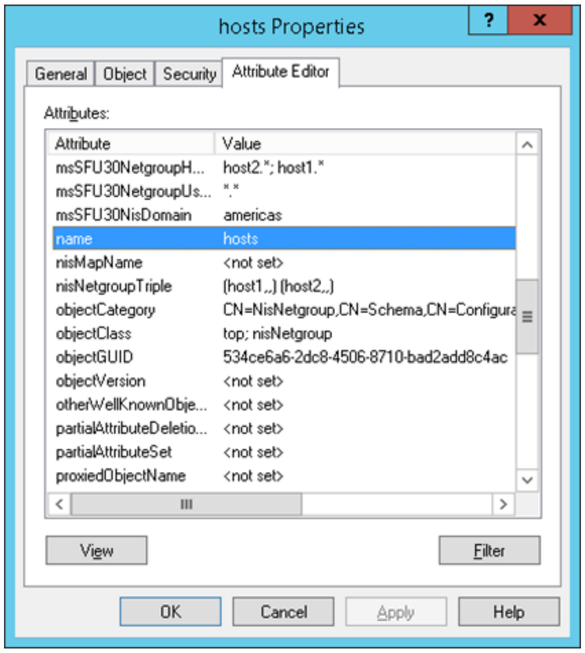
Figure 21) Example of the hosts netgroup created in Active Directory LDAP with nismap.



Name	Type	Description
hosts	nisNetgroup	

You can view the attributes for the object by double-clicking the attribute and selecting Attribute Editor; see Figure 22.

Figure 22) Netgroup properties in Active Directory LDAP.



Attributes:

Attribute	Value
msSFU30NetgroupH...	host2.*; host1.*
msSFU30NetgroupUs...	*.*
msSFU30NisDomain	americas
name	hosts
nisMapName	<not set>
nisNetgroupTriple	(host1,,) (host2,,)
objectCategory	CN=NisNetgroup,CN=Schema,CN=Configura
objectClass	top; nisNetgroup
objectGUID	534ce6a6-2dc8-4506-8710-bad2add8c4ac
objectVersion	<not set>
otherWellKnownObje...	<not set>
partialAttributeDeletio...	<not set>
partialAttributeSet	<not set>
proxiedObjectName	<not set>

Use of PowerShell to create or to manage new netgroups

PowerShell also includes cmdlets that give administrators a way to use a more familiar tool to create and to manage netgroups.

Those cmdlets are as follows:

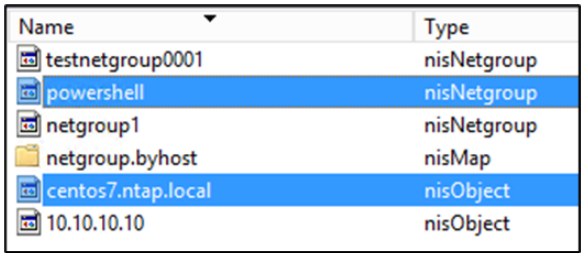
```
New-NfsNetgroup
Get-NfsNetgroup
Set-NfsNetgroup
Remove-NfsNetgroup
```

For example, create a new netgroup called `powershell`, of which the host `centos7.ntap.local` is a member.

```
C:\> New-NfsNetgroup -NetGroupName powershell -AddMember centos7.ntap.local -LdapNamingContext
"OU=netgroups,DC=NTAP,DC=local" -LdapServer ntap.local
```

When you run the preceding command, two entries are created in the location that you specified: the netgroup called `powershell` and a host entry named `centos7.ntap.local`. See Figure 23.

Figure 23) Entries created by New-NfsNetgroup in Active Directory.



Name	Type
testnetgroup0001	nisNetgroup
powershell	nisNetgroup
netgroup1	nisNetgroup
netgroup.byhost	nisMap
centos7.ntap.local	nisObject
10.10.10.10	nisObject

By default, those entries use the classic netgroup functionality in ONTAP, which queries a netgroup, fetches all hosts in the netgroup, and populates the netgroup cache.

To modify the host entry to use `netgroup.byhost` functionality, simply rename the object by using the `Rename-ADObject` PowerShell cmdlet. This step is necessary to change the host name to append `.*` to the end of the name so that ONTAP knows that the DNS query ends there.

For example:

```
PS C:\> Rename-ADObject -Identity "CN=centos7.ntap.local,OU=netgroups,DC=NTAP,DC=local" -NewName
centos7.ntap.local.*
```

After that step, you can use `netgroup.byhost` functionality with netgroups that are created in Active Directory. For more information about `netgroup.byhost` functionality, see section, "netgroup.byhost Support," in this document.

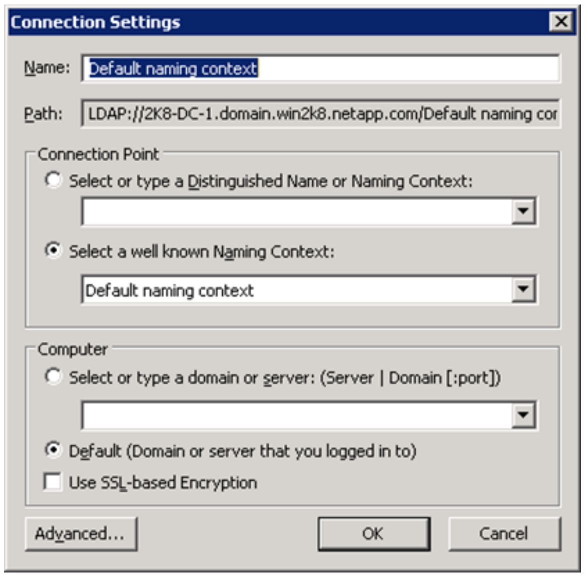
Use of ADSI Edit to create new NIS objects

Another way to create NIS objects is to use the ADSI Edit tool in Active Directory. To use ADSI Edit, make sure that it is installed.

Note: **ADSI Edit should be used with extreme caution**, because serious damage to the Active Directory schema can occur if it is not used correctly. If you need help with using ADSI Edit, contact Microsoft technical support.

After ADSI Edit is installed, open the ADSI Edit console and connect to the default naming context path. See Figure 24.

Figure 24) Connecting to default naming context.



Connection Settings

Name: Default naming context

Path: LDAP://2K8-DC-1.domain.win2k8.netapp.com/Default naming cor

Connection Point

( ) Select or type a Distinguished Name or Naming Context:

(●) Select a well known Naming Context: Default naming context

Computer

( ) Select or type a domain or server: (Server | Domain [:port])

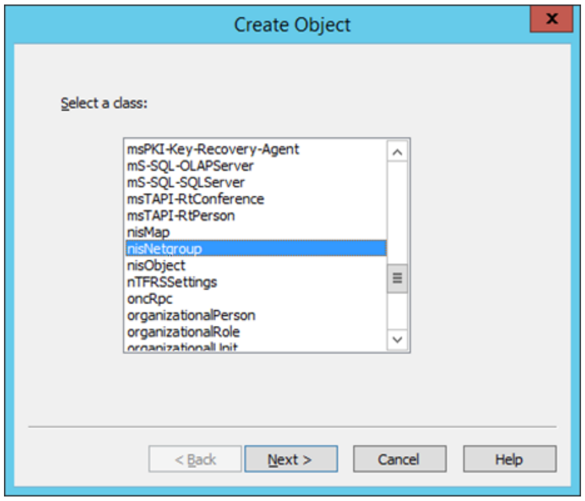
(●) Default (Domain or server that you logged in to)

☐ Use SSL-based Encryption

After you are connected, the entire Active Directory schema is shown. If a container for NIS objects does not exist, it might make sense to create one for organizational purposes.

To create a container, right-click when the desired location is highlighted and select New > Object. This step brings up a new dialog box that enables you to specify the object type (or object class). See Figure 25.

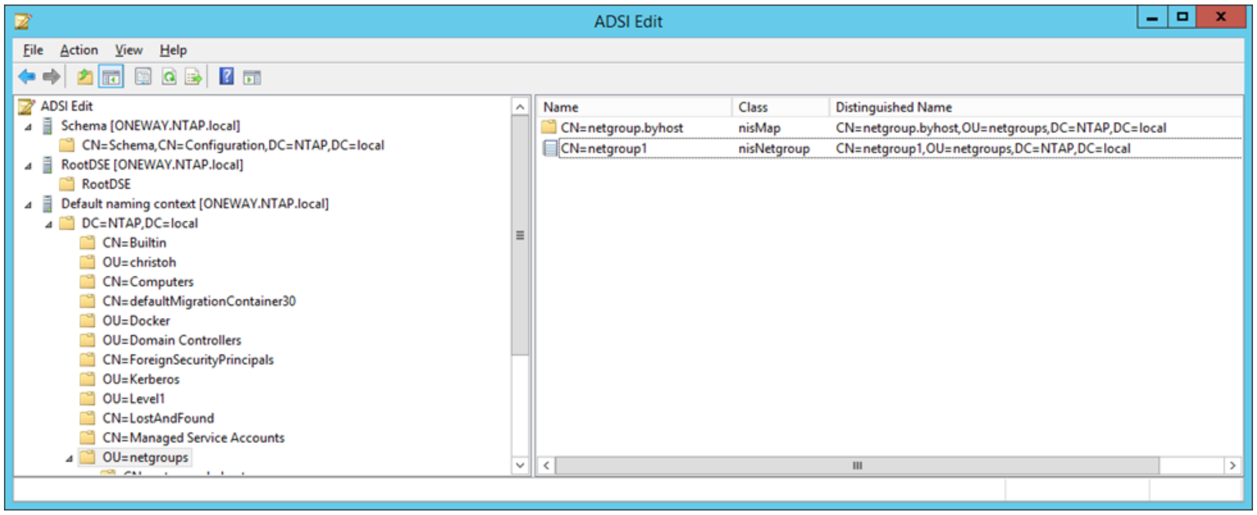
Figure 25) Creating a new object.



- **nisMap** enables you to create a `netgroup.byhost` map entry.
- **nisNetgroup** creates a classic netgroup.
- **nisObject** enables you to create a host entry to use for netgroup lookups.

For example, the LDAP server in Figure 26 has two entries in the netgroups OU.

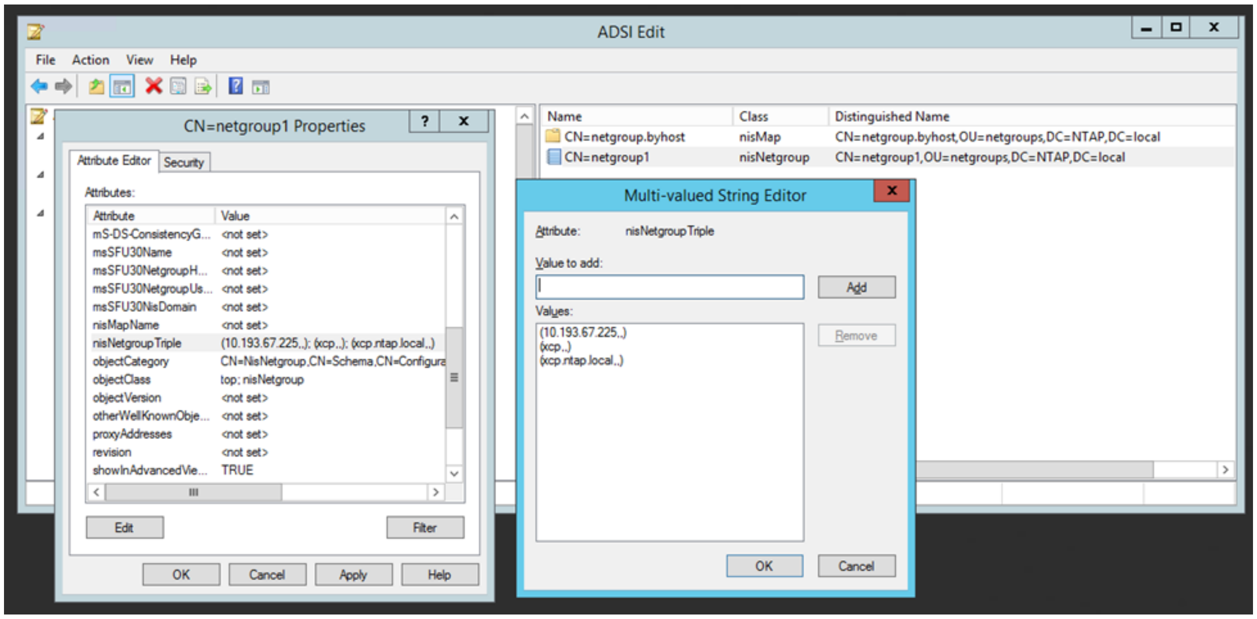
Figure 26) Netgroup objects in Active Directory.


ADSI Edit
File
Action
View
Help
ADSI Edit
Schema [ONEWAY.NTAP.local]
CN=Schema,CN=Configuration,DC=NTAP,DC=local
RootDSE [ONEWAY.NTAP.local]
RootDSE
Default naming context [ONEWAY.NTAP.local]
DC=NTAP,DC=local
CN=Builtin
OU=christoh
CN=Computers
CN=defaultMigrationContainer30
OU=Docker
OU=Domain Controllers
CN=ForeignSecurityPrincipals
OU=Kerberos
OU=Level1
CN=LostAndFound
CN=Managed Service Accounts
OU=netgroups

Name	Class	Distinguished Name
CN=netgroup.byhost	nisMap	CN=netgroup.byhost,OU=netgroups,DC=NTAP,DC=local
CN=netgroup1	nisNetgroup	CN=netgroup1,OU=netgroups,DC=NTAP,DC=local

In the preceding example, `netgroup1` is a regular netgroup. It uses the typical `nisNetgroupTriple` logic, such as (hostname,-,-). See Figure 27.

Figure 27) Entries in netgroup1.



Name	Class	Distinguished Name
CN=netgroup.byhost	nisMap	CN=netgroup.byhost,OU=netgroups,DC=NTAP,DC=local
CN=netgroup1	nisNetgroup	CN=netgroup1,OU=netgroups,DC=NTAP,DC=local

Attributes:

Attribute	Value
mS-DS-ConsistencyG...	<not set>
msSFU30Name	<not set>
msSFU30NetgroupH...	<not set>
msSFU30NetgroupUs...	<not set>
msSFU30NisDomain	<not set>
nisMapName	<not set>
nisNetgroupTriple	(10.193.67.225,,); (xcp,,); (xcp.ntap.local,,)
objectCategory	CN=NisNetgroup,CN=Schema,CN=Configura
objectClass	top; nisNetgroup
objectVersion	<not set>
otherWellKnownObje...	<not set>
proxyAddresses	<not set>
revision	<not set>
showInAdvancedVie...	TRUE

Attribute: nisNetgroupTriple

Value to add:

Values:
(10.193.67.225,,)
(xcp,,)
(xcp.ntap.local,,)

Create a netgroup.byhost entry

To create a `netgroup.byhost` entry, create a `nisObject` for the host name, with `.*` appended to the end of the name. This step tells ONTAP that the host entry's DNS name is finished and can be used for host name lookup. For example, a host named `centos7.ntap.local` is created as `centos7.ntap.local.*` when creating the `netgroup.byhost` entry.

Following is a working `netgroup.byhost` netgroup query in ONTAP, using Active Directory LDAP:

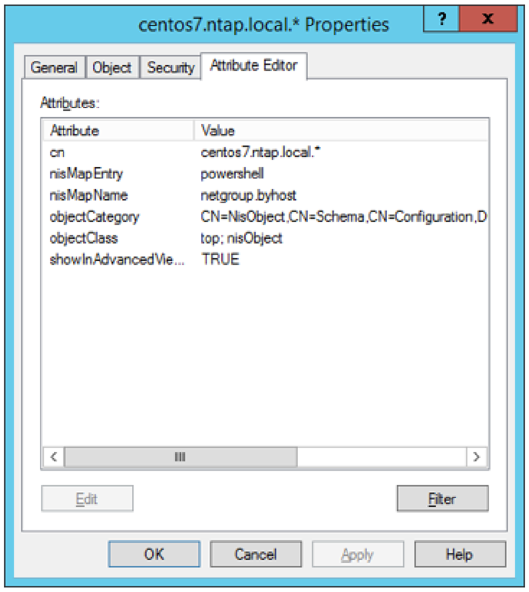
```
cluster::*> getxxbyyy netgrpcheck -node node01 -vserver DEMO -netgroup powershell -clientIP
10.193.67.225 -show-source true
  (vserver services name-service getxxbyyy netgrpcheck)
Success. Client 10.193.67.225 is member of netgroup powershell
Searched using NETGROUP_BYHOST
Source used for lookup: LDAP
```

The `nisMap` attribute tells the LDAP server and client that the entry is a type of map. For an explanation of NIS maps and to see examples of different types of NIS maps, go to NIS Maps. ONTAP supports only `netgroup.byhost` as a NIS map.

The examples in Figure 28 show a netgroup and a `netgroup.byhost` object in Active Directory, along with their associated attributes.

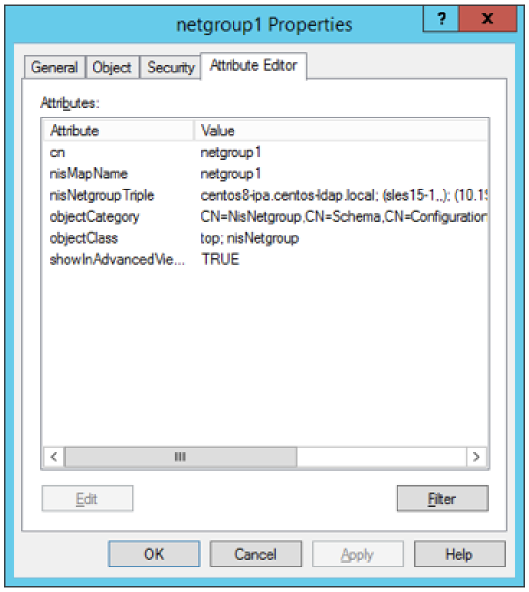
Figure 28) Netgroup and netgroup.byhost entries in Active Directory LDAP.

netgroup.byhost entry



Attribute	Value
cn	centos7.ntap.local.*
nisMapEntry	powershell
nisMapName	netgroup.byhost
objectCategory	CN=NisObject,CN=Schema,CN=Configuration,D
objectClass	top; nisObject
showInAdvancedVie...	TRUE

Netgroup entry



Attribute	Value
cn	netgroup1
nisMapName	netgroup1
nisNetgroupTriple	centos8-ipa.centos-ldap.local; (sles15-1,,); (10.1
objectCategory	CN=NisNetgroup,CN=Schema,CN=Configuration
objectClass	top; nisNetgroup
showInAdvancedVie...	TRUE

Manage netgroup objects with the GUI in Windows

After a netgroup object has been created with ADSI Edit or one of the CLI methods, you can manage the entries with the Active Directory Users and Computers (ADUC) MMC. Because there are safeguards in ADUC, that method is preferred over ADSI Edit. Everything in Figure 28 except the CN field can be modified in the GUI, including adding, changing, and removing netgroup clients or changing the `nisMapEntry`. To modify the CN field, use the `Rename-ADObject` command in PowerShell.

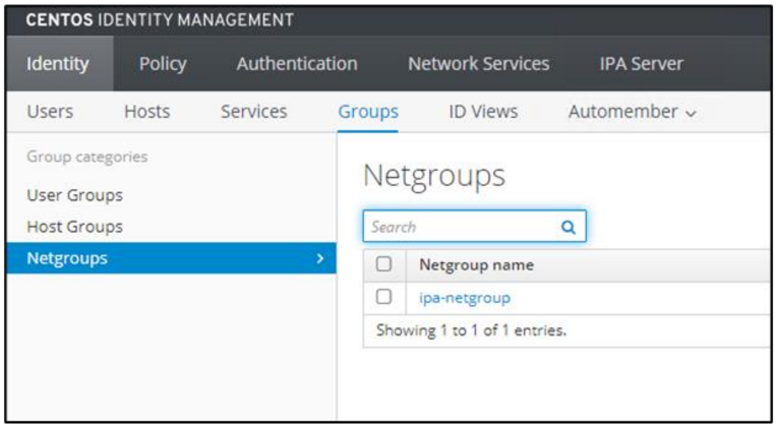
Creating netgroups with FreeIPA LDAP

You can also use FreeIPA LDAP to create and to manage netgroups. The easiest method is through the provided GUI webpage. To connect to the FreeIPA web interface, simply navigate to `http://freeipaserver` in a web browser.

Add netgroups in FreeIPA LDAP

The netgroup management GUI is in Identity > Groups in the FreeIPA GUI. See Figure 29.

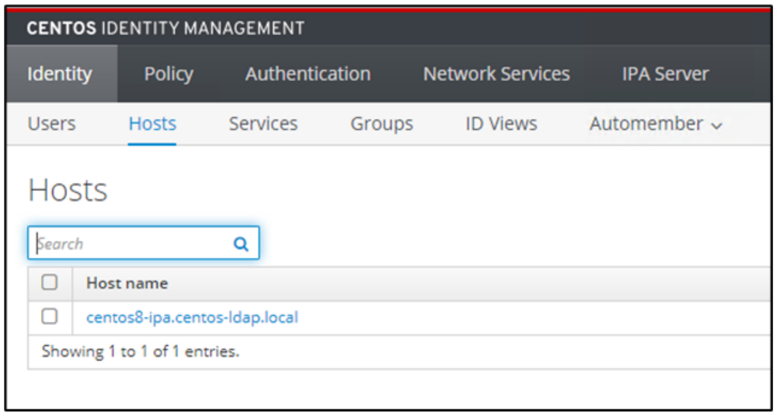
Figure 29) FreeIPA Netgroups.



To create new netgroups, click Add. To edit existing netgroups (add or remove hosts or IP addresses), select the netgroup name.

To add hosts, you can use the Hosts tab under the same Identity part of the GUI. See Figure 30.

Figure 30) FreeIPA Hosts.



After you have created a netgroup, you can verify that it works through the ONTAP CLI.

```
cluster::*> getxxbyyy netgrpcheck -node node1 -vserver NFS -netgroup ipa-netgroup -clientIP
10.193.67.222 -show-source true
  (vserver services name-service getxxbyyy netgrpcheck)
Success. Client 10.193.67.222 is member of netgroup ipa-netgroup
Searched using NETGROUP_BYNAME
Source used for lookup: LDAP
```

Netgroup caches in ONTAP

ONTAP uses several caches to store information such as host names and netgroups locally. This method is faster than having to retrieve this information from an external source each time that it is required.

Export policies and rules control access to NFS exports. Each export policy contains rules, and each rule contains parameters to control client access. Some of these parameters require ONTAP to contact an external source such as DNS or NIS servers to resolve objects such as domain names, host names, or netgroups. Communications with external sources can have associated latency because of the load, network, and so on. To improve performance, ONTAP reduces the amount of time that it takes to resolve export policy rule objects by storing information locally in several caches.

One main disadvantage to the use of caches to store information locally is that if the information about the external name server was changed after ONTAP retrieved and stored it locally, the caches might contain outdated information. As a result, client access requests that should succeed could fail, and client access requests that should fail could succeed. To help avoid such issues, ONTAP flushes caches automatically after a certain period and provides commands that enable you to view and to manually flush some of the export policy caches.

For more information about commands to view and flush caches and to view and modify timeout values, see section, “ONTAP CLI commands for LDAP troubleshooting.”

NIS netgroup strict (nfs.netgroup.strict)

In ONTAP operating in 7-Mode, the option `nfs.netgroup.strict` allowed control of whether a netgroup entry required the @ sign so that Data ONTAP recognized the netgroup as a netgroup.

ONTAP currently has no equivalent to the `nfs.netgroup.strict` option. All netgroups in export policy rules must be designated with the @ sign to be recognized as netgroups. If no @ sign is present, ONTAP treats the entry as a host name and attempts to resolve the name in DNS or local hosts.

netgroup.byhost Support

`netgroup.byhost` entries can vastly speed up netgroup entry lookup. With `netgroup.byhost`, the cluster can avoid having to query every entry in a netgroup for access and instead can fetch the netgroup by way of LDAP lookup per host. In large environments with netgroups that have many entries, this approach can drastically speed up the time for lookups and can avoid access issues due to timeouts on LDAP queries. Support for `netgroup.byhost` was added to ONTAP starting with version 8.3.

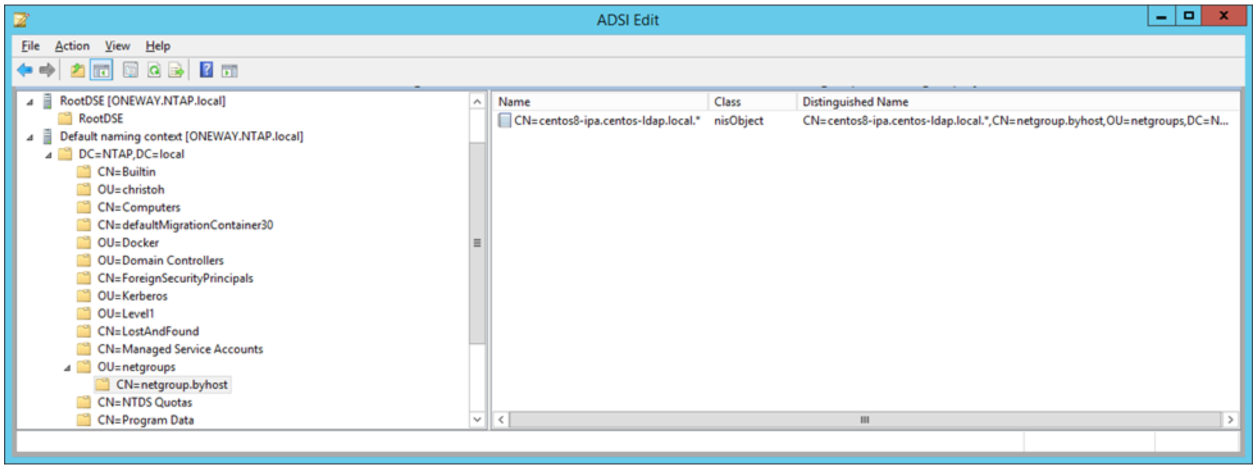
netgroup.byhost Example

The section, “Creating netgroups With Active Directory LDAP,” showed you how to create a netgroup by using Windows Active Directory. One of the netgroups that was created is named `netgroup1`, and it is also a `nisMapEntry`. Therefore, it can act as a standalone netgroup (`-is-netgroup-byhost-enabled false`) or as a way for host-performed netgroup queries to map to a netgroup (`-is-netgroup-byhost-enabled true`).

The previously mentioned section also showed examples of host entries that you can use with `netgroup.byhost`.

For example, say that you have a host set in the `netgroup.byhost` object. That host is your Free IPA server, `centos8-ipa`, with an IP address of 10.193.67.222. Note in Figure 31 that `.*` is at the end of the name to alert ONTAP that there are no more parts of the name to look up in DNS.

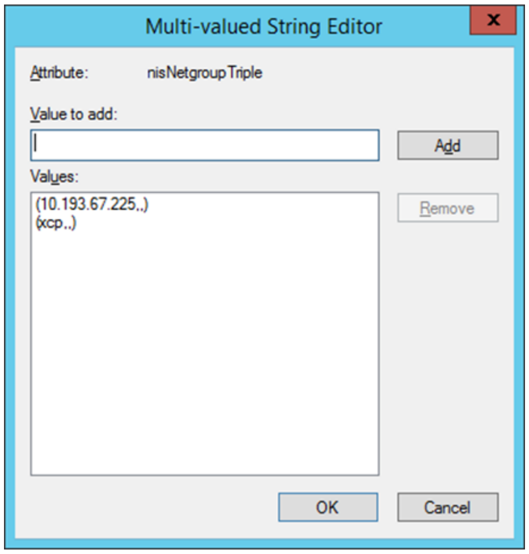
Figure 31) Hosts in the netgroup.byhost object.



RootDSE [ONEWAY.NTAP.local]
RootDSE
Default naming context [ONEWAY.NTAP.local]
DC=NTAP,DC=local
CN=Builtin
OU=christoh
CN=Computers
CN=defaultMigrationContainer30
OU=Docker
OU=Domain Controllers
CN=ForeignSecurityPrincipals
OU=Kerberos
OU=Level1
CN=LostAndFound
CN=Managed Service Accounts
OU=netgroups
CN=netgroup.byhost
CN=NTDS Quotas
CN=Program Data

Name	Class	Distinguished Name
CN=centos8-ipa.centos-ldap.local.*	nisObject	CN=centos8-ipa.centos-ldap.local.*,CN=netgroup.byhost,OU=netgroups,DC=N...

Figure 32) nisNetgroupTriple entries in netgroup1.



Attribute: nisNetgroupTriple

Value to add:

Values:
(10.193.67.225,,)
(xcp,,)

As Figure 32 shows, `netgroup1` has only the following `nisNetgroupTriple` entries.

Therefore:

- When `netgroup.byhost` support is enabled, then only `centos8-ipa` has access to exports that have `netgroup1` assigned, because it is the only host that is defined.
- When `netgroup.byhost` support is disabled, then `centos8-ipa` is denied access and the hosts in the `nisNetgroupTriple` field get access.

You can verify this information with the command `export-policy check-access`. (You can find more information about this command in the section, "export-policy.")

Example of netgroup.byhost disabled

In this example, because `netgroup.byhost` is disabled, the `centos8-ipa` client does not have access to the volume with the netgroup export policy, but clients in the `nisNetgroupTriple` field (`10.193.67.225` and `xcp`) do.

```
cluster::*> ldap client show -client-config DEMO -fields is-netgroup-byhost-enabled
vserver client-config is-netgroup-byhost-enabled
------- ------------- --------------------------
DEMO    DEMO          false

cluster::*> export-policy check-access -vserver DEMO -volume netgrpvol -client-ip 10.193.67.222 -
authentication-method sys -protocol nfs3 -access-type read-write
                                                      Policy    Policy       Rule
Path                          Policy     Owner     Owner Type  Index Access
----------------------------- ---------- --------- ---------- ------ ----------
/                             default    vsroot    volume          2 read
/netgrpvol                    netgroup   netgrpvol volume          0 denied
```

```
cluster::*> export-policy check-access -vserver DEMO -volume netgrpvol -client-ip 10.193.67.225 -
authentication-method sys -protocol nfs3 -access-type read-write
                                         Policy    Policy       Rule
Path                          Policy     Owner     Owner Type  Index Access
----------------------------- ---------- --------- ---------- ------ ----------
/                             default    vsroot    volume          2 read
/netgrpvol                    netgroup   netgrpvol volume          1 read-write

cluster::*> export-policy check-access -vserver DEMO -volume netgrpvol -client-ip 10.193.67.233 -
authentication-method sys -protocol nfs3 -access-type read-write
                                         Policy    Policy       Rule
Path                          Policy     Owner     Owner Type  Index Access
----------------------------- ---------- --------- ---------- ------ ----------
/                             default    vsroot    volume          2 read
/netgrpvol                    netgroup   netgrpvol volume          1 read-write
```

When you view the netgroup cache, you can see that the successful clients used `netgroup_byname` (or `netgrp_byname)` to gain access. The failed access shows a source of `none`, which means that it is in the negative cache.

Example of netgroup.byhost enabled

In this example, the cache is cleared, and `netgroup.byhost` support is enabled on the LDAP client. This action reverses the results; `centos8-ipa` has access and the other clients do not.

```
cluster::*> name-service cache netgroups ip-to-netgroup delete-all -vserver DEMO
  (vserver services name-service cache netgroups ip-to-netgroup delete-all)
Notice: This operation  may take some time to complete.

cluster::*> name-service cache netgroups ip-to-netgroup show -vserver DEMO
  (vserver services name-service cache netgroups ip-to-netgroup show)
There are no entries matching your query.

cluster::*> ldap client modify -client-config DEMO -vserver DEMO -is-netgroup-byhost-enabled true

Warning: For the netgroup.byhost feature to work correctly, ensure that the values for the "nis-
object-class", "nis-mapname-attribute" and "nis-mapentry-attribute" parameters in the associated
schema match your LDAP schema using the "vserver services name-service ldap client schema"
commands.

cluster::*> ldap client show -client-config DEMO -fields is-netgroup-byhost-enabled
vserver client-config is-netgroup-byhost-enabled
------- ------------- --------------------------
DEMO    DEMO          true

cluster::*> export-policy check-access -vserver DEMO -volume netgrpvol -client-ip 10.193.67.222 -
authentication-method sys -protocol nfs3 -access-type read-write
                                         Policy    Policy       Rule
Path                          Policy     Owner     Owner Type  Index Access
----------------------------- ---------- --------- ---------- ------ ----------
/                             default    vsroot    volume          2 read
/netgrpvol                    netgroup   netgrpvol volume          0 denied

cluster::*> export-policy check-access -vserver DEMO -volume netgrpvol -client-ip 10.193.67.225 -
authentication-method sys -protocol nfs3 -access-type read-write
                                         Policy    Policy       Rule
Path                          Policy     Owner     Owner Type  Index Access
----------------------------- ---------- --------- ---------- ------ ----------
/                             default    vsroot    volume          2 read
/netgrpvol                    netgroup   netgrpvol volume          1 read-write

cluster::*> export-policy check-access -vserver DEMO -volume netgrpvol -client-ip 10.193.67.233 -
authentication-method sys -protocol nfs3 -access-type read-write
                                         Policy    Policy       Rule
Path                          Policy     Owner     Owner Type  Index Access
----------------------------- ---------- --------- ---------- ------ ----------
/                             default    vsroot    volume          2 read
/netgrpvol                    netgroup   netgrpvol volume          1 read-write
```

```
cluster::*> name-service cache netgroups ip-to-netgroup show -vserver DEMO
  (vserver services name-service cache netgroups ip-to-netgroup show)
Vserver     IP Address  Netgroup     Source  Create Time
---------- ----------- ------------ ------- -----------
DEMO        10.193.67.222
                        netgroup1    none    2/20/2020 22:09:18
DEMO        10.193.67.225
                        netgroup1    netgrp_byname
                                             2/20/2020 22:09:25
DEMO        10.193.67.233
                        netgroup1    netgrp_byname
                                             2/20/2020 22:09:31
```

Enable netgroup.byhost support in ONTAP

`netgroup.byhost` support is not enabled by default in ONTAP. To enable it, the following options in the LDAP client configuration must be modified:

```
-is-netgroup-byhost-enabled
-netgroup-byhost-dn
-netgroup-byhost-scope
```

Naturally, `-is-netgroup-byhost-enabled` must be enabled to allow the use of `netgroup.byhost` functionality.

DN and scope specify the filters that you want for `netgroup.byhost` functionality. For more information, see the administration guides for your release of ONTAP. Keep in mind that support for this feature applies only to ONTAP 8.3 and later versions.

Configure external LDAP clients

ONTAP SVMs are LDAP clients that can communicate with LDAP servers to query users and groups. You can also configure client OSs to use LDAP queries to the same LDAP server. With this configuration, ONTAP and Linux/NFS clients can use the same source for users and groups, which provides consistent access permissions with minimal file management.

This section covers the SSSD LDAP module. Other LDAP clients are not covered in this section, but the same general concepts apply.

In general, you follow these steps:

1. Install or update the LDAP client if it is not already installed or updated.
2. Join the client to the Active Directory domain if you are using Active Directory LDAP and if you want to use Kerberos for LDAP binds.
3. Ensure that the DNS is configured properly on the client.
4. Configure the `nsswitch.conf` file to use `sss` for passwd, group, and netgroup (if necessary).

   Note: Comment out initgroups, as it can break supplemental GID lookups.
5. Configure the LDAP client to use `LDAP` for the `id_provider`.
6. Configure the LDAP client to use the LDAP client schema options that you want.

Detailed steps for SSSD are in the following section.

Note: For other LDAP client configurations, see the vendor documentation.

SSSD—Linux LDAP client

SSSD is a system daemon that Red Hat and Fedora developed as a replacement for PADL, Samba Winbind, and other Active Directory–based PAM and `nss` modules. SSSD delivers access to different identity and authentication providers. To use the new LDAP interface, a new PAM module called `pam_sss` was created. SSSD includes an Active Directory provider type, enabling easy integration with

Windows Active Directory 2003, 2008, and 2012. SSSD leverages TLS encryption and LDAP by using GSSAPI, which enables more secure LDAP binding and lookups over the wire.

The steps in this document cover setting up SSSD to use GSSAPI (Kerberos) for authenticated LDAP binds. SSSD uses the strongest Kerberos encryption type that is supported by the client and the Active Directory domain controller.

SSSD configuration uses the `/etc/sssd/sssd.conf` file on clients that support SSSD. Each time that you change the configuration, you should restart SSSD.

You can configure SSSD to cache the name database on the client. For performance reasons, NetApp recommends that you do this step. However, caching can cause confusion in troubleshooting, so when you restart the service during troubleshooting, use the following to clear the cache:

```
[client] # service sssd stop
[client] # rm -f /var/lib/sss/db/*
[client] # service sssd start
```

SSSD is also case sensitive by default. Because Microsoft Active Directory does not care about case sensitivity, NetApp recommends that you configure SSSD to ignore case sensitivity.

RHEL, CentOS, and Fedora client configuration

The following assumes that the kernel that is running supports the SSSD LDAP package. Some newer versions of Linux include SSSD by default in basic installations. If SSSD is not installed, install it.

To check for the application, run the following command:

```
[client] # yum list | grep sssd
```

To install it, run the following command:

```
[client] # yum install -y sssd
```

If the application is already installed, it might be beneficial to upgrade by running the following command:

```
[client] # yum update -y sssd
```

For Active Directory LDAP environments, to make setup and use easier, join the Linux client to the domain. This step allows the client to use the KDC functionality of the Active Directory domain without extra setup steps, which provides secure binds through Kerberos and automatically configures SSSD and the `krb5.conf` file for Active Directory user lookup. UNIX identity lookups require a bit of additional configuration, but the brunt of the work is performed by the `realmd` application.

```
[client] # yum install -y realmd
```

Older clients might require manual Kerberos configuration or the use of `net ads` commands. For details, see TR-4616 or the client OS documentation.

After the applications are installed, you can start the configuration process.

Configure DNS

DNS is necessary for various functions, including Kerberos and LDAP. Specifically, DNS is used to resolve host names, which are used to query for SPNs. Also, DNS queries for LDAP SRV records.

You can configure DNS through one of the client-specific command utility wizards or through basic editing of the `/etc/resolv.conf` file. The DNS server and search domains that you apply should be able to query for host names and SPNs that are in use by the client.

For information about how to configure DNS in RHEL and CentOS, see Changing Domain DNS Configuration on the Red Hat Customer Portal.

Join the Key Distribution Center

Key Distribution Centers (KDCs) provide Kerberos authentication services to environments. LDAP applications such as SSSD use LDAP servers through logins called “binds.” Binds can be anonymous or use plaintext passwords, but, ideally, binds use as much security as possible. The use of Kerberos interaction with KDCs for binds is one way to promote such extensive security.

SSSD provides a way to bind to LDAP through a Kerberos SPN to encrypt binds with the strongest available Kerberos encryption type (currently AES-256 in newer KDCs). It can be done manually through the `sssd.conf` file, or it can be done automatically by using domain join tools, such as `realm`.

Following are the available `realm` commands:

```
# realm
 realm discover -v [realm-name]
   Discover available realm

 realm join -v [-U user] realm-name
   Enroll this machine in a realm

 realm leave -v [-U user] [realm-name]
   Unenroll this machine from a realm

 realm list
   List known realms

 realm permit [-ax] [-R realm] user ...
   Permit user logins

 realm deny --all [-R realm]
   Deny user logins
```

You can check that DNS is doing its job, as well as check for application dependencies, with the `realm discover -v [realm-name]` command.

```
# realm discover -v NTAP.LOCAL
 * Resolving: _ldap._tcp.ntap.local
 * Performing LDAP DSE lookup on: 10.193.67.236
 * Successfully discovered: NTAP.LOCALNTAP.LOCAL
NTAP.LOCALNTAP.LOCAL
  type: kerberos
  realm-name: NTAP.LOCAL
  domain-name: NTAP.LOCALNTAP.LOCAL
  configured: no
  server-software: active-directory
  client-software: sssd
  required-package: sssd-tools
  required-package: sssd
  required-package: adcli
  required-package: samba-client
ntap.local
  type: kerberos
  realm-name: NTAP.LOCAL
  domain-name: ntap.local
  configured: no
```

Before you run the `realm join` command, check your `krb5.conf` file. In this example, you see that nothing is configured.

```
# cat /etc/krb5.conf
# Configuration snippets may be placed in this directory as well
includedir /etc/krb5.conf.d/

[logging]
 default = FILE:/var/log/krb5libs.log
 kdc = FILE:/var/log/krb5kdc.log
 admin_server = FILE:/var/log/kadmind.log
```

```
[libdefaults]
# default_realm = EXAMPLE.COM

[realms]
# EXAMPLE.COM = {
#  kdc = kerberos.example.com
#  admin_server = kerberos.example.com
# }

[domain_realm]
# .example.com = EXAMPLE.COM
# example.com = EXAMPLE.COM
```

Now join the KDC realm. If you are missing package dependencies, they are automatically installed.

```
# realm join NTAP.LOCAL
Password for Administrator:
 * Installing necessary packages: adcli sssd-tools
```

Then you can check your `realm list`.

```
# realm list
NTAP.LOCALNTAP.LOCAL
  type: kerberos
  realm-name: NTAP.LOCAL
  domain-name: ntap.local
  configured: kerberos-member
  server-software: active-directory
  client-software: sssd
  required-package: sssd-tools
  required-package: sssd
  required-package: adcli
  required-package: samba-client
  login-formats: %U@ntap.local
  login-policy: allow-realm-logins
```

When a realm is joined, the `krb5.conf` file is modified to include the new realm information.

```
default_realm = NTAP.LOCAL
[realms]
# EXAMPLE.COM = {
#  kdc = kerberos.example.com
#  admin_server = kerberos.example.com
# }

 NTAP.LOCAL = {
 }

[domain_realm]
# .example.com = EXAMPLE.COM
# example.com = EXAMPLE.COM
 ntap.local = NTAP.LOCAL
 .ntap.local = NTAP.LOCAL
```

And `sssd.conf` also gets the Active Directory information.

```
[domain/NTAP.LOCALNTAP.LOCAL]
ad_domain = NTAP.LOCALNTAP.LOCAL
krb5_realm = NTAP.LOCAL
realmd_tags = manages-system joined-with-adcli
cache_credentials = True
id_provider = ad
krb5_store_password_if_offline = True
default_shell = /bin/bash
ldap_id_mapping = True
use_fully_qualified_names = True
fallback_homedir = /home/%u@%d
access_provider = ad
```

Configure the /etc/sssd/sssd.conf file

When you join a domain with `realm`, the SSSD configuration uses the `id_provider` of `ad`. This approach uses the SSSD UID/GID algorithms (SSSD Active Directory provider) method that is covered later in this document. The UNIX IDs that this method provides are not supported by ONTAP, so you must add a second configuration section in the SSSD configuration that includes LDAP as the `id_provider`.

The following is a sample configuration, which might vary depending on your environment:

```
[domain/DOMAIN]
auth_provider = krb5
chpass_provider = krb5
id_provider = ldap
ldap_search_base = dc=ntap,dc=local
ldap_schema = rfc2307bis
ldap_sasl_mech = GSSAPI
ldap_user_object_class = user
ldap_group_object_class = group
ldap_user_home_directory = unixHomeDirectory
ldap_user_principal = userPrincipalName
ldap_account_expire_policy = ad
ldap_force_upper_case_realm = true
ldap_user_search_base = cn=Users,dc=ntap,dc=local
ldap_group_search_base = cn=Users,dc=ntap,dc=local
ldap_sasl_authid = CENTOS7$@NTAP.LOCAL
krb5_server = ntap.local
krb5_realm = NTAP.LOCAL
krb5_kpasswd = ntap.local
use_fully_qualified_names = false
```

The preceding example uses:

- Kerberos binds through `ldap_sasl_mech` and `ldap_sasl_authid`
- The machine account as the `ldap_sasl_authid` SPN
- LDAP as the `id_provider`
- Short names for lookups (`use_fully_qualified_names = false`)

The `realm` command configured SSSD to use fully qualified names by default (for example, `user@REALM.COM`), so the LDAP lookups depend on how the name lookups are issued.

For example, if you look for `prof1@NTAP.LOCAL`, SSSD uses the Active Directory provider and generates a UID based on the Active Directory security identifier (SID).

```
# id prof1@NTAP.LOCAL
uid=1587401110(prof1@NTAP.LOCALNTAP.LOCAL) gid=1587400513(domainusers@NTAP.LOCALNTAP.LOCAL)
groups=1587400513(domainusers@NTAP.LOCALNTAP.LOCAL),1587401106(group2@NTAP.LOCALNTAP.LOCAL),15874
01122(sharedgroup@NTAP.LOCALNTAP.LOCAL),1587401111(profgroup@NTAP.LOCALNTAP.LOCAL),1587401105(gro
up1@NTAP.LOCALNTAP.LOCAL),1587401107(group3@NTAP.LOCALNTAP.LOCAL)
```

If you look for `prof1`, you get the UNIX attributes from LDAP rather than having SSSD generate a UID for you.

```
# id prof1
uid=1100(prof1) gid=1101(ProfGroup)
groups=1101(ProfGroup),1201(group1),1203(group3),1202(group2),1220(sharedgroup)
```

This configuration provides flexibility for environments that use both types of user lookups.

SSSD UID/GID algorithms (SSSD Active Directory provider)

SSSD, which is an LDAP client that is provided by Red Hat, offers two different ways to provide user and group identities. When you configure SSSD to use LDAP as the ID provider, SSSD performs normal LDAP search queries that use RFC 2307–based schema standards for user and group lookups. For instance, when a user named `user` is looked up by using the LDAP provider, SSSD searches for `uid=user` and for the pertinent information for user authentication, such as UID numbers, home directory paths, and group memberships.

SSSD also supports an [Active Directory integrated solution]() (ID provider AD). This solution provides UNIX IDs based on an algorithm that uses the preexisting Windows SIDs for users and groups to create numeric UID and GID values for UNIX identity management. The intention is to eliminate the need to create UNIX attributes for each user and group, and instead to rely on SSSD to do the work.

For instance, on the following example SSSD client, SSSD is configured to use both `LDAP` and `AD` for ID providers:

```
[domain/DOMAIN]
auth_provider = krb5
chpass_provider = krb5
id_provider = ldap
ldap_search_base = dc=ntap,dc=local
ldap_schema = rfc2307bis
ldap_sasl_mech = GSSAPI
ldap_user_object_class = user
ldap_group_object_class = group
ldap_user_home_directory = unixHomeDirectory
ldap_user_principal = userPrincipalName
ldap_account_expire_policy = ad
ldap_force_upper_case_realm = true
ldap_user_search_base = cn=Users,dc=ntap,dc=local
ldap_group_search_base = cn=Users,dc=ntap,dc=local
ldap_sasl_authid = CENTOS7$@NTAP.LOCAL
krb5_server = ntap.local
krb5_realm = NTAP.LOCAL
krb5_kpasswd = ntap.local
use_fully_qualified_names = false

[domain/NTAP.LOCALNTAP.LOCAL]
ad_domain = NTAP.LOCALNTAP.LOCAL
krb5_realm = NTAP.LOCAL
realmd_tags = manages-system joined-with-adcli
cache_credentials = True
id_provider = ad
krb5_store_password_if_offline = True
default_shell = /bin/bash
ldap_id_mapping = True
use_fully_qualified_names = True
fallback_homedir = /home/%u@%d
access_provider = ad
```

The preceding configuration queries LDAP when no FQDN is provided, and when a user has an FQDN, the configuration uses Active Directory. This approach delivers two different UIDs for the same user.

Without an FQDN, the following is returned:

```
# id prof1
uid=1100(prof1) gid=1101(ProfGroup)
groups=1101(ProfGroup),1201(group1),1203(group3),1202(group2),1220(sharedgroup)
```

With an FQDN, that same user gets the following:

```
# id prof1@NTAP.LOCAL
uid=1587401110(prof1@NTAP.LOCALNTAP.LOCAL) gid=1587400513(domainusers@NTAP.LOCALNTAP.LOCAL)
groups=1587400513(domainusers@NTAP.LOCALNTAP.LOCAL),1587401107(group3@NTAP.LOCALNTAP.LOCAL),15874
01111(profgroup@NTAP.LOCALNTAP.LOCAL),1587401105(group1@NTAP.LOCALNTAP.LOCAL),1587401122(sharedgr
oup@NTAP.LOCALNTAP.LOCAL),1587401106(group2@NTAP.LOCAL)
```

The numeric UID `1587401110` is generated based on the user's SID and the SSSD algorithm.

```
cluster::*> vserver services access-check authentication translate -vserver DEMO -win-name prof1
S-1-5-21-3552729481-4032800560-2279794651-1110
```

ONTAP currently does not support this method of UNIX user ID creation. The generated UID is not physically stored anywhere that ONTAP can query, and ONTAP does not currently use this algorithm to create UNIX user and group IDs.

When you use SSSD with ONTAP, either use LDAP as the ID provider and populate the LDAP server with the UNIX attributes, or create local `passwd` and `group` entries in the SVM with the same UID and GID information that the SSSD algorithm uses.

DNS considerations with SSSD

SSSD can use Kerberos authentication for secure LDAP binds. Therefore, you must configure DNS properly to include information about the LDAP universal resource identifier (URI) that is used in the SSSD configuration. SSSD does not support the use of round-robin DNS entries for failover. For failover to work properly, each entry must be unique and in DNS. For details, see the SSSD documentation.

Another limitation to SSSD is that failover depends on the order of entries in `/etc/resolv.conf`. If the first DNS server in the file is inaccessible, SSSD black-holes the attempt until the DNS server is available or until the `/etc/resolv.conf` file is modified. For more information about this point, see Red Hat bug 966757.

LDAP authentication for cluster administration

You can also use LDAP servers to host users and groups that are used in cluster logins and authentication for CLI, API, and ONTAP System Manager access (users only).

This use is different from Active Directory domain tunneling. For the steps on how to use Active Directory domain tunneling, see the product documentation.

This section covers LDAP that uses FreeIPA for name services and KDC functionality on CentOS 8. These steps are not for setting up LDAP for user names and groups for file access. Instead, they are for logging in to the cluster for administration. However, many of the steps are identical to setting up LDAP for UNIX users and groups for file access.

Basic steps

At a high level, the following steps are how to set up LDAP for use with ONTAP for cluster logins. These steps are all performed on the cluster administration SVM, not on SVMs that are hosting data:

1. Verify that the password hashes that the LDAP server supports are among the supported methods in ONTAP:
   – CRYPT (all types), SHA, SSHA
2. Set up DNS on the cluster SVM.
3. Create the LDAP client schema from a template:
   – Be sure that the client schema matches your LDAP server.
4. Create an LDAP client that is owned by the cluster SVM:
   – Be sure that the client schema sets the bind user as one with permissions to view password hashes.
   – Be sure to set the bind password.
   – Be sure that the base, user, or group DN are set to the proper locations.
5. Enable LDAP on the cluster SVM.
6. Modify the `ns-switch` database to use LDAP.
7. Check LDAP lookups.
8. Create a security login account for the desired user or group with `nsswitch` as the authentication method.

9. Test logins.

Detailed steps

The following section covers in further detail how to set up LDAP for user and group logins to ONTAP for cluster administration.

You can find the steps to create the FreeIPA server on CentOS 8 at the following link:

https://kifarunix.com/install-and-setup-freeipa-server-on-centos-8/

FreeIPA considerations

With FreeIPA, there are a few things to consider when you try to use it for LDAP authentications through a password hash exchange.

FreeIPA schema—Compat

FreeIPA, by default, creates two different CN areas that contain users. One is called `compat`, which is intended to provide backward compatibility for older LDAP and NIS environments. This CN can work fine for user and group lookups, but it does not contain `userPassword` fields, which are required for use with LDAP authentication in ONTAP.

For example, following is the output of `ldapsearch` from a user in `CN=compat` and the `CN=accounts`. Note that there is no `userPassword` attribute for the user in `CN=compat`.

```
# ldapsearch -D "cn=Directory Manager" -W -p 389 -h 10.193.67.222 -b "dc=centos-ldap,dc=local" -s
sub "(uid=idm-ldap)"
Enter LDAP Password:
# extended LDIF
#
# LDAPv3
# base <dc=centos-ldap,dc=local> with scope subtree
# filter: (uid=idm-ldap)
# requesting: ALL
#

# idm-ldap, users, compat, centos-ldap.local
dn: uid=idm-ldap,cn=users,cn=compat,dc=centos-ldap,dc=local
objectClass: posixAccount
objectClass: ipaOverrideTarget
objectClass: top
gecos: IDM LDAP
cn: IDM LDAP
uidNumber: 1971600001
gidNumber: 1971600000
loginShell: /bin/sh
homeDirectory: /home/idm-ldap
ipaAnchorUUID:: OklQQTpjZW50b3MtbGRhcC5sb2NhbDowYzA2OGMxYS00N2EwLTExZWEtOWZhNS
0wMDUwNTY5ZWM0N2Q=
uid: idm-ldap

# idm-ldap, users, accounts, centos-ldap.local
dn: uid=idm-ldap,cn=users,cn=accounts,dc=centos-ldap,dc=local
givenName: IDM
sn: LDAP
uid: idm-ldap
cn: IDM LDAP
displayName: IDM LDAP
initials: IL
gecos: IDM LDAP
krbPrincipalName: idm-ldap@CENTOS-LDAP.LOCAL
gidNumber: 1971600000
userClass: user
objectClass: top
objectClass: person
objectClass: organizationalperson
```

```
objectClass: inetorgperson
objectClass: inetuser
objectClass: posixaccount
objectClass: krbprincipalaux
objectClass: krbticketpolicyaux
objectClass: ipaobject
objectClass: ipasshuser
objectClass: ipauser
objectClass: ipaSshGroupOfPubKeys
objectClass: mepOriginEntry
objectClass: ipauserauthtypeclass
loginShell: /bin/sh
homeDirectory: /home/idm-ldap
mail: idm-ldap@centos-ldap.local
krbCanonicalName: idm-ldap@CENTOS-LDAP.LOCAL
userPassword:: cGFzc3dvcmQ=
ipaUniqueID: 0c068c1a-47a0-11ea-9fa5-0050569ec47d
krbPrincipalKey:: MIHeoAMCAQGhAwIBAaIDAgEOowMCAQGkgccwgcQwaKAbMBmgAwIBBKESBBBf
V1MkWEtbaWJHIzUoPT8koUkwR6ADAgESoUAEPiAAyXz46+O9PYO29Jp9jtSsjzBmRfP807GukpwDF
4UuPueLD5N+alOaMeh32YUfBe4DsyRNWo17VMw4sE3UMFigGzAZoAMCAQShEgQQdkR6KVVIU3hZXn
gnXSpQX6E5MDegAwIBEaEwBC4QANcX45dw98u/gynzQDKQ02dTvcOOp6uTE5wgJyzZZVaEON2l2hW
Dow8i/2Fo
uidNumber: 1971600001
krbPasswordExpiration: 20200206034103Z
krbLastPwdChange: 20200206034103Z
krbExtraData:: AALPijtecm9vdC9hZG1pbkBDRU5UT1MtTERBUC5MT0NBTAA=
mepManagedEntry: cn=idm-ldap,cn=groups,cn=accounts,dc=centos-ldap,dc=local
memberOf: cn=ipausers,cn=groups,cn=accounts,dc=centos-ldap,dc=local
krbLastFailedAuth: 20200205022117Z
krbLoginFailedCount: 0
krbTicketFlags: 128
ipaUserAuthType: password
```

When you set up the ONTAP LDAP client on the cluster SVM, you specify a `base-dn` field. Generally, this field is the top-level domain. However, with FreeIPA, it might cause the users and groups in the `compat` CN to be discovered first and then LDAP logins fail, even if you can properly query LDAP for user and group information.

To get around this issue, configure the `user-dn` and `group-dn` options in the LDAP client from the advanced privilege to use the proper user DNs that contain password information.

LDAP client example for working authentication with FreeIPA:

```
cluster::*> ldap client show -client-config IDM

Client Configuration Name: IDM
LDAP Server List: 10.x.x.x
(DEPRECATED)-LDAP Server List: -
Active Directory Domain: -
Preferred Active Directory Servers: -
Bind Using the Vserver's CIFS Credentials: false
Schema Template: IPA
LDAP Server Port: 389
Query Timeout (sec): 3
Minimum Bind Authentication Level: simple
Bind DN (User): uid=ONTAPLDAP,cn=sysaccounts,cn=etc,dc=centos-ldap,dc=local
Base DN: dc=centos-ldap,dc=local
Base Search Scope: subtree
User DN: cn=accounts,dc=centos-ldap,dc=local
User Search Scope: subtree
Group DN: cn=accounts,dc=centos-ldap,dc=local
Group Search Scope: subtree
Netgroup DN: -
Netgroup Search Scope: subtree
Vserver Owns Configuration: false
Use start-tls Over LDAP Connections: false
Enable Netgroup-By-Host Lookup: false
Netgroup-By-Host DN: -
Netgroup-By-Host Scope: subtree
```

```
Client Session Security: none
LDAP Referral Chasing: false
Group Membership Filter:
```

FreeIPA—View password hashes in LDAP queries

You can modify FreeIP LDAP schemas through an administrative user called the "Directory Manager." This user can also see password hashes. By default, other users in the LDAP server cannot see password hashes, which is problematic for setting up LDAP authentication that requires comparison of password hashes, such as with ONTAP.

As a result, when you create an LDAP client, anonymous binds do not work, because anonymous binds do not have permissions to see password hashes. Also, when you set up a simple or SASL bind, it works only if you provide a user that has access to view password hashes, such as the Directory Manager or a new user you have created with the proper access rights. The FreeIPA best practices themselves state that you should not use the Directory Manager with remote services. The best practices linked page says to create a system account instead. The main goal here is the same: to have a bind user that can see the `userPassword` field in queries.

Following is an example of LDAP queries with users that can and cannot see the field.

Nonworking bind example—no `userPassword` populated:

```
cluster::*> ldap client show -client-config IDM -fields bind-dn
vserver client-config bind-dn
------- ------------- --------------------
DEMO    IDM           idm-ldap

cluster::*> getxxbyyy getpwbyname -vserver cluster -username idm-ldap
  (vserver services name-service getxxbyyy getpwbyname)
pw_name: idm-ldap
pw_passwd:
pw_uid: 1971600001
pw_gid: 1971600000
pw_gecos:
pw_dir:
pw_shell: /bin/sh
```

Working bind example—`userPassword` populated:

```
cluster::*> ldap client show -client-config IDM -fields bind-dn
vserver client-config bind-dn
------- ------------- --------------------
DEMO    IDM           CN=Directory Manager

cluster::*> getxxbyyy getpwbyname -vserver cluster -username idm-ldap
  (vserver services name-service getxxbyyy getpwbyname)
pw_name: idm-ldap
pw_passwd:
{crypt}$6$Z7$P4yQSiVYP513mNeH2PJLqOPUSOxLyh/nGUWtFclPsEUj7tHU5y4eu6SRH1XijBgycZnAQHMCdpmJiKWFkajp4
0
pw_uid: 1971600001
pw_gid: 1971600000
pw_gecos:
pw_dir:
pw_shell: /bin/sh
```

When you specify the newly created system account, be sure to use the full DN path. For instance:

```
-bind-dn uid=ONTAPLDAP,cn=sysaccounts,cn=etc,dc=centos-ldap,dc=local
```

If necessary, drop the `-min-bind-level` option to anonymous while you change the `-bind-dn` option. Or you can use the `-skip-configuration-validation true` option until you can modify the bind password or modify the bind password first.

Creating a non-Directory Manager user that can view passwords

If you want to create a system account that is not the Directory Manager that can also view passwords to be used for your bind DN, create a file `bind-auth.update` that uses the following format:

```
dn: uid=bind-auth,cn=sysaccounts,cn=etc,dc=example,dc=com
add: objectClass: account
add: objectClass: simplesecurityobject
add: uid: bind-auth
add: userPassword: REALPASSWORDGOESHERE
add: passwordExpirationTime: 20380119031407Z
add: nsIdleTimeout: 0

dn: cn=users,cn=accounts,dc=example,dc=com
add: aci:(targetattr="userPassword")(targetfilter="(objectClass=posixAccount)")(version 3.0; acl
"Allow bind user to read password hashes for authentication"; allow(read, search, compare)
userdn="ldap:///uid=bind-auth,cn=sysaccounts,cn=etc,dc=example,dc=com";)
```

Apply it with the command `ipa-ldap-updater bind-auth.update` or use `ldapmodify` and test if you can view passwords from your ONTAP SVM using the new service account as the bind DN.

FreeIPA Schema—Password hash encryption level

When a user logs in with LDAP as the authentication method for ONTAP, a password hash comparison is performed as part of the login process. If the password hash encryption method is not supported by ONTAP, LDAP authentication fails. By default, FreeIPA uses the most secure password hash algorithm possible: SSHA512.

However, ONTAP currently supports only the following password hash lengths:

- CRYPT (all types)
- SHA1/SHA2
- SSHA1/SSHA2

For SSH or web logins to work with LDAP authentication, when you create a user for authentication, the password hash must be one of the preceding lengths.

If you need to change the password hash length for FreeIPA:

```
# ldapmodify -D "cn=Directory Manager" -W -p 389 -h centos8-ipa -x
Enter LDAP Password:
dn: cn=config
changetype: modify
replace: passwordStorageScheme
passwordStorageScheme: CRYPT-SHA512

modifying entry "cn=config"


# ldapsearch -D "cn=Directory Manager" -W -p 389 -h centos8-ipa -b "cn=config" | grep
passwordStorageScheme
Enter LDAP Password:
passwordStorageScheme: CRYPT-SHA512
```

Note: In ONTAP 9.7P8 and earlier, CRYPT-SHA512 was currently the strongest supported password hash length for ONTAP. ONTAP 9.7P9 and later supports SHA/SSHA-512 encryption through bug 1264152. As a result, no password scheme changes would be needed with Free IPA in those releases.

You might not want to change the password hashes for all users, however. So, a workaround could be to modify the `passwordStorageScheme` value, create the desired users and passwords (or change existing passwords) with the new `passwordStorageScheme`, then set `passwordStorageScheme` back to the original value. Only new users or changed passwords would have the new `passwordStorageScheme` hash length.

FreeIPA—LDAP groups

In some cases, you might want to use an LDAP group instead of a single user. The use of groups helps avoid extra overhead when you create login users on the cluster. By providing a centralized location, it also simplifies management of logins when you add or remove users. The one limitation of LDAP groups for ONTAP cluster administration is that you currently can't specify an LDAP group for use with HTTP or System Manager.

To get LDAP groups working with ONTAP logins, first and foremost, the group memberships must be properly seen from the ONTAP cluster. You can test it by using the `getxxbyyy` command set; see the section, "GetXXbyYY." Because FreeIPA uses the member LDAP scheme attribute for group memberships, you should modify the ONTAP LDAP client schema to reflect that aspect, as well as use RFC 2307bis.

The following schema template shows the custom schema to use with FreeIPA. It is based on the RFC 2307bis schema. Differences in schema attributes from the template are highlighted in yellow. Your schema template modifications might vary. For details, check with your LDAP administrator.

Free IPA LDAP schema template example:

```
                                    Schema Template: IPA
                                            Comment:
                 RFC 2307 posixAccount Object Class: person
                   RFC 2307 posixGroup Object Class: posixgroup
                  RFC 2307 nisNetgroup Object Class: nisNetgroup
                             RFC 2307 uid Attribute: uid
                       RFC 2307 uidNumber Attribute: uidNumber
                       RFC 2307 gidNumber Attribute: gidNumber
                 RFC 2307 cn (for Groups) Attribute: cn
              RFC 2307 cn (for Netgroups) Attribute: cn
                    RFC 2307 userPassword Attribute: userPassword
                           RFC 2307 gecos Attribute: gecos
                   RFC 2307 homeDirectory Attribute: homeDirectory
                      RFC 2307 loginShell Attribute: loginShell
                       RFC 2307 memberUid Attribute: member
                RFC 2307 memberNisNetgroup Attribute: memberHost
                RFC 2307 nisNetgroupTriple Attribute: nisNetgroupTriple
                Enable Support for Draft RFC 2307bis: true
         RFC 2307bis groupOfUniqueNames Object Class: posixgroup
                 RFC 2307bis uniqueMember Attribute: member
Data ONTAP Name Mapping windowsToUnix Object Class: posixAccount
  Data ONTAP Name Mapping windowsAccount Attribute: windowsAccount
   Data ONTAP Name Mapping windowsToUnix Attribute: windowsAccount
   No Domain Prefix for windowsToUnix Name Mapping: false
                                Vserver Owns Schema: false
 Maximum groups supported when RFC 2307bis enabled: 256
                    RFC 2307 nisObject Object Class: ipahost
                      RFC 2307 nisMapName Attribute: cn
                     RFC 2307 nisMapEntry Attribute: cn
```

Following is an example of a working getxxbyyy command that queries group memberships:

```
cluster::*> getxxbyyy getgrlist -node node1 -vserver cluster -username ipa-user
(vserver services name-service getxxbyyy getgrlist)
pw_name: ipa-user
Groups: 1971600000 1971600004


cluster::*> getxxbyyy getgrbygid -node node1 -vserver cluster -groupID 1971600000
(vserver services name-service getxxbyyy getgrbygid)
name: admins
gid: 1971600000
gr_mem: admin uid=admin cn=users cn=accounts dc=centos-ldap dc=local

cluster::*> getxxbyyy getgrbygid -node node1 -vserver cluster -groupID 1971600004
(vserver services name-service getxxbyyy getgrbygid)
name: ontap-ldap
```

```
gid: 1971600004
gr_mem: idm-ldap ipa-user uid=idm-ldap cn=users cn=accounts dc=centos-ldap dc=local uid=ipa-user
cn=users cn=accounts dc=centos-ldap dc=local
```

After you have determined that LDAP group membership queries are populating the expected users, you can create security logins for the LDAP group. One difference from creating LDAP user accounts for logins is that you must inform ONTAP that the accounts that you are creating are LDAP groups with the `–is-ns-switch-group yes` option.

```
cluster::*> security login create -user-or-group-name ontap-ldap -application ssh -
authentication-method nsswitch -role admin -is-ns-switch-group yes -second-authentication-method
none -vserver cluster

cluster::*> security login create -user-or-group-name ontap-ldap -application ontapi -
authentication-method nsswitch -role admin -is-ns-switch-group yes -second-authentication-method
none -vserver cluster

cluster::*> security login show -vserver cluster -user-or-group-name ontap-ldap -fields is-ns-
switch-group
vserver         user-or-group-name application authentication-method is-ns-switch-group
--------------- ------------------ ----------- --------------------- ------------------
cluster         ontap-ldap         ontapi      nsswitch              yes
cluster         ontap-ldap         ssh         nsswitch              yes
```

LDAP group authentication cache

When an LDAP group is used for authentication, it gets cached in ONTAP. If you need to flush the cache, use the following:

```
cluster::*> security login group-authentication cache clear -vserver cluster -user ipa-user -
application ssh
```

Common issues and troubleshooting steps

The following information covers common problems and troubleshooting steps to resolve LDAP issues in NetApp ONTAP. This section attempts to include as many scenarios and issues as possible, but it is not exhaustive. If you encounter an issue that is not covered here, be sure to collect the information as outlined in the section, “What information to collect before you contact NetApp Support.” After you have all the pertinent information, contact NetApp technical support.

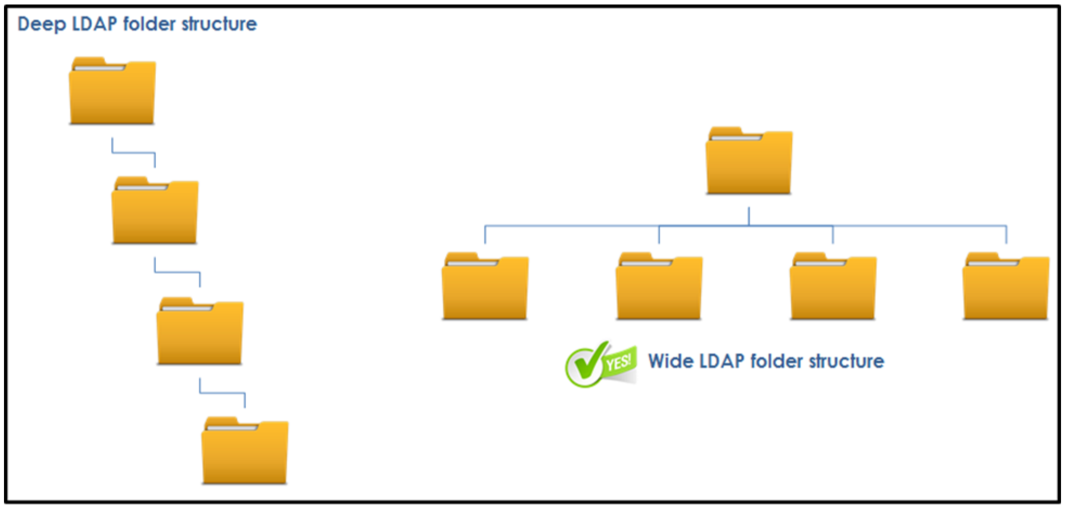
Optimize LDAP searches

When you use ONTAP as an LDAP client for enterprise NAS, to eliminate delays in access, it is imperative that you make sure that the LDAP searches perform as quickly as possible. Although there is a copious amount of caching in ONTAP for NAS, there is still a cost associated with initial lookups. To enable optimal LDAP performance, you should follow the best practices that are outlined here. For a complete list of name service best practices, see TR-4668: Name Services Best Practice Guide:

- Make sure that LDAP servers and associated name service servers (such as DNS) are on low-latency network links.
- Ideally, LDAP servers and DNS servers are local to the ONTAP cluster.
- Make sure that LDAP servers are not overworked (high CPU, and so on). Overworked LDAP servers return answers to queries more slowly. LDAP servers often have specific tools to measure performance, such as the Active Directory Performance Testing Tool (ADTest.exe). For more information about performance testing for LDAP, contact the LDAP server vendor.
- To troubleshoot search issues, use LDAP query tools such as `ldapsearch` or `ldp.exe`.
- To enable load balancing and redundancy, include multiple LDAP servers in any client configuration.
- Maintain your LDAP schemas to remove old records that are no longer in use.

Build LDAP schema structures and distinguished names (DNs) with a wide design rather than a deep design. Wide schemas allow shorter DNs. See Figure 33 for an example.

Figure 33) LDAP schema structure examples.



Points of failure

When you attempt to get LDAP queries working with ONTAP, remember that an ONTAP SVM is acting as an LDAP client that connects to an LDAP server, just like any UNIX or Windows OS would. Therefore, when an issue occurs, there are multiple possible failure points for you to investigate.

Network

LDAP server connectivity starts and ends with the network. An ONTAP SVM provides IP addresses by way of data *LIFs*, virtual IP addresses that reside on physical network ports on a cluster node. Network failures can occur for various reasons, all of which are common network troubleshooting scenarios for any TCP/IP-dependent applications, for example:

- A network cable failed.
- A network port failed.
- The data LIF does not exist in the SVM.
- The network route is not configured for the SVM.
- Firewalls are blocking traffic.
- The data LIF resides on a network port that cannot reach the LDAP server’s network.
- The LDAP server’s network is down.

When the LDAP server is unreachable through a basic ping, ONTAP prevents LDAP configuration from being applied. For details on how to find network issues, see the “Troubleshooting tools” section of this report.

DNS

DNS plays a part in LDAP failures in scenarios where LDAP host names are specified in the LDAP server list, where Active Directory domains are specified, or in cases where LDAP SRV records must be queried. DNS configuration is not required for use with LDAP, but NetApp highly recommends it. DNS failures can occur for multiple reasons, including, but not limited to:

- Network connectivity issues

- DNS query timeouts
- Hosts that are not found
- Incorrect DNS configuration

When the DNS server is unreachable through a basic ping, ONTAP prevents DNS configuration from being applied. For details on how to find DNS issues, see the “Troubleshooting tools” section.

Name service switch (ns-switch) configuration

Name service switches tell clients where they should look for various name services and in what order they should look. ONTAP SVMs each have their own `ns-switch` configurations to specify external name services or local files for user, group, netgroup, and host name lookups.

To make ONTAP SVMs able to communicate with LDAP servers, ns-switch configuration is a required step; see the section, “Modify the SVM name service switch (ns-switch).”

LDAP ports

LDAP port configuration is how ONTAP SVMs know which network ports to use for communication with LDAP servers. Port 389 is the standard LDAP port, but in some environments, the LDAP port might be different based on LDAP server configuration. For instance, the use of LDAP over SSL requires port 636 in many cases. In other cases, LDAP ports might be changed to nonstandard LDAP ports for security considerations through obfuscation. ONTAP SVMs support only port 636 if you use LDAP over SSL, and they support only port 389 if you use LDAP with StartTLS. Standard LDAP calls can use any port as configured on the server and client. To verify which port is being used for LDAP communication, check with the LDAP administrator.

LDAP binds

An LDAP bind is the way that LDAP clients log in to an LDAP server to perform read-only queries for name and group lookups. In most cases, any user in LDAP can bind to the LDAP server to read the schema attributes. In the case of user password fields, a privileged LDAP user might be required (such as the Directory Manager in Linux-based LDAP for cluster administration by using LDAP logins).

Binds can be set up in three different ways, but LDAP servers might be configured to support only specific ways of binding:

- **Anonymous,** which allows anyone to read the LDAP schema
- **Simple,** which is the basic user name and password bind
- **SASL,** which is the most secure form of binding and can be done through various encryption methods, including Kerberos and NTLM

If an LDAP bind fails, then user and group lookups also fail. If an LDAP bind fails, ONTAP logs messages to the event log, as does the LDAP server. For details on how to find LDAP bind issues, see the “Troubleshooting tools” section.

LDAP DN search configuration

DN search configuration refers to the schema locations that you specify in LDAP client configurations to help direct LDAP searches to look in the most efficient places. The base DN is specified to direct the main searches, but user, group, and netgroup DN filters also help narrow down queries further to help reduce the amount of time that is spent on looking up objects.

If an LDAP DN is misconfigured or if the wrong DN is specified, then searches for users and groups succeed but do not return the expected results (or any results at all). An analogy is looking for someone named “Smith” in the “R” section of a phone book.

Issues with LDAP DN configuration can be difficult to track down. There are no errors other than `object not found`, so troubleshooting requires a bit more digging. For details on how to find LDAP DN issues, see the “Troubleshooting tools” section.

LDAP client schema configuration

ONTAP provides several default, read-only LDAP schema templates for use with LDAP client configuration. For ease of use, these templates offer common schema attribute values. In some cases, however, an LDAP server might be using a schema configuration that does not match the templates. In those cases, you can copy schema templates to new writable templates for modification.

These schema attributes help formulate the LDAP search queries that ONTAP generates for user and group lookups. If the wrong schema attributes are specified, then ONTAP sends the wrong values and does not retrieve the proper results from the LDAP server. This result causes file access issues, because ONTAP cannot discern who a user is based on the incoming client request and cannot apply the proper permissions to the user.

Incorrect schema configurations can also result in incorrect secondary group memberships. To help get the schema attributes right, be sure to follow the instructions in the “LDAP schema configuration” section of this report.

For details on how to discover LDAP schema configuration issues, see the “Troubleshooting tools” section.

Troubleshooting tools

This section covers specific tools and commands that you can use to troubleshoot LDAP issues in your environment.

Third-party tools and utilities

In some cases, troubleshooting LDAP issues require third-party utilities. This section covers a few of those tools.

Basic network troubleshooting: Ping, nslookup, dig, telnet, and nmap

Basic troubleshooting for LDAP generally calls for checking network connectivity. Pings can check whether networks are connecting properly between the LDAP server, client, and ONTAP. Basic pings, however, might sometimes be blocked in networks, so a utility such as telnet or nmap to check that port connectivity can be useful. Also, checking name resolution with DNS is important in some LDAP configurations, so you can use a tool such as nslookup or dig to test DNS.

Example of `nmap` to an LDAP server that is running Windows 2012 R2:

```
# nmap x.x.x.x

Starting Nmap 6.40 ( http://nmap.org ) at 2020-02-14 23:34 EST
Nmap scan report for oneway.ntap.local (x.x.x.x)
Host is up (0.00023s latency).
Not shown: 977 closed ports
PORT      STATE SERVICE
21/tcp    open  ftp
53/tcp    open  domain
80/tcp    open  http
88/tcp    open  kerberos-sec
111/tcp   open  rpcbind
135/tcp   open  msrpc
139/tcp   open  netbios-ssn
389/tcp   open  ldap
445/tcp   open  microsoft-ds
464/tcp   open  kpasswd5
593/tcp   open  http-rpc-epmap
```

```
636/tcp   open  ldapssl
2049/tcp  open  nfs
3268/tcp  open  globalcatLDAP
3269/tcp  open  globalcatLDAPssl
3389/tcp  open  ms-wbt-server
```

Example of `nslookup` and `dig`:

```
# nslookup ntap.local
Server:         x.x.x.x
Address:        x.x.x.x#53

Non-authoritative answer:
Name:   ntap.local
Address: x.x.x.x

# dig ntap.local

; <<>> DiG 9.9.4-RedHat-9.9.4-61.el7_5.1 <<>> ntap.local
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 9482
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4000
;; QUESTION SECTION:
;ntap.local.                    IN      A

;; ANSWER SECTION:
ntap.local.             590     IN      A       x.x.x.x

;; Query time: 1 msec
;; SERVER: x.x.x.x#53(x.x.x.x)
;; WHEN: Fri Feb 14 23:37:57 EST 2020
;; MSG SIZE  rcvd: 55
```

Use of `dig` to query SRV records:

```
# dig SRV ldap/oneway.ntap.local

; <<>> DiG 9.9.4-RedHat-9.9.4-61.el7_5.1 <<>> SRV ldap/oneway.ntap.local
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NXDOMAIN, id: 31583
;; flags: qr rd ra; QUERY: 1, ANSWER: 0, AUTHORITY: 1, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4000
;; QUESTION SECTION:
;ldap/oneway.ntap.local.                IN      SRV

;; AUTHORITY SECTION:
ntap.local.             900     IN      SOA     oneway.ntap.local. hostmaster.ntap.local. 2399
900 600 86400 3600

;; Query time: 1 msec
;; SERVER: x.x.x.x#53(x.x.x.x)
;; WHEN: Fri Feb 14 23:39:09 EST 2020
;; MSG SIZE  rcvd: 105

# dig SRV _ldap._tcp.ntap.local

; <<>> DiG 9.9.4-RedHat-9.9.4-61.el7_5.1 <<>> SRV _ldap._tcp.ntap.local
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 62440
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 2

;; OPT PSEUDOSECTION:
```

```
; EDNS: version: 0, flags:; udp: 4000
;; QUESTION SECTION:
;_ldap._tcp.ntap.local.         IN      SRV

;; ANSWER SECTION:
_ldap._tcp.ntap.local.  600     IN      SRV     0 100 389 oneway.ntap.local.

;; ADDITIONAL SECTION:
oneway.ntap.local.      3600    IN      A       x.x.x.x

;; Query time: 1 msec
;; SERVER: x.x.x.x#53(x.x.x.x)
;; WHEN: Fri Feb 14 23:40:08 EST 2020
;; MSG SIZE  rcvd: 103
```

SSS_cache

When you use SSSD on Linux clients, you can flush the SSSD cache with the sss_cache command.

This process can be done globally with:

```
# sss_cache -E
```

Or on a per user or group basis with:

```
# sss_cache -u usernamre
# sss_cache -g groupname
```

Packet traces

Often, packet traces can be invaluable for isolating a wide array of LDAP issues—from basic connectivity, to bind issues, to LDAP search issues. You can use any packet tracing utility from tcpdump to Wireshark. In cases where LDAP traffic is encrypted through SSL or certificates, packet traces are not as useful, but you can sometimes use the cert keys to decrypt traces. The following links give some examples of this approach:

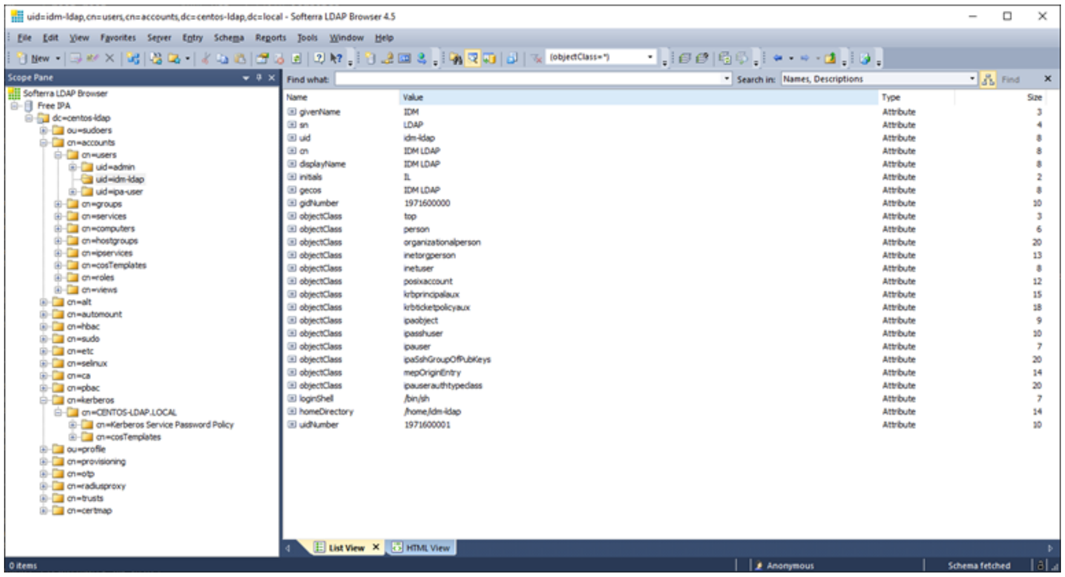
- IDMWORKS: Decrypting LDAPS traffic to Active Directory
- Microsoft Docs: Reading LDAP SSL Network Traffic with NetMon 3.4 and NMDecrypt
- Wireshark: Trouble decoding LDAP over SSL

For an example of LDAP communication as seen through packet capture, see section, “LDAP traffic as seen from a packet trace.”

LDAP browser—Softerra

Softerra offers a free LDAP browser application that allows you to see LDAP schemas, test binds and queries, and so on. This browser can use all the same types of binds that ONTAP uses, including SSL certificates, and is useful for finding which attributes you need for custom LDAP client schemas. See Figure 34.

Figure 34) Softerra LDAP browser.


File Edit View Favorites Server Entry Schema Reports Tools Window Help
New
Scope Pane
Find what:
Search in: Names, Descriptions
Find
List View
HTML View
0 items
Anonymous
Schema fetched

uid=idm-ldap,cn=users,cn=accounts,dc=centos-ldap,dc=local - Softerra LDAP Browser 4.5

(objectClass=*)

```
Softerra LDAP Browser
  Free IPA
    dc=centos-ldap
      ou=sudoers
      cn=accounts
        cn=users
          uid=admin
          uid=idm-ldap
          uid=ipa-user
        cn=groups
        cn=services
        cn=computers
        cn=hostgroups
        cn=ipservices
        cn=cosTemplates
        cn=roles
        cn=views
      cn=alt
      cn=automount
      cn=hbac
      cn=sudo
      cn=etc
      cn=selinux
      cn=ca
      cn=pbac
      cn=kerberos
        cn=CENTOS-LDAP.LOCAL
          cn=Kerberos Service Password Policy
          cn=cosTemplates
      ou=profile
      cn=provisioning
      cn=otp
      cn=radiusproxy
      cn=trusts
      cn=certmap
```

Name	Value	Type	Size
givenName	IDM	Attribute	3
sn	LDAP	Attribute	4
uid	idm-ldap	Attribute	8
cn	IDM LDAP	Attribute	8
displayName	IDM LDAP	Attribute	8
initials	IL	Attribute	2
gecos	IDM LDAP	Attribute	8
gidNumber	1971600000	Attribute	10
objectClass	top	Attribute	3
objectClass	person	Attribute	6
objectClass	organizationalperson	Attribute	20
objectClass	inetorgperson	Attribute	13
objectClass	inetuser	Attribute	8
objectClass	posixaccount	Attribute	12
objectClass	krbprincipalaux	Attribute	15
objectClass	krbticketpolicyaux	Attribute	18
objectClass	ipaobject	Attribute	9
objectClass	ipasshuser	Attribute	10
objectClass	ipauser	Attribute	7
objectClass	ipaSshGroupOfPubKeys	Attribute	20
objectClass	mepOriginEntry	Attribute	14
objectClass	ipauserauthtypeclass	Attribute	20
loginShell	/bin/sh	Attribute	7
homeDirectory	/home/idm-ldap	Attribute	14
uidNumber	1971600001	Attribute	10

Ldp

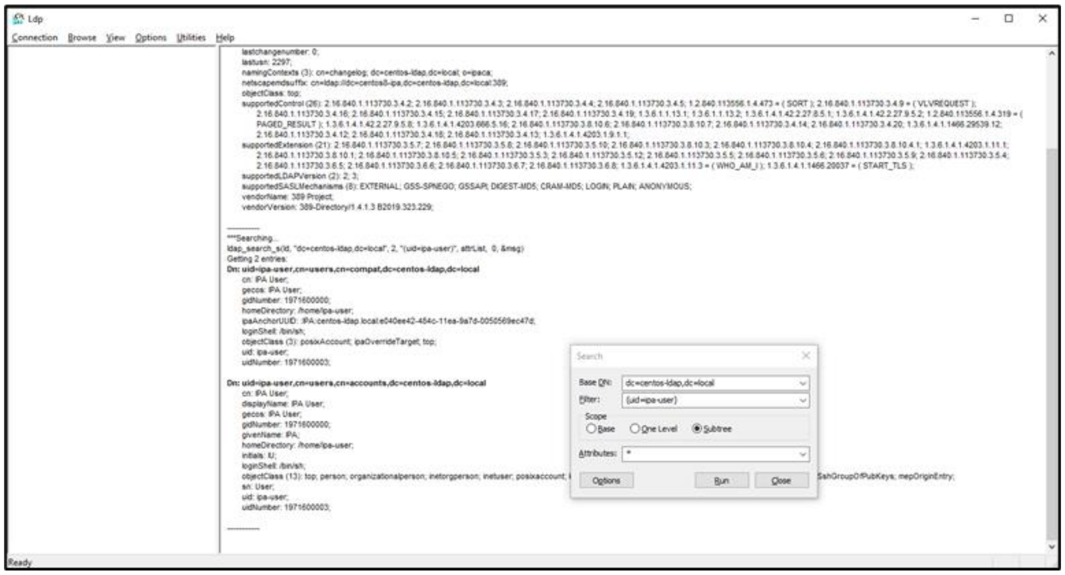
Ldp is an LDAP client the Microsoft Windows provides. This utility has functionality that is similar to the Softerra LDAP browser, but without as much GUI interaction. This tool is usually found on Active Directory domain controllers, but it can also be installed on Windows clients.

Ldp enables you to:

- Connect
- Bind
- Use StartTLS and/or LDAP over SSL
- Browse
- Run search queries

This functionality provides a way for you to test LDAP functionality outside of ONTAP so that you can confirm the LDAP servers are working properly and are honoring search queries. See Figure 35 for a sample search.

Figure 35) Sample LDAP search by using Ldp.



```
    lastchangenumber: 0;
    lastusn: 2297;
    namingContexts (3): cn=changelog; dc=centos-ldap,dc=local; o=ipaca;
    netscapemdsuffix: cn=ldap://dc=centos8-ipa,dc=centos-ldap,dc=local:389;
    objectClass: top;
    supportedControl (26): 2.16.840.1.113730.3.4.2; 2.16.840.1.113730.3.4.3; 2.16.840.1.113730.3.4.4; 2.16.840.1.113730.3.4.5; 1.2.840.113556.1.4.473 = ( SORT ); 2.16.840.1.113730.3.4.9 = ( VLVREQUEST );
        2.16.840.1.113730.3.4.16; 2.16.840.1.113730.3.4.15; 2.16.840.1.113730.3.4.17; 2.16.840.1.113730.3.4.19; 1.3.6.1.1.13.1; 1.3.6.1.1.13.2; 1.3.6.1.4.1.42.2.27.8.5.1; 1.3.6.1.4.1.42.2.27.9.5.2; 1.2.840.113556.1.4.319 = (
        PAGED_RESULT ); 1.3.6.1.4.1.42.2.27.9.5.8; 1.3.6.1.4.1.4203.666.5.16; 2.16.840.1.113730.3.8.10.6; 2.16.840.1.113730.3.8.10.7; 2.16.840.1.113730.3.4.14; 2.16.840.1.113730.3.4.20; 1.3.6.1.4.1.1466.29539.12;
        2.16.840.1.113730.3.4.12; 2.16.840.1.113730.3.4.18; 2.16.840.1.113730.3.4.13; 1.3.6.1.4.1.4203.1.9.1.1;
    supportedExtension (21): 2.16.840.1.113730.3.5.7; 2.16.840.1.113730.3.5.8; 2.16.840.1.113730.3.5.10; 2.16.840.1.113730.3.8.10.3; 2.16.840.1.113730.3.8.10.4; 2.16.840.1.113730.3.8.10.4.1; 1.3.6.1.4.1.4203.1.11.1;
        2.16.840.1.113730.3.8.10.1; 2.16.840.1.113730.3.8.10.5; 2.16.840.1.113730.3.5.3; 2.16.840.1.113730.3.5.12; 2.16.840.1.113730.3.5.5; 2.16.840.1.113730.3.5.6; 2.16.840.1.113730.3.5.9; 2.16.840.1.113730.3.5.4;
        2.16.840.1.113730.3.6.5; 2.16.840.1.113730.3.6.6; 2.16.840.1.113730.3.6.7; 2.16.840.1.113730.3.6.8; 1.3.6.1.4.1.4203.1.11.3 = ( WHO_AM_I ); 1.3.6.1.4.1.1466.20037 = ( START_TLS );
    supportedLDAPVersion (2): 2; 3;
    supportedSASLMechanisms (8): EXTERNAL; GSS-SPNEGO; GSSAPI; DIGEST-MD5; CRAM-MD5; LOGIN; PLAIN; ANONYMOUS;
    vendorName: 389 Project;
    vendorVersion: 389-Directory/1.4.1.3 B2019.323.229;

-----------
***Searching...
ldap_search_s(ld, "dc=centos-ldap,dc=local", 2, "(uid=ipa-user)", attrList, 0, &msg)
Getting 2 entries:
Dn: uid=ipa-user,cn=users,cn=compat,dc=centos-ldap,dc=local
    cn: IPA User;
    gecos: IPA User;
    gidNumber: 1971600000;
    homeDirectory: /home/ipa-user;
    ipaAnchorUUID: :IPA:centos-ldap.local:e040ee42-484c-11ea-9a7d-0050569ec47d;
    loginShell: /bin/sh;
    objectClass (3): posixAccount; ipaOverrideTarget; top;
    uid: ipa-user;
    uidNumber: 1971600003;

Dn: uid=ipa-user,cn=users,cn=accounts,dc=centos-ldap,dc=local
    cn: IPA User;
    displayName: IPA User;
    gecos: IPA User;
    gidNumber: 1971600000;
    givenName: IPA;
    homeDirectory: /home/ipa-user;
    initials: IU;
    loginShell: /bin/sh;
    objectClass (13): top; person; organizationalperson; inetorgperson; inetuser; posixaccount;                SshGroupOfPubKeys; mepOriginEntry;
    sn: User;
    uid: ipa-user;
    uidNumber: 1971600003;

-----------
```

Search

Base DN: dc=centos-ldap,dc=local

Filter: (uid=ipa-user)

Scope: ○ Base ○ One Level [✓ Subtree]

Attributes: *

ldapsearch

ldapsearch is a standard Linux-based utility that allows command-line interaction with LDAP servers to perform standard LDAP searches. This command allows you to specify bind level, certificates to use, search filters, and various other useful mechanisms that assist in LDAP server and schema troubleshooting.

Example of `ldapsearch`:

```
# ldapsearch -h x.x.x.x -p 389 -x -b 'dc=centos-ldap,dc=local' -s sub '(uid=ipa-user)'
# extended LDIF
#
# LDAPv3
# base <dc=centos-ldap,dc=local> with scope subtree
# filter: (uid=ipa-user)
# requesting: ALL
#

# ipa-user, users, accounts, centos-ldap.local
dn: uid=ipa-user,cn=users,cn=accounts,dc=centos-ldap,dc=local
givenName: IPA
sn: User
uid: ipa-user
cn: IPA User
displayName: IPA User
initials: IU
gecos: IPA User
gidNumber: 1971600000
objectClass: top
objectClass: person
objectClass: organizationalperson
objectClass: inetorgperson
objectClass: inetuser
objectClass: posixaccount
objectClass: krbprincipalaux
objectClass: krbticketpolicyaux
objectClass: ipaobject
objectClass: ipasshuser
objectClass: ipauser
objectClass: ipaSshGroupOfPubKeys
objectClass: mepOriginEntry
loginShell: /bin/sh
homeDirectory: /home/ipa-user
```

```
uidNumber: 1971600003
```

PowerShell

If you use Active Directory for your UNIX LDAP environment, you can use PowerShell to dump attributes for users and groups. A list of attributes of users and groups is invaluable for creating and troubleshooting LDAP client schema issues.

Example of UNIX user and group attributes dump by using PowerShell:

```
PS C:\> Get-ADUser prof1 -properties *


AccountExpirationDate                 :
accountExpires                        : 9223372036854775807
AccountLockoutTime                    :
AccountNotDelegated                   : False
AllowReversiblePasswordEncryption     : False
AuthenticationPolicy                  : {}
AuthenticationPolicySilo              : {}
BadLogonCount                         : 0
badPasswordTime                       : 132146010015585937
badPwdCount                           : 0
CannotChangePassword                  : False
CanonicalName                         : NTAP.LOCAL/Users/prof1
Certificates                          : {}
City                                  :
CN                                    : prof1
codePage                              : 0
Company                               :
CompoundIdentitySupported             : {}
Country                               :
countryCode                           : 0
Created                               : 1/14/2017 12:23:19 PM
createTimeStamp                       : 1/14/2017 12:23:19 PM
Deleted                               :
Department                            :
Description                           :
DisplayName                           : prof1
DistinguishedName                     : CN=prof1,CN=Users,DC=NTAP,DC=local
Division                              :
DoesNotRequirePreAuth                 : False
dSCorePropagationData                 : {12/31/1600 7:00:00 PM}
EmailAddress                          :
EmployeeID                            :
EmployeeNumber                        :
Enabled                               : True
Fax                                   :
gecos                                 : Prof1
gidNumber                             : 1101
GivenName                             : prof1
HomeDirectory                         :
HomedirRequired                       : False
HomeDrive                             :
HomePage                              :
HomePhone                             :
Initials                              :
instanceType                          : 4
isDeleted                             :
KerberosEncryptionType                : {}
LastBadPasswordAttempt                : 10/3/2019 2:30:01 PM
LastKnownParent                       :
lastLogoff                            : 0
lastLogon                             : 132255810960575467
LastLogonDate                         : 2/13/2020 3:27:30 PM
lastLogonTimestamp                    : 132260992500117213
LockedOut                             : False
loginShell                            : /bin/sh
logonCount                            : 142
```

```
LogonWorkstations                    :
Manager                              :
MemberOf                             : {CN=sharedgroup,CN=Users,DC=NTAP,DC=local,
CN=ProfGroup,CN=Users,DC=NTAP,DC=local, CN=group3,CN=Users,DC=NTAP,DC=local,
CN=group2,CN=Users,DC=NTAP,DC=local...}
MNSLogonAccount                      : False
MobilePhone                          :
Modified                             : 2/13/2020 3:27:30 PM
modifyTimeStamp                      : 2/13/2020 3:27:30 PM
msDS-User-Account-Control-Computed   : 0
Name                                 : prof1
nTSecurityDescriptor                 : System.DirectoryServices.ActiveDirectorySecurity
ObjectCategory                       : CN=Person,CN=Schema,CN=Configuration,DC=NTAP,DC=local
ObjectClass                          : user
ObjectGUID                           : 0973b3f1-da85-499c-80b4-a210e0d0fb2f
objectSid                            : S-1-5-21-3552729481-4032800560-2279794651-1110
Office                               :
OfficePhone                          :
Organization                         :
OtherName                            :
PasswordExpired                      : False
PasswordLastSet                      : 1/23/2018 10:18:37 AM
PasswordNeverExpires                 : True
PasswordNotRequired                  : False
POBox                                :
PostalCode                           :
PrimaryGroup                         : CN=Domain Users,CN=Users,DC=NTAP,DC=local
primaryGroupID                       : 513
PrincipalsAllowedToDelegateToAccount : {}
ProfilePath                          :
ProtectedFromAccidentalDeletion      : False
pwdLastSet                           : 131611943171895803
SamAccountName                       : prof1
sAMAccountType                       : 805306368
ScriptPath                           :
sDRightsEffective                    : 15
ServicePrincipalNames                : {}
SID                                  : S-1-5-21-3552729481-4032800560-2279794651-1110
SIDHistory                           : {}
SmartcardLogonRequired               : False
State                                :
StreetAddress                        :
Surname                              :
Title                                :
TrustedForDelegation                 : False
TrustedToAuthForDelegation           : False
uid                                  : {prof1}
uidNumber                            : 1100
unixHomeDirectory                    : /home/prof1
UseDESKeyOnly                        : False
userAccountControl                   : 66048
userCertificate                      : {}
UserPrincipalName                    : prof1@NTAP.LOCAL
uSNChanged                           : 832283
uSNCreated                           : 12924
whenChanged                          : 2/13/2020 3:27:30 PM
whenCreated                          : 1/14/2017 12:23:19 PM

PS C:\> Get-ADGroup profgroup -properties *


CanonicalName                   : NTAP.LOCAL/Users/ProfGroup
CN                              : ProfGroup
Created                         : 1/14/2017 12:24:31 PM
createTimeStamp                 : 1/14/2017 12:24:31 PM
Deleted                         :
Description                     :
DisplayName                     :
DistinguishedName               : CN=ProfGroup,CN=Users,DC=NTAP,DC=local
dSCorePropagationData           : {12/31/1600 7:00:00 PM}
gidNumber                       : 1101
```

```
GroupCategory                    : Security
GroupScope                       : Global
groupType                        : -2147483646
HomePage                         :
instanceType                     : 4
isDeleted                        :
LastKnownParent                  :
ManagedBy                        :
member                           : {CN=quota user,CN=Users,DC=NTAP,DC=local,
CN=prof1,CN=Users,DC=NTAP,DC=local, CN=student2,CN=Users,DC=NTAP,DC=local,
CN=Administrator,CN=Users,DC=NTAP,DC=local}
MemberOf                         : {}
Members                          : {CN=quota user,CN=Users,DC=NTAP,DC=local,
CN=prof1,CN=Users,DC=NTAP,DC=local, CN=student2,CN=Users,DC=NTAP,DC=local,
CN=Administrator,CN=Users,DC=NTAP,DC=local}
Modified                         : 8/30/2019 3:38:12 PM
modifyTimeStamp                  : 8/30/2019 3:38:12 PM
Name                             : ProfGroup
nTSecurityDescriptor             : System.DirectoryServices.ActiveDirectorySecurity
ObjectCategory                   : CN=Group,CN=Schema,CN=Configuration,DC=NTAP,DC=local
ObjectClass                      : group
ObjectGUID                       : e2fae6f6-e682-4c37-b998-d0e2215e8e66
objectSid                        : S-1-5-21-3552729481-4032800560-2279794651-1111
ProtectedFromAccidentalDeletion : False
SamAccountName                   : ProfGroup
sAMAccountType                   : 268435456
sDRightsEffective                : 15
SID                              : S-1-5-21-3552729481-4032800560-2279794651-1111
SIDHistory                       : {}
uSNChanged                       : 680730
uSNCreated                       : 12933
whenChanged                      : 8/30/2019 3:38:12 PM
whenCreated                      : 1/14/2017 12:24:31 PM
```

For a search of netgroup attributes, use `Get-AdObject`:

```
PS C:\> Get-ADObject -LDAPFilter "(objectClass=nisNetgroup)" -Properties *


CanonicalName                    : NTAP.LOCAL/netgroups/netgroup1
CN                               : netgroup1
Created                          : 3/1/2017 3:04:00 PM
createTimeStamp                  : 3/1/2017 3:04:00 PM
Deleted                          :
Description                      :
DisplayName                      :
DistinguishedName                : CN=netgroup1,OU=netgroups,DC=NTAP,DC=local
dSCorePropagationData            : {12/31/1600 7:00:00 PM}
instanceType                     : 4
isDeleted                        :
LastKnownParent                  :
Modified                         : 2/20/2020 9:43:17 PM
modifyTimeStamp                  : 2/20/2020 9:43:17 PM
Name                             : netgroup1
nisNetgroupTriple                : {(10.193.67.225,,), (xcp,,)}
nTSecurityDescriptor             : System.DirectoryServices.ActiveDirectorySecurity
ObjectCategory                   : CN=NisNetgroup,CN=Schema,CN=Configuration,DC=NTAP,DC=local
ObjectClass                      : nisNetgroup
ObjectGUID                       : 3cb36ede-668c-4e5c-a9b0-a6d927dfdec7
ProtectedFromAccidentalDeletion : False
sDRightsEffective                : 15
showInAdvancedViewOnly           : True
uSNChanged                       : 834544
uSNCreated                       : 24423
whenChanged                      : 2/20/2020 9:43:17 PM
whenCreated                      : 3/1/2017 3:04:00 PM
```

ONTAP CLI commands for LDAP troubleshooting

ONTAP provides several commands and log files that you can use to troubleshoot LDAP issues. This section covers those commands.

Network pings

ONTAP can run network pings to any destination host name or address, including a way to force the traffic out of a specific data LIF and SVM.

```
cluster::*> network ping ?
   {  -node <nodename>                    Node
   |  -lif <lif-name>  }                  Logical Interface
    -vserver <vserver>                    Vserver
  [ -use-source-port {true|false} ]       *(DEPRECATED)-Use Source Port of Logical Interface
   [-destination] <Remote InetAddress>    Destination
  [ -show-detail|-s [true] ]              Show Detail Output
  [ -record-route|-R [true] ]             Record Route
  [ -verbose|-v [true] ]                  Show All ICMP Packets
  [ -packet-size <integer> ]              Packet Size
  [ -count <integer> ]                    Count
  [ -wait <integer> ]                     Packet Send Wait Time (secs)
  [ -flood [true] ]                       *Flood Ping
  [ -disallow-fragmentation|-D [true] ]   Disallow Packet Fragmentation (default: false)
  [ -wait-response <integer> ]            Packet Response Wait Time (ms) (default: 10000)
```

GetXXbyYY

ONTAP provides a command in the advanced privilege (`getxxbyyy`) that allows searches to be performed from an SVM to the name services that are configured in the `ns-switch` file for the SVM.

Following are the available commands:

```
cluster::*> getxxbyyy ?
  (vserver services name-service getxxbyyy)
  getaddrinfo                 *Gets the IP address information by using the host name.
  getgrbygid                  *Gets the group members by using the group identifier or GID.
  getgrbyname                 *Gets the group members by using the group name.
  getgrlist                   *Gets the group list by using the user name.
  gethostbyaddr               *Gets the host information from the IP address.
  gethostbyname               *Gets the IP address information from host name.
  getnameinfo                 *Gets the name information by using the IP address.
  getpwbyname                 *Gets the password entry by using the user name.
  getpwbyuid                  *Gets the password entry by using the user identifier or UID.
  netgrpcheck                 *Check if a client is part of a netgroup using combined API
```

`getxxbyyy` can query LDAP, NIS, or local files for users, groups, group memberships, and netgroups and can query DNS or local files for host names. In addition, the command can specify which name service source the results came from (`-show-source true`) and can provide granular errors from the commands (hidden option `-show-granular-err true`). You can also bypass the cache to verify that lookups are coming from name services with `-use-cache false`.

Example of `getxxbyyy` to look up a UNIX user:

```
cluster::*> getxxbyyy getpwbyname -vserver NFS -node node1 -username ipa-user -show-source true -
show-granular-err true
  (vserver services name-service getxxbyyy getpwbyname)
Source used for lookup: LDAP
pw_name: ipa-user
pw_passwd:
{crypt}$6$GX$kUwi9EhRKmzY8RQwvYwzNW0as5xFPV12i9B5PNZa3.soXLnQFmmTCuojtZ/H9dqt6vjUBHS4V2IFKZZE5Pk9
c.
pw_uid: 1971600003
pw_gid: 1971600000
pw_gecos:
pw_dir: /home/ipa-user
```

```
pw_shell: /bin/sh

NIS:
Error code:    NS_ERROR_NONE
Error message: No error
LDAP:
Error code:    NS_ERROR_NONE
Error message: No error
DNS:
Error code:    NS_ERROR_NONE
Error message: No error
FILES:
Error code:    NS_ERROR_NONE
Error message: No error
Deterministic Result: Success
```

Example of `getxxbyyy` to retrieve group membership:

```
cluster::*> getxxbyyy getgrlist -node node1 -vserver DEMO -username seventeengids
  (vserver services name-service getxxbyyy getgrlist)
pw_name: seventeengids
Groups: 1201 12348 123411 123415 12345 12344 123414 12349 12341 12347 123417 1234 12346 123416
123410 123413 12343 123412 12342 1202 1203 1204 1220 1205 1206 1207 1208 1209 1210 1211 1212 1213
1214 1215 1216 1217
```

Example of host name lookup with `getxxbyyy`:

```
cluster::*> getxxbyyy gethostbyname -node node1 -vserver DEMO -hostname centos8 -show-source true
  (vserver services name-service getxxbyyy gethostbyname)
Source used for lookup: DNS
Host name: centos8
Canonical name: centos8.NTAP.LOCAL
IPv4: x.x.x.x
```

Example of netgroup member check:

```
cluster::*> getxxbyyy netgrpcheck -node node1 -vserver DEMO -netgroup netgroup1 -clientIP
10.193.67.225 -show-source true
  (vserver services name-service getxxbyyy netgrpcheck)
Success. Client 10.193.67.225 is member of netgroup netgroup1
Searched using NETGROUP_BYNAME
Source used for lookup: LDAP
```

vserver services access-check

ONTAP 9.3 and later versions offer commands for interaction with name services, including:

- Authentication
- DNS
- Name mapping
- Server discovery

These commands live under the `vserver services access-check` command set. The `access-check` commands are essentially `diag secd` commands that are ported to the advanced privilege.

Authentication

Authentication commands allow storage administrators to review users, groups, group memberships, numeric IDs, and name mappings for multiprotocol NAS environments. These commands are useful mostly to verify that users and IDs match their expected results and to check whether group membership information is working across both SMB and NFS protocols.

One of the more detailed commands is the `show-creds` command. This command works only if NFS and SMB are configured for the SVM, but it offers a wide array of information about the user that is being queried, including numeric IDs, SIDs, name mappings, and so on.

Example of `show-creds` command:

```
cluster::*> vserver services access-check authentication show-creds -vserver DEMO -win-name prof1
-list-id true -list-name true

 UNIX UID: 1100 (prof1) <> Windows User: S-1-5-21-3552729481-4032800560-2279794651-1110
(NTAP\prof1 (Windows Domain User)) << Name Mapping

 GID: 1101 (ProfGroup) << Primary UNIX group
 Supplementary GIDs: << UNIX group membership
  1101  (ProfGroup)
  1201  (group1)
  1202  (group2)
  1203  (group3)
  1220  (sharedgroup)

 Primary Group SID: S-1-5-21-3552729481-4032800560-2279794651-513   NTAP\DomainUsers (Windows
Domain group)

 Windows Membership: << Windows SMB group membership
  S-1-5-21-3552729481-4032800560-2279794651-1106   NTAP\group2 (Windows Domain group)
  S-1-5-21-3552729481-4032800560-2279794651-513   NTAP\DomainUsers (Windows Domain group)
  S-1-5-21-3552729481-4032800560-2279794651-1122   NTAP\sharedgroup (Windows Domain group)
  S-1-5-21-3552729481-4032800560-2279794651-1105   NTAP\group1 (Windows Domain group)
  S-1-5-21-3552729481-4032800560-2279794651-1107   NTAP\group3 (Windows Domain group)
  S-1-5-21-3552729481-4032800560-2279794651-1111   NTAP\ProfGroup (Windows Domain group)
  S-1-18-2   Service asserted identity (Windows Well known group)
  S-1-5-32-551   BUILTIN\Backup Operators (Windows Alias)
  S-1-5-32-545   BUILTIN\Users (Windows Alias)
 User is also a member of Everyone, Authenticated Users, and Network Users

 Privileges (0x2086): << Windows privileges
  SeBackupPrivilege
  SeRestorePrivilege
  SeChangeNotifyPrivilege
```

DNS

The `access-check` command can also query DNS for forward or SRV lookups. Alternatively, you can use the `getxxbyyy` command.

Name mapping

Name mapping in ONTAP occurs for users in multiprotocol NAS environments. The intent is to authenticate users based on the Security styles of the volumes or the qtree that is being accessed, because a valid user must be present to determine access permissions based on the ACL styles on the file or folder. (See the “Security styles” section.) For instance, with NTFS security styles, UNIX users must map to valid Windows users. LDAP helps centralize users and groups to provide more seamless name mapping for multiprotocol NAS environments.

The `access-check name-mapping` command allows storage administrators to verify that name mappings are correct for UNIX and Windows users, as well as for Kerberos SPN mappings for Kerberized NFS access.

Example of `access-check name-mapping` command:

```
cluster::*> access-check name-mapping show -vserver DEMO -direction win-unix -name NTAP\prof1
  (vserver services access-check name-mapping show)
'NTAP\prof1' maps to 'prof1'
```

vserver services name-service

Another set of commands that can help with LDAP and NAS troubleshooting are the `vserver services name-service` commands. The following set of commands is available in the advanced privilege:

```
cluster::*> vserver services name-service ?
  cache>                     *The cache directory
  dns>                       Manage DNS service
  getxxbyyy>                 *Execute getXXbyYY for the given command.
  ldap>                      Manage LDAP configuration
  netgroup>                  Manage local netgroups
  nis-domain>                Manage Network Information Service domains
  ns-switch>                 Manage Name Services Switch ordering
  unix-group>                Manage local UNIX group accounts
  unix-user>                 Manage local UNIX user accounts
  ypbind>                    *The ypbind directory
```

This section discusses these commands and where they fit into LDAP and NAS troubleshooting.

cache

To help reduce the overall load on networks and name servers, ONTAP caches many name service requests. These caches are covered in detail in TR-4668. With these commands, you can check, flush, and configure cache lifetimes.

Following are the available caches that you can manage:

```
cluster::*> name-service cache
    group-membership hosts            netgroups        settings
    show-count       unix-group       unix-user
```

Example of `group-membership` cache:

```
cluster::*> name-service cache group-membership show -vserver DEMO -user prof1
  (vserver services name-service cache group-membership show)
                                Number of
Vserver    User        Group    Groups    Groups      Create Time    Is Partial
---------- ----------- -------- --------- ----------- -------------- ----------
DEMO       prof1       1101     5         1101, 1201, 1202, 1203, 1220
                                                      2/13/2020 15:32:00
                                                                     False
```

You can also delete a group membership cache in the SVM on a per-user basis. This capability comes in handy if a user has been added or removed from a group recently and the cache does not accurately reflect that change.

Cache views and flushes also can be applied to DNS host names, UNIX users and groups, and netgroups.

Example of DNS host name cache:

```
cluster::*> name-service cache hosts forward-lookup show -vserver DEMO -host *
  (vserver services name-service cache hosts forward-lookup show)
                   IP       Address IP                     Create
Vserver   Host     Protocol Family  Address        Source  Time       TTL(sec)
--------- -------- -------- ------- -------------- ------- ---------- --------
DEMO      oneway.ntap.local
                   Any      Any     xx.xxx.xx.xxx  dns     2/13/2020  3600
                                                           15:39:27
DEMO      oneway.ntap.local
                   Any      Ipv4    xx.xxx.xx.xxx  dns     2/13/2020  3600
                                                           15:51:03
```

Example of `unix-user` cache:

```
cluster::*> name-service cache unix-user user-by-name show -vserver DEMO -pw-name prof1
  (vserver services name-service cache unix-user user-by-name show)

            Vserver: DEMO
      pw_name field: prof1
       pw_uid field: 1100
       pw_gid field: 1101
        Create Time: 2/13/2020 15:27:30
Source of the Entry: ldap
```

When a netgroup query is run for a single host, ONTAP populates the cache with all the hosts from the netgroup, which reduces the amount of load on the cluster. When you check the caches, you can see the `ip-to-netgroup` cache of specific hosts that were queried:

```
cluster::*> name-service cache netgroups ip-to-netgroup show -vserver DEMO
  (vserver services name-service cache netgroups ip-to-netgroup show)
Vserver    IP Address  Netgroup     Source  Create Time
---------- ----------- ------------ ------- -----------
DEMO       10.193.67.222
                       netgroup1    ldap    2/20/2020 21:21:21
DEMO       10.193.67.225
                       netgroup1    none    2/20/2020 21:21:28
DEMO       10.193.67.233
                       netgroup1    netgrp_byname
                                            2/20/2020 21:14:12
```

Or you can see the full list of members, whether they were queried or not:

```
cluster::*> name-service cache netgroups members show -vserver DEMO
  (vserver services name-service cache netgroups members show)
Vserver    Netgroup    Hosts        Source  Create Time
---------- ----------- ------------ ------- -----------
DEMO       netgroup1   10.193.67.225,xcp.ntap.local,xcp
                                    ldap    2/20/2020 21:08:58
```

Caches all have a specific timeout period (Time to Live, or TTL), after which entries age out to prevent stale entries from lingering. There are also negative TTL values, where a lookup that has failed resides to prevent overrunning a system with objects that might not exist. You can adjust the cache timeout values by using the `settings` command under each cache type. You can also enable or disable caches.

Table 13 shows the default cache timeout values for each cache in ONTAP 9.7.

Table 13) Default cache timeout values in ONTAP 9.7 and later.

Cache	Default timeout
Group membership list	24-hour TTL
Hosts	24-hour TTL, 1-minute negative TTL
Netgroups	24-hour TTL, 30-minute negative TTL
UNIX groups	24-hour TTL, 1-minute negative TTL
UNIX users	24-hour TTL, 1-minute negative TTL

Note: Cache timeout values might change depending on the ONTAP release. Be sure to verify the cache settings for your ONTAP release.

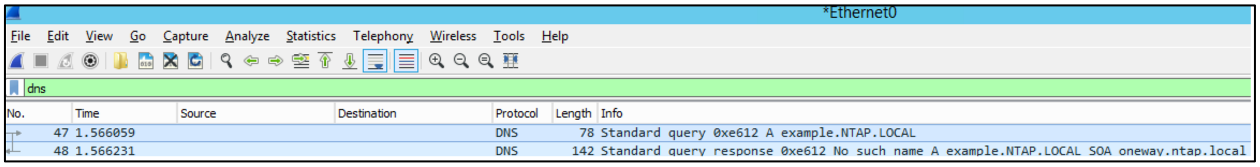
In addition, the name service cache also undergoes a total cache eviction every 4 hours by default, but you can control this period with the global `name-service cache settings` command. This command also can control whether the `name-service` cache replicates between nodes to provide a global `name-service` cache for SVMs.

DNS

With `name-service dns` commands, you can configure DNS or local host file entries, enable dynamic DNS updates, or check the DNS server status.

For purposes of troubleshooting, `dns check` can provide information about connectivity and the speed of a request. When you run this command, a standard “A” record query for `example.dnsdomain.com` is performed to the configured DNS server, as shown in Figure 36.

Figure 36) Configured DNS server.


*Ethernet0
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
dns

```
No.  Time      Source  Destination  Protocol  Length  Info
  47 1.566059                       DNS           78  Standard query 0xe612 A example.NTAP.LOCAL
  48 1.566231                       DNS          142  Standard query response 0xe612 No such name A example.NTAP.LOCAL SOA oneway.ntap.local
```

Example of `dns check`:

```
cluster::*> name-service dns check -vserver DEMO
  (vserver services name-service dns check)
                                Name Server
Vserver       Name Server      Status       Status Details
------------- --------------- ------------ --------------------------
DEMO          xx.xxx.xx.xxx    up           Response time (msec): 1
```

Note: By default, `dns check` is run when DNS configurations are created. If `dns check` fails during any of the tests, then the configuration modification fails, unless `-skip-config-validation` is set to `true`.

getxxbyyy

This command is covered in the previous section, “GetXXbyYY” and is used for `name-service` checks for users, groups, and DNS lookups.

ldap

With `name-service ldap` commands, you can configure LDAP clients and schemas or check the LDAP server status.

For purposes of troubleshooting, `ldap check` can provide information about connectivity and the speed of a request. When you run this command, the following occurs:

- Basic connectivity to the LDAP server is checked:
  - If a host name is set in `-ldap-servers`, DNS is queried to resolve to an IP address.
  - If an IP address is configured, DNS is not used.
  - If the `-ad-domain` setting is configured, then DNS searches for the LDAP SRV record.
- An LDAP bind takes place based on the LDAP client configuration:
  - The minimum bind level is the minimum bind level that is allowed. More secure bind methods are tried first, starting with SASL.
- If the bind is successful, the configured DNs are checked:
  - Queries are performed if base, user, group, and/or netgroup DNs are configured.
  - Queries are basic `wholeSubtree` and are looking only for the LDAP server to respond that the DNs exist.

  Note: By default, `ldap check` is run when LDAP client configurations are created. If `ldap check` fails during any of the tests, then the configuration modification fails, unless `-skip-config-validation` is set to `true`.

Example of `ldap check`:

```
cluster::> name-service ldap check -vserver DEMO
  (vserver services name-service ldap check)

                  Vserver: DEMO
Client Configuration Name: DEMO
              LDAP Status: up
      LDAP Status Details: Successfully connected to LDAP server "x.x.x.x".
   LDAP DN Status Details: All the configured DNs are available.
```

netgroup

The `netgroup` commands allow netgroup files to be loaded through the URI from external sources to caches on the local SVM for faster access. Files are loaded through FTP or HTTP.

Example of `netgroup load`:

```
cluster::*> netgroup load -vserver NFS -source http://x.x.x.x/files/netgroupfile.txt
[Job 25720] Job succeeded: Netgroup Load Job Success
cluster::*> netgroup file show -vserver NFS
                    Member
Vserver    Netgroup Netgroup    Host          User         Domain
---------- -------- ----------- ------------- ------------ -------------------
NFS
           netgroupfile
                    -           centos8       ipa-user     ,
```

nis-domain

This command set is unrelated to LDAP and instead is used for interaction with NIS.

ns-switch

This command set is used to manage the `ns-switch` configuration for an SVM, such as specifying LDAP as a source for user and group lookups.

unix-user and unix-group

These command sets are used to manage local users and groups, as well as to enable file-only mode for users and groups. For details on file-only mode, see the section, “Use of local files in ONTAP.”

ypbind

This command is a standard NIS command that is used to test connectivity to NIS servers. It does not apply to LDAP.

export-policy

Export policies in ONTAP are containers for export rules for NFS (or, if desired, SMB) share access. Unlike share or file permissions, access is controlled by client IP address, host name, netgroup, or subnet. Export policy rules are intended to be an initial gating option and should not be considered as the sole way to secure NFS. You should also use other methods, such as Kerberos, encryption, and user permissions.

This section covers commands under the `export-policy` set that pertain to LDAP functionality, because LDAP can serve netgroups to the cluster, which can then be applied to exports.

check-access

The `check-access` command enables you to specify volumes, qtrees, and client IP addresses to check the level of access that is allowed to the export. ONTAP resolves DNS host names, searches LDAP for netgroups, and sends test operations to the export during this process.

The following options are available with the command:

```
cluster::*> export-policy check-access ?
  [ -instance | -fields <fieldname>, ... ]
   -vserver <vserver name>                           Vserver Name
  [-volume] <volume name>                            Volume Name
  [-client-ip] <IP Address>                          Client IP Address
  [-authentication-method] <authentication method>  Authentication Method
  [-protocol] <Client Access Protocol>               Protocol
  [-access-type] {read|read-write}                   Access Rights to Check for
  [ -qtree <qtree name> ]                             Name of the Qtree
  [ -path <text> ]                                    Path
  [ -policy <text> ]                                  Export Policy
  [ -policy-owner <text> ]                            Export Policy Owner
  [ -policy-owner-type {volume|qtree} ]               Type of Export Policy Owner
  [ -rule-index <integer> ]                           Export Policy Rule Index
  [ -access {read|read-write} ]                       Access Rights
  [ -partial-rule-match {true|false} ]                Did a Subset of the Rules Match?
  [ -clientmatch <text> ]                             Client Match Spec
```

This example tests an export policy that has a netgroup in the rule set.

```
cluster::*> vol show -vserver DEMO -volume netgrpvol -fields policy
vserver volume    policy
------- --------- --------
DEMO    netgrpvol netgroup

cluster::*> export-policy rule show -vserver DEMO -policyname netgroup
             Policy          Rule    Access   Client                RO
Vserver      Name            Index   Protocol Match                 Rule
------------ --------------- ------  -------- --------------------- ---------
DEMO         netgroup        1       any      @netgroup1            any

cluster::*> export-policy check-access -vserver DEMO -volume netgrpvol -client-ip 10.193.67.222 -
authentication-method sys -protocol nfs3 -access-type read-write
                                          Policy    Policy       Rule
Path                          Policy     Owner     Owner Type  Index Access
----------------------------- ---------- --------- ---------- ------ ----------
/                             default    vsroot    volume          2 read
/netgrpvol                    netgroup   netgrpvol volume          1 read-write
```

You can see that the netgroup cache is populated after the command is run:

```
cluster::*> cache netgroups ip-to-netgroup show -vserver DEMO
  (vserver services name-service cache netgroups ip-to-netgroup show)
Vserver    IP Address  Netgroup     Source  Create Time
---------- ----------- ------------ ------- -----------
DEMO       10.193.67.222
                       netgroup1    ldap    2/21/2020 09:10:27
```

When a qtree is queried, it queries the entire path:

```
cluster::*> export-policy check-access -vserver DEMO -volume netgrpvol -client-ip 10.193.67.222 -
authentication-method sys -protocol nfs3 -access-type read-write -qtree tree
                                          Policy    Policy       Rule
Path                          Policy     Owner     Owner Type  Index Access
----------------------------- ---------- --------- ---------- ------ ----------
/                             default    vsroot    volume          2 read
/netgrpvol                    netgroup   netgrpvol volume          1 read
/netgrpvol/tree               netgroup   tree      qtree           1 read-write
```

When you change the export policy rule to deny writes, following is the result:

```
cluster::*> export-policy rule modify -vserver DEMO -policyname netgroup -ruleindex 1 -rorule
never

cluster::*> export-policy check-access -vserver DEMO -volume netgrpvol -client-ip 10.193.67.222 -
authentication-method sys -protocol nfs3 -access-type read-write
                                         Policy    Policy       Rule
Path                          Policy     Owner     Owner Type  Index Access
----------------------------- ---------- --------- ---------- ------ ----------
/                             default    vsroot    volume          2 read
/netgrpvol                    netgroup   netgrpvol volume          1 denied
```

cache flush

Export policies also use caches to reduce the amount of time that is spent looking up IP addresses, host names, netgroups, and so on. This approach helps reduce the amount of time that is needed for mounting and traversing NFS exports.

In some cases, caches might become stale and require flushing, such as when a netgroup is changed to remove or to add a client, or if a client’s access level has changed. You can view caches through the other `export-policy` commands that are listed in this section.

The following command can flush individual caches or all caches en masse:

```
cluster::*> export-policy cache flush ?
   [-vserver] <vserver name>                                 Vserver
  [[-node] <nodename>]                                       Node
  [ -cache {all|access|host|id|name|netgroup|showmount|ip} ]  Cache Name
```

Note: To avoid having to repopulate all caches, when possible, flush only individual caches or use other commands in this section to flush individual entries.

The following caches are available to help you flush caches:

```
cluster::*> export-policy cache flush -vserver DEMO -cache ?
  all                         All
  access                      Access Cache in the Nblade
  host                        Host Name to IP Cache in the Mgwd
  id                          ID to Credential Cache in the Mgwd
  name                        Name to ID Cache in the Mgwd
  netgroup                    Netgroup cache in the Mgwd
  showmount                   Showmount Caches in the Mgwd and the Nblade
  ip                          IP to Host Name Cache in the Mgwd
```

access-cache

With the `access-cache` command, you can view and manage the export policy access caches. With this command, you can specify policies and hosts that have accessed a volume through NFS.

In the following instance, two clients attempt to access a volume with the netgroup export policy. Only one has access:

```
cluster::*> export-policy check-access -vserver DEMO -volume netgrpvol -client-ip 10.193.67.225 -
authentication-method sys -protocol nfs3 -access-type read-write
                                         Policy    Policy       Rule
Path                          Policy     Owner     Owner Type  Index Access
----------------------------- ---------- --------- ---------- ------ ----------
/                             default    vsroot    volume          2 read
/netgrpvol                    netgroup   netgrpvol volume          0 denied

cluster::*> export-policy check-access -vserver DEMO -volume netgrpvol -client-ip 10.193.67.222 -
authentication-method sys -protocol nfs3 -access-type read-write
                                         Policy    Policy       Rule
Path                          Policy     Owner     Owner Type  Index Access
----------------------------- ---------- --------- ---------- ------ ----------
/                             default    vsroot    volume          2 read
/netgrpvol                    netgroup   netgrpvol volume          1 read-write
```

When the `.225` client attempts to mount, it is denied.

```
[root@centos7 ~]# mount -o nfsvers=3 DEMO:/netgrpvol /netgrpvol
mount.nfs: access denied by server while mounting DEMO:/netgrpvol
```

When the `.222` client mounts, it is allowed.

```
[root@centos8-ipa ~]# mount -o nfsvers=3 DEMO:/netgrpvol /netgrpvol
[root@centos8-ipa ~]# mount | grep netgrp
DEMO:/netgrpvol on /netgrpvol type nfs
(rw,relatime,vers=3,rsize=1048576,wsize=1048576,namlen=255,hard,proto=tcp,timeo=600,retrans=2,sec
=sys,mountaddr=10.193.67.219,mountvers=3,mountport=635,mountproto=udp,local_lock=none,addr=10.193
.67.219)
```

This result is reflected in the `access-cache`. `Positive` denotes successful access, and `negative` denotes unsuccessful access. Caches are per node and depend on nodes that own data LIFs where clients are connected.

```
cluster::*> export-policy access-cache show -node node2 -vserver DEMO -policy netgroup -address
10.193.67.222 -instance

                                        Node: node2
                                     Vserver: DEMO
                                 Policy Name: netgroup
                                  IP Address: 10.193.67.222
                    Access Cache Entry Flags: has-usable-data
                                 Result Code: 0
                 First Unresolved Rule Index: -
                      Unresolved Clientmatch: -
              Number of Matched Policy Rules: 1
         List of Matched Policy Rule Indexes: 1
                                Age of Entry: 83s
                 Access Cache Entry Polarity: positive
Time Elapsed since Last Use for Access Check: 83s
      Time Elapsed since Last Update Attempt: 83s
               Result of Last Update Attempt: 0
                List of Client Match Strings: @netgroup1

cluster::*> export-policy access-cache show -node node2 -vserver DEMO -policy netgroup -address
10.193.67.225 -instance

                                        Node: node2
                                     Vserver: DEMO
                                 Policy Name: netgroup
                                  IP Address: 10.193.67.225
                    Access Cache Entry Flags: has-usable-data
                                 Result Code: 0
                 First Unresolved Rule Index: -
                      Unresolved Clientmatch: -
              Number of Matched Policy Rules: 0
         List of Matched Policy Rule Indexes: -
                                Age of Entry: 41s
                 Access Cache Entry Polarity: negative
Time Elapsed since Last Use for Access Check: 41s
      Time Elapsed since Last Update Attempt: 41s
               Result of Last Update Attempt: 0
                List of Client Match Strings: -
```

netgroup

The `export-policy netgroup` command has the following available options:

```
cluster::*> export-policy netgroup ?
  cache>                        The cache directory
  check-membership              Check to see if the client is a member of the netgroup
  queue>                        The queue directory
```

In ONTAP 9.3 and later, a global name service cache was added (see TR-4668 for details), so `netgroup cache` commands were moved to the `vserver services name-service netgroup` command. However, you can still check membership for netgroups by using `check-membership`. The success of this command depends on the existence of an export policy rule that contains the netgroup that is being queried.

```
cluster::*> export-policy rule show -vserver DEMO -policyname netgroup
Policy          Rule    Access   Client                RO
Vserver      Name            Index   Protocol Match                 Rule
------------ --------------- ------  -------- --------------------- ---------
DEMO         netgroup        1       any      @netgroup1            any


cluster::*> export-policy netgroup check-membership -vserver DEMO -netgroup netgroup1 -client-ip
10.193.67.222
Client 10.193.67.222 is a member of netgroup "netgroup1" for Vserver "DEMO" with state "name
service cache".
```

For more information about the `check-membership` command, see the manual pages.

CIFS domain

Active Directory domains can trust other domains. If an LDAP user lives in a trusted domain, then ONTAP can query either domain with the same bind credentials. In some cases, the domain trust might not be working properly, so you might need to use the following commands to find an issue.

cifs domain trusts

This command reviews what ONTAP sees when it queries the domain trusts for the joined Active Directory domain, and it offers the option to rediscover the trusts. If a trusted domain does not show properly, LDAP communication between the domains does not work.

```
NAME
     vserver cifs domain trusts -- Manage discovered trusted domains

DESCRIPTION
     Manage discovered trusted domains

COMMANDS
     rediscover - Reset and rediscover trusted domains for a Vserver

     show - Display discovered trusted domain information
```

cifs domain discovered-servers

This command enables storage administrators to see how ONTAP sees the Active Directory domain to verify whether server connectivity to domain controllers is functioning properly.

```
cluster::*> cifs domain discovered-servers ?
  discovery-mode>             *The discovery-mode directory
  reset-servers               Reset and rediscover servers for a Vserver
  show                        Display discovered server information
```

event log show

When an issue occurs in ONTAP, it is logged in the event log subsystem. These logs are maintained for a period on-box and are available through NetApp Active IQ® digital advisor if you need to look at issues earlier in the event log history that might have rolled off.

You can filter event log messages by date, time, severity, message name, and various other ways, as in the following list of command options:

```
cluster::*> event log show ?
```

```
  [ -detail | -detailtime | -instance | -fields <fieldname>, ... ]
  [[-node] <nodename>]                        Node
  [[-seqnum] <Sequence Number>]               Sequence#
  [ -time <"MM/DD/YYYY HH:MM:SS"> ]           Time
  [ -severity {EMERGENCY|ALERT|ERROR|NOTICE|INFORMATIONAL|DEBUG} ]
  Severity (default: <=ERROR)
  [ -ems-severity {NODE_FAULT|SVC_FAULT|NODE_ERROR|SVC_ERROR|WARNING|NOTICE|INFO|DEBUG|VAR} ]
  *EMS Severity
  [ -source <text> ]                          Source
  [ -message-name <Message Name> ]            Message Name
  [ -event <text> ]                           Event
  [ -kernel-generation-num <integer> ]        *Kernel Generation Number
  [ -kernel-sequence-num <integer> ]          *Kernel Sequence Number
  [ -action <text> ]                          Corrective Action
  [ -description <text> ]                     Description
  [ -filter-name <text> ]                     Filter Name
```

Note: You can find more information about these commands in the manual pages for your ONTAP release.

For name service issues, such as LDAP connectivity, you can use a specific subset of message names to filter event logs to find issues faster. The following list is not comprehensive, but it can get you started.

Note: Message names are case-sensitive.

For LDAP:

```
cluster::*> event route show -message-name *ldap*
                                                                 Freq    Time
Message                          Severity       Destinations   Threshd Threshd
-------------------------------- -------------- -------------- ------- -------
ldap.false.configs.removed       NOTICE         -              0       0
netgroup.ldap.byhost.missing     INFORMATIONAL  -              0       0
netgroup.ldap.config             ERROR          -              0       0
secd.ldap.connectFailure         ALERT          -              0       0
secd.ldap.hostnames.not.resolved ERROR          -              0       0
secd.ldap.hostnames.resolved.partially
                                 ERROR          -              0       0
secd.ldap.noServers              EMERGENCY      -              0       0
secd.ldap.query.timed.out        ERROR          -              0       0
secd.ldap.referralError          INFORMATIONAL  -              0       0
secd.ldap.slowServer             ERROR          -              0       0
secd.netgroup.ldap.badFilter     ERROR          -              0       0
```

For exports:

```
cluster::*> event route show -message-name *export*
                                                                 Freq    Time
Message                          Severity       Destinations   Threshd Threshd
-------------------------------- -------------- -------------- ------- -------
Nblade.exportAccessChkFailed     ERROR          -              0       0
Nblade.exportAccessIndeterm      ERROR          -              0       0
crypto.export.failed             ALERT          -              0       0
exports.anon.noCredForId         ERROR          -              0       0
exports.dns.config               ERROR          -              0       0
exports.dom.notFound             ERROR          -              0       0
exports.dom.transient            ERROR          -              0       0
exports.hostname.notFound        INFORMATIONAL  -              0       0
exports.hostname.transient       ERROR          -              0       0
exports.netgroup.dnsNoPtrRec     ERROR          -              0       0
exports.netgroup.notFound        ERROR          -              0       0
exports.netgroup.partial         ERROR          -              0       0
exports.ngbh.allFailed           ERROR          -              0       0
exports.nsdb.anonNameToId        ERROR          -              0       0
exports.policy.empty             NOTICE         -              0       0
exports.policy.last.rule         ERROR          -              0       0
```

For NFS authorization:

```
cluster::*> event route show -message-name *nfsAuth*
                                                                 Freq    Time
Message                          Severity       Destinations   Threshd Threshd
-------------------------------- -------------- -------------- ------- -------
secd.nfsAuth.noCifsCred          ERROR          -              0       0
secd.nfsAuth.noCifsSid           ERROR          -              0       0
secd.nfsAuth.noCifsUser          ERROR          -              0       0
secd.nfsAuth.noNameMap           ERROR          -              0       0
secd.nfsAuth.noUnixCreds         ERROR          -              0       0
secd.nfsAuth.problem             ERROR          -              0       0

cluster::*> event route show -message-name *unix*
                                                                 Freq    Time
Message                          Severity       Destinations   Threshd Threshd
-------------------------------- -------------- -------------- ------- -------
secd.unixLookupFailure           ERROR          -              0       0
```

For netgroups:

```
cluster::*> event route show -message-name *netgroup*
                                                                 Freq    Time
Message                          Severity       Destinations   Threshd Threshd
-------------------------------- -------------- -------------- ------- -------
exports.netgroup.dnsNoPtrRec     ERROR          -              0       0
exports.netgroup.notFound        ERROR          -              0       0
exports.netgroup.partial         ERROR          -              0       0
netgroup.files.missing           ERROR          -              0       0
netgroup.ldap.byhost.missing     INFORMATIONAL  -              0       0
netgroup.ldap.config             ERROR          -              0       0
netgroup.nis.byhost.decode       ERROR          -              0       0
netgroup.nis.byhost.missing      INFORMATIONAL  -              0       0
netgroup.nis.config              ERROR          -              0       0
secd.netgroup.ldap.badFilter     ERROR          -              0       0
```

For name translations:

```
cluster::*> event route show -message-name *nameTrans*
                                                                 Freq    Time
Message                          Severity       Destinations   Threshd Threshd
-------------------------------- -------------- -------------- ------- -------
secd.nameTrans.groupNotFound     ERROR          -              0       0
secd.nameTrans.invalidConfig     ERROR          -              0       0
secd.nameTrans.invalidUser       ERROR          -              0       0
secd.nameTrans.noNameMapping     ERROR          -              0       0
secd.nameTrans.unknownUser       ERROR          -              0       0
secd.nameTrans.userNotFound      ERROR          -              0       0
```

Statistics

ONTAP has a statistics subsystem that you can enable to track down performance issues or to look for incrementing errors.

These statistics are on demand and are started with the `statistics start` command, with filters available for objects and counters.

Following is the manual page entry:

```
cluster::*> man statistics start
statistics start                Data ONTAP 9.7                statistics start

NAME
statistics start -- Start data collection for a sample

AVAILABILITY
This command is available to cluster and Vserver administrators at the advanced privilege level.

DESCRIPTION
```

```
This command starts the collection of performance data. Use the statistics stop command to stop
the collection. You view the sample of performance data by using the statistics show command. You
can collect more than one sample at a time.

PARAMETERS
 [-object <text>] - Object
Selects the objects for which you want to collect performance data. This parameter is required.
To view a list of valid object names, type statistics catalog object show at the command prompt.
To specify multiple objects, use "|" between each object.

Caution: You should limit the scope of this command to only a few objects at a time to avoid a
potentially significant impact on the performance of the system.

 [-instance <text>] - Instance
Selects the instances for which you want to collect performance data. If you do not specify this
parameter, the command collects statistics for all of the instances associated with the specified
objects. To specify multiple instances, use "|" between each instance.

For example, if you want to collect disk object statistics, you can use this parameter to specify
the name of a specific disk whose statistics you want to view. If you do not specify this
parameter, the command will collect statistics for all disks in the system.

 [-counter <text>] - Counter
Selects the counters for which you want to collect performance data. If you do not specify this
parameter, the command collects statistics for all of the counters in the specified objects.

To specify multiple counters, use "|" between each counter.

 [-preset <text>] - Preset
If this parameter is specified, the command displays statistics for the specified preset.

 [-sample-id <text>] - Sample Identifier
Specifies an identifier for the sample. Identifiers must be unique and are restricted to the
characters 0-9, a-z, A-Z, and "_". If you do not specify this parameter, the command generates a
sample identifier for you and defines this sample as the default sample for the CLI session. When
you run the statistics show command without specifying the -sample-id parameter, data from the
default sample displays. If you run this command during the same CLI session and do not specify
the -sample-id parameter, the command overwrites the previous sample. The command does not delete
the default sample when you close your session.

 [-vserver <vserver name>] - Vserver
Selects the vserver for which you want to collect performance data. If you do not specify this
parameter, the command collects statistics for all of the Vservers in the cluster.

 [-node {<nodename>|local}] - Node
Selects the node for which you want to collect performance data. If you do not specify this
parameter, the command collects statistics for all of the nodes in the cluster.

 [-filter <text>] - Filter
Selects performance data for the instance that matches the specified filter criteria. For
example, to display the instances from node1, specify -filter "node_name=node1".

 [-duration <integer>] - Sample Duration in Minutes
If this parameter is specified, the command will collect the closing sample after the time
specified. Duration can be specified in minutes.

 [-sample-type {User|System}] - Sample Type (privilege: diagnostic)
If this parameter is specified, the command will set the sample owner type to user or system. The
default sample type is user.

 [-max <integer>] - Tracker Size
Specifies the number of most active instances of an active object to display. The default setting
is to display all of the instances.

 [-sort-key <text>] - Counter Used For Sorting
If this parameter is specified, the command displays statistics sorted by the specified counter.
Only one counter can be specified.

 [-sort-order {ascending|descending}] - Sort Order
```

```
This parameter may be used in conjunction with the -sort-key parameter. This parameter changes
the order in which statistics are sorted. Possible values are ascending and descending. The
default setting is descending.
```

For name services and LDAP statistics, you can specify the following objects with the `-object` option, which can help you with potential issues and troubleshooting:

```
accesscache*
credstore
external_service*
nfs_credstore
nfs_exports_access_cache
nfs_exports_cache
secd*
```

You can specify multiple objects in a single statistics command with the pipe (`|`) value.

For example:

```
cluster::*> statistics start -object
accesscache*|credstore|external_service*|nfs_credstore|secd*|nfs_exports_access_cache|nfs_exports
_cache
Statistics collection is being started for sample-id: sample_235
```

Statistics for caches give information about the number of cache entries, how many times the cache was hit, how many missed cache entries there were, and so on.

Statistics for external services give information about DNS and LDAP queries, such as latency, number of operations, and servers that are being used.

In the following example, you can filter by Vserver/SVM, object, and instance name to obtain a refined view of the external service counters—all the way down to the LDAP server IP address. The use case here is to find out how many anonymous binds have occurred from this SVM.

```
cluster::*> statistics show -vserver NFS -object external_service* -instance
*LDAP*AnonymousBind:10.193.67.222 -counter num*

Object: external_service_op
Instance: NFS:LDAP (NIS & Name Mapping):AnonymousBind:10.193.67.222
Start-time: 3/3/2020 15:16:43
End-time: 3/3/2020 15:25:32
Elapsed-time: 529s
Scope: NFS

    Counter                                                    Value
    -------------------------------- --------------------------------
    num_not_found_responses                                        0
    num_request_failures                                           0
    num_requests_sent                                              0
    num_responses_received                                         0
    num_successful_responses                                       0
    num_timeouts                                                   0
```

The next example shows how to find out how many times a user has been looked up.

```
cluster::*> statistics show -vserver NFS -object external_service* -instance
*LDAP*GetUserInfoFromName:10.193.67.222 -counter num*

Object: external_service_op
Instance: NFS:LDAP (NIS & Name Mapping):GetUserInfoFromName:10.193.67.222
Start-time: 3/3/2020 15:16:43
End-time: 3/3/2020 15:27:40
Elapsed-time: 657s
Scope: NFS

    Counter                                                    Value
    -------------------------------- --------------------------------
    num_not_found_responses                                        0
    num_request_failures                                         1
    num_requests_sent                                            2
    num_responses_received                                       2
    num_successful_responses                                     1
    num_timeouts                                                 0
    num_not_found_responses                                      0
    num_request_failures                                         0
    num_requests_sent                                            0
    num_responses_received                                       0
    num_successful_responses                                     0
    num_timeouts                                                 0
```

For `secd*` objects, you can find out the number of times that an error has occurred since the statistics were started. The specific object is `secd_rpc_error`:

```
cluster::*> statistics show -vserver NFS -object secd_rpc_error -instance *ERROR* -counter count

Object: secd_rpc_error
Instance: NFS:secd_rpc_check_ldap_config:RESULT_ERROR_SECD_NO_SERVER_AVAILABLE
Start-time: 3/3/2020 15:16:43
End-time: 3/3/2020 15:31:49
Elapsed-time: 906s
Scope: NFS

    Counter                                                  Value
    -------------------------------- --------------------------------
    count                                                        0
    count                                                        0

Object: secd_rpc_error
Instance: NFS:secd_rpc_ldap_get_netgroup_match_by_host:RESULT_ERROR_SECD_GROUP_NOT_FOUND
Start-time: 3/3/2020 15:16:43
End-time: 3/3/2020 15:31:49
Elapsed-time: 906s
Scope: NFS

    Counter                                                  Value
    -------------------------------- --------------------------------
    count                                                        1

Object: secd_rpc_error
Instance:
NFS:secd_rpc_ldap_get_netgroup_match_by_host:RESULT_ERROR_SECD_NETGROUP_BYHOST_NOT_ENABLED
Start-time: 3/3/2020 15:16:43
End-time: 3/3/2020 15:31:49
Elapsed-time: 906s
Scope: NFS

    Counter                                                  Value
    -------------------------------- --------------------------------
    count                                                        0

Object: secd_rpc_error
Instance: NFS:secd_rpc_ldap_get_passwd:RESULT_ERROR_SECD_USER_NOT_FOUND
Start-time: 3/3/2020 15:16:43
End-time: 3/3/2020 15:31:49
Elapsed-time: 906s
Scope: NFS

    Counter                                                  Value
    -------------------------------- --------------------------------
    count                                                        0
    count                                                        0
6 entries were displayed.
```

After the statistics have run for as long as you want them to run, you should turn them off to reduce load on the cluster and to keep statistics files small.

```
cluster::*> statistics stop
```

```
Statistics collection is being stopped for sample-id: sample_235
```

You can also view or delete existing statistics samples.

```
cluster::*> statistics samples
    delete show
```

vserver security file-directory show

For storage administrators to easily view the permissions of files and folders in a file system, ONTAP provides the command `vserver security file-directory show`. This command is useful for troubleshooting permissions or access issues.

To run this command, use the SVM and full path of the file or folder in the volume. For more information about the command, use `man vserver security file-directory show`.

The following examples show the output from the command based on the security style of the object and the style of ACL that is applied.

Example of NTFS security style:

```
cluster::> vserver security file-directory show -vserver DEMO -path /data/Windows.iso

                Vserver: DEMO
              File Path: /data/Windows.iso
      File Inode Number: 15770
         Security Style: ntfs
        Effective Style: ntfs
         DOS Attributes: 20
 DOS Attributes in Text: ---A----
Expanded Dos Attributes: -
           UNIX User Id: 0
          UNIX Group Id: 0
         UNIX Mode Bits: 777
 UNIX Mode Bits in Text: rwxrwxrwx
                   ACLs: NTFS Security Descriptor
                         Control:0x8004
                         Owner:BUILTIN\Administrators
                         Group:NTAP\DomainUsers
                         DACL - ACEs
                           ALLOW-Everyone-0x1f01ff-(Inherited)
```

Example of UNIX security style—mode bit permissions:

```
cluster::> vserver security file-directory show -vserver DEMO -path /flexgroup_16/newfile1

                Vserver: DEMO
              File Path: /flexgroup_16/newfile1
      File Inode Number: 3358476
         Security Style: unix
        Effective Style: unix
         DOS Attributes: 20
 DOS Attributes in Text: ---A----
Expanded Dos Attributes: -
           UNIX User Id: 0
          UNIX Group Id: 0
         UNIX Mode Bits: 644
 UNIX Mode Bits in Text: rw-r--r--
                   ACLs: -
```

Example of mixed security style—NFSv4.x ACLs:

```
cluster::> vserver security file-directory show -vserver DEMO -path /home/student2

                Vserver: DEMO
              File Path: /home/student2
      File Inode Number: 97
```

```
         Security Style: mixed
        Effective Style: unix
         DOS Attributes: 10
 DOS Attributes in Text: ----D---
Expanded Dos Attributes: -
           UNIX User Id: 0
          UNIX Group Id: 0
         UNIX Mode Bits: 775
 UNIX Mode Bits in Text: rwxrwxr-x
                   ACLs: NFSV4 Security Descriptor
                         Control:0x8014
                         DACL - ACEs
                           ALLOW-OWNER@-0x1601ff
                           ALLOW-user-student2-0x1601ff
                           ALLOW-user-prof1-0x21
                           ALLOW-user-admin-0x1601ff
                           ALLOW-GROUP@-0x1201ff-IG
                           ALLOW-EVERYONE@-0x1200a9
```

Example of mixed security style—NTFS effective security:

```
cluster::> vserver security file-directory show -vserver DEMO -path /mixed/nfs3

                Vserver: DEMO
              File Path: /mixed/nfs3
      File Inode Number: 32636
         Security Style: mixed
        Effective Style: ntfs
         DOS Attributes: 20
 DOS Attributes in Text: ---A----
Expanded Dos Attributes: -
           UNIX User Id: 1100
          UNIX Group Id: 1101
         UNIX Mode Bits: 777
 UNIX Mode Bits in Text: rwxrwxrwx
                   ACLs: NTFS Security Descriptor
                         Control:0x8004
                         Owner:NTAP\prof1
                         Group:NTAP\DomainUsers
                         DACL - ACEs
                           ALLOW-NTAP\Administrator-0x1201ff
                           ALLOW-NTAP\prof1-0x1f01ff
                           ALLOW-Everyone-0x1201ff
```

Security styles affect how name mappings occur in ONTAP, and the user who attempts access must resolve to a user name that fits into the permission structures that are set on the object.

What information to collect before you contact NetApp Support

If you encounter an LDAP issue and cannot resolve it on your own, NetApp Support is readily available to assist. When you open a support case, the technical support engineer must gather some data to troubleshoot the issue. To expedite that process, the following is a list of questions that you can answer and information that you can provide to help resolve support cases faster. This list is not exhaustive—you might be asked for more data from the technical support engineer—but it is a start:

- What date and time did the problem occur?
- What LDAP server type and OS are being used?
- What LDAP clients are being used?
- Which user or group is affected?
- Is the problem still occurring? Is it intermittent?
- Can the LDAP administrator be present for the call-in case the technical support engineer needs extra information from the LDAP server?
- Does the LDAP server use any sort of encryption?

- Does the issue occur on all nodes? Some nodes? Specific IP addresses?
- Can the LDAP server be reached through the network from ONTAP?
- Generate a new AutoSupport report with `-type all` (`autosupport invoke * -type all`):
  - This command gathers information about the LDAP client, client schema, DNS, network, event logs, and so on.
- Have you checked the troubleshooting command output by using the instructions in the "ONTAP CLI commands for LDAP troubleshooting" section?
- Can other clients outside of ONTAP query LDAP properly with the commands that are listed in the "Third-party tools and utilities" section?
- For LDAP query issues (unable to find user) or LDAP configuration issues, collect output from the LDAP schema for a user and a group. This output helps verify that the correct schemas are being used.
- Packet traces during an issue from the client, LDAP server, and ONTAP system.
- Provide statistics capture information for name services and caches; see the "Statistics" section.

For information about collecting packet traces in ONTAP, see the following NetApp Knowledge Base articles:

- How to Capture Packet Traces (tcpdump) on ONTAP 9.2+ Systems
- How to Collect Rolling Packet Traces Using pktt on ONTAP 9.1 and Below Systems

Best practices

This section covers best practices for specific scenarios when you use LDAP with NetApp ONTAP. These best practices are not hard requirements; they are simply guidelines for success. Best practices can help prevent simple issues, but they are not guarantees that no issues will occur in an environment. This list is not exhaustive, but it attempts to address multiple scenarios.

LDAP server best practices

The following is a summary of best practices for LDAP servers:

- Use multiple LDAP servers to prevent overloading a single server.
- Keep LDAP servers updated to the latest OS release and patch release.
- Where possible, use encryption for binds and LDAP searches (such as SASL bind and StartTLS or SMB signing for queries).
- Use StartTLS instead of LDAP over SSL (LDAPS); LDAPS has been deprecated as a standard.
- Create service accounts to use with binds to LDAP clients in ONTAP rather than the administrator or Directory Manager users.
- Disable anonymous binds on the LDAP server.
- In Windows Active Directory LDAP where multiple domains in a forest have UNIX attributes, consider replicating attributes to the global catalog for UNIX identity management. See the section, "LDAP that uses Active Directory for UNIX identity management" and the "Active Directory global catalog searches" subsection.
- Create DNS A records for multiple LDAP servers by using the same name (for example, `ldap.ntap.local`) to provide DNS load balancing or use an external network load balancer to help spread network connections across servers.
- If possible, set up automation for user and group creation that automatically populates UNIX attributes in the LDAP server. This best practice pertains mainly to multiprotocol NAS environments, where Windows and UNIX accounts are being used.

- When you create UNIX user names in multiprotocol NAS environments, to avoid the need for explicit name mapping rules, try to use the same user name as the Windows name.

DNS server best practices

Following is a summary of best practices for DNS servers. TR-4523 covers DNS load balancing in detail:

- For redundancy and load balancing, use multiple DNS servers that replicate information to each other.
- Ensure that hosts have forward- and reverse-lookup records in DNS.
- Verify that LDAP has SRV records available in DNS.
- For redundancy, specify multiple DNS servers in the ONTAP SVM DNS configuration.

Cache management best practices

This section covers a summary of best practices for cache management in ONTAP.

Cache timeout settings

Name service caches have specific timeout settings by default because caches should age out over time to prevent situations in which entries become stale. The default cache settings in ONTAP 9.7 and later are listed in Table 14.

Many cache timeout values in ONTAP are modifiable. The following best practices apply to timeout settings for caches:

- In nearly all cases, leave the cache timeouts as the defaults. To remove stale entries in caches, use `cache flush` commands.
- If your environment has high churn (users are constantly added or removed from groups, netgroups add or remove hosts, and so on) consider lowering the cache timeout values to update more frequently.
- If your environment has low churn (users rarely change and netgroups rarely change), consider increasing the timeout values to maintain caches longer.
- Keep in mind that lowering the cache timeout values increases network traffic between ONTAP and name services and increases the load on CPU for ONTAP and name services, which can negatively affect performance. Increasing the cache timeout values results in more frequent stale entries, and users might be incorrectly granted or denied access.
- To monitor statistics related to name service servers:

```
cluster::> set diag
cluster::*> statistics start -object external_service_server
cluster::*> statistics show -object external_service_server
```

Manual cache flush considerations

By flushing caches manually, you remove information from them that might be outdated because of the following reasons:

- A recent change to export policy rules
- A recent change to user information or group membership
- A recent change to host name records in name servers
- A recent change to netgroup entries in name servers
- Recovery from a network outage that prevented netgroups from being fully loaded

Flushing the caches removes the outdated information and forces ONTAP to retrieve the current information from the appropriate external resources.

Note: Repopulation of caches can be resource-intensive. You should flush a cache only if you are trying to resolve a specific issue, and if possible, flush only the offending entry.

Some caches can have individual entries removed. Other caches must be flushed en masse. Table 14 shows at what level caches can be flushed in ONTAP 9.7 and later. The level to which a cache can be flushed also often corresponds to the level that it can be viewed.

Table 14) Manual cache flush operability in ONTAP 9.7 and later.

Cache	Cache flush operability
Netgroup member cache	Individual clients or all clients
Netgroup IP-to-host cache	Individual clients or all clients
LDAP group authentication	Individual names
Export-policy cache	Individual caches or all caches
Name service: group membership	Individual user and group
Name service: hosts	Individual forward and reverse DNS lookup
Name service: UNIX users and groups	Individual users and groups or all users and groups
Export-policy access-cache	Individual client/policy

Export policy best practices

This section covers a summary of best practices for export policies and rules in ONTAP.

Export policies and rules help control access to NFS exports based on the client that is requesting access. You can find most general export policy best practices in TR-4067. The following best practices pertain to export policies and rules as they relate to LDAP servers:

- If you specify a large number of clients with the same access permissions in an export policy, to reduce the complexity of storage management, consider using netgroups.
- Ensure that the SVM's DNS configuration is working properly and can resolve hosts through forward and reverse lookups.
- With export policy rules, the rule index order determines which export policy rule is applied first. If you want to set a more restrictive policy to an entire subnet but allow specific clients to have root access to a mount, set the rule index for the admin clients higher in the list so that they are processed first. If the more restrictive policy rule is listed first, then clients are denied access based on that policy, even if root access is granted later in the rule index.
- If you specify a netgroup in an export policy rule, use the `@netgroup` syntax; otherwise, ONTAP interprets the netgroup as a host name. For example, if you specify `netgroup1` in a rule, use `@netgroup1`.

Netgroup best practices

Following is a summary of best practices for netgroups in ONTAP:

- Ensure that hosts added to netgroups exist in DNS.
- Specify netgroups in export policy rules by using the @ sign.
- When you use `netgroup.byhost`, consider the following to enable the desired access results for hosts:
  - Forward and reverse DNS records for host names.
  - Host triple entry in netgroup file.
  - Netgroup specification for the host's `netgroup.byhost` entry.
  - Need to always use lowercase hosts to avoid case-sensitivity issues.

  - Syncing of DNS and `netgroup.byhost` entries, including case sensitivity.
  - If you use `netgroup.byhost` with NIS, be sure that the triples are configured to avoid using dashes (`-`) in the entries. For example, the entries should look like (`host,,`) not (`host,-,-`). ONTAP supports only the host portion of the triple. NIS treats any entry in the other portions of the triple as an attempted entry.
- NetApp highly recommends that you use `netgroup.byhost` functionality for large environments with exceptionally large netgroups. To enable access to work properly, the `netgroup.byhost` and netgroup entries must be synchronized.

LDAP client best practices

Following is a summary of best practices for LDAP clients (including ONTAP, which is also an LDAP client):

- Configure LDAP clients to bind and to search with the most secure methods available. For ONTAP, it includes binding as the CIFS server (if it exists), binding with SMB signing, and/or using LDAPS or StartTLS.
- For Linux clients, NetApp recommends SSSD for its ease of configuration and setup.
- When you use SSSD for LDAP, only the LDAP identity provider is supported. The Active Directory identity provider generates unique UID numerics based on the Active Directory SIDs and is not supported in ONTAP today. For more information, see the section, “SSSD UID/GID algorithms (SSSD Active Directory provider).”
- Ensure that LDAP clients all return the same user and group information (including group memberships) through `ldapsearch` and ONTAP CLI commands.
- Avoid having local users or groups on the clients that have conflicting names or numeric IDs. This situation can cause unpredictable behavior for file and folder access.

Appendix A: Command examples and other information

This section presents command examples and other information that did not quite fit in the previous sections of this document.

Use of local files in ONTAP

In some cases, it might not be possible (no access to external name services) or necessary (not enough users to justify setting up LDAP) to use name service servers for users, groups, netgroups, and so on.

In those cases, NetApp ONTAP provides several methods for you to create local file entries for these objects. It is still a best practice to use external name services because of the centralized management and consistency across clients.

There are two main ways to use local files in ONTAP:

- Create individual entries for users, groups, hosts, and so on, through System Manager or the CLI.
- Import files into the ONTAP SVM through `the load-from-uri` command, which requires access to HTTP or FTP servers that can pull the files over.

You can use local files for users, groups, group memberships, hosts, NIS databases, and netgroups.

For more information about how to create local users and groups, see the product documentation.

Scaled mode/file-only mode

In some cases, an environment might have thousands of users and groups, but no LDAP server. However, by default, there are limits on the number of local users and groups that you can create per SVM.

Scaled mode/file-only mode for local users and groups in ONTAP 9.1 enables storage administrators to expand the limits of local users and groups. It does so by enabling a diag-level name service option and then using the `load-from-uri` functionality to load files into the cluster to provide higher numbers of users and groups. Scaled mode/file-only mode also can improve the performance of name service lookups, because there is no longer a need for external dependencies on name service servers, networks, and so on. However, this performance comes at the expense of ease of management of the name services because file management adds overhead to the storage management and introduces more potential for human error. In addition, local file management must be performed per cluster, adding an extra layer of complexity.

To enable this option for users and groups, use the `vserver services name-service unix-user file-only` and `vserver services name-service unix-group file-only` commands.

```
NAME
vserver services name-service unix-user file-only modify -- Change configuration for UNIX-user
file download

AVAILABILITY
This command is available to cluster and Vserver administrators at the diagnostic privilege
level.

DESCRIPTION
The vserver services name-service unix-user file-only modify command enables you to load UNIX
user files with large number of UNIX users beyond the maximum configurable limit of 65536 for the
cluster. Once it is enabled, individual operations on UNIX users are not allowed, and the users
can only be managed using the vserver services name-service unix-user load-from-uri command.


PARAMETERS
-vserver <vserver name> - Vserver
Use this parameter to specify the Vserver for which you want to modify the file-only mode.

[-is-enabled {true|false}] - Is File-Only Download Enabled?
Use this parameter with value true to enable the file-only mode. This field is set to false by
default.
```

After the mode is enabled, use the following command to load the user and group files from the URI.

```
cluster::*> vserver services name-service unix-user load-from-uri
```

Note: If you load files larger than 10MB for users and 25MB for groups, use the `–skip-file-size-check` option.

When you use file-only mode, individual operations on users and groups are not allowed. This configuration is not currently supported in NetApp MetroCluster™ or SVM disaster recovery (SVM DR) scenarios.

When you use this command, some warnings are issued:

```
cluster::*> vserver services name-service unix-user file-only modify -vserver SVM1 -is-enabled
true

Warning: Do not enable the file-only configuration if you are using, or plan to use, MetroCluster
or Vserver Async DR.
         If you enable the file-only configuration:
         - Modifying individual user entries will not be possible.
         - Local Unix-users must be managed by downloading a file using the "vserver services
name-service unix-user load-from-uri" command.
```

```
         - Downloading the users will replace all existing users. The standard set of users must
be present in the file. If the users "root", "pcuser" and "nobody" are not defined, a data
serving interruption might occur.
         This command may take some time to complete.
Do you want to continue? {y|n}: y
```

To check the status of local user and group files, use:

```
cluster::*> vserver services unix-user file status
Vserver   Node            Load Time           Hash Value
--------- --------------- ------------------- --------------------------------
Hash Value DB                     File Size
--------------------------------- -----------
SVM1
          node-01
                          10/11/2016 10:55:27 6b617f426b0646df581fe94b0d20b7cc
1e0e62ca1bd18174174e9f562f1aea88 75B
          node-02
                          10/11/2016 10:55:27 6b617f426b0646df581fe94b0d20b7cc
1e0e62ca1bd18174174e9f562f1aea88 75B
```

Can you still use external name services?

File-only mode does not mean that you cannot use LDAP or NIS as a name service; it means that management of local users and groups is performed with files only. In the following example, file-only mode is enabled on the SVM, and LDAP can still be used to perform name lookups:

```
cluster::*> name-service ns-switch show -vserver SVM1
  (vserver services name-service ns-switch show)
                               Source
Vserver         Database       Order
--------------- ------------   ---------
SVM1            hosts          files,
                               dns
SVM1            group          files,
                               ldap
SVM1            passwd         files,
                               ldap
SVM1            netgroup       files
SVM1            namemap        files
5 entries were displayed.

cluster::*> vserver services unix-user file-only show -vserver SVM1

                       Vserver: SVM1
Is File-Only Download Enabled?: true

cluster::*> getxxbyyy getpwbyname -node ontap9-tme-8040-01 -vserver SVM1 -username ldapuser
-show-source true
  (vserver services name-service getxxbyyy getpwbyname)
Source used for lookup: LDAP
pw_name: ldapuser
pw_passwd:
pw_uid: 1108
pw_gid: 513
pw_gecos:
pw_dir: /home/ldapuser
pw_shell: /bin/sh
```

Keep in mind that when `file-only` is enabled, the default local users of `root`, `pcuser`, and `nobody` are removed if the file that is being loaded does not have those users. Be sure to include the local users and groups in your `passwd` and `group` files when you use `file-only`.

```
cluster::*> unix-user show -vserver SVM1

Error: show failed: File-only configuration is enabled. Use the command "vserver services name-
service unix-user file show" instead.

cluster::*> vserver services name-service unix-user file show -vserver SVM1
```

```
   Line No  File content
----------  ----------------
         1  nobody:*:65535:65535::::::
         2  pcuser:*:65534:65534::::::
         3  root:*:0:1::::::
```

Limits

This section covers the limits for local users and groups in ONTAP. Table 15 presents a summary. These limits are clusterwide.

Table 15) Limits on local users and groups in ONTAP clusters.

Local UNIX user/group limits	File-only user and group limits
32,768 (default) 65,536 (maximum)	`passwd` file size (users): 10MB `group` file size: 25MB **Note:** You can override `passwd` and `group` file sizes with `–skip-file-size-check`, but larger file sizes have not been tested. Users: 400,000 Groups: 15,000 Group memberships: 300,000 SVMs: 6

The local UNIX user and group limits are clusterwide and affect clusters with multiple SVMs. Thus, if a cluster has four SVMs, then the maximum number of users in each SVM must add up to the maximum limit set on the cluster.

For example:

- `SVM1` has 2,000 local UNIX users.
- `SVM2` has 40,000 local UNIX users.
- `SVM3` has 20 local UNIX users.
- `SVM4` then has 23,516 local UNIX users available to be created.

Any attempted creation of a UNIX user or group beyond the limit results in an error message.

For example:

```
cluster::> unix-group create -vserver NAS -name test -id 12345

Error: command failed: Failed to add "test" because the system limit of {limit number}
       "local unix groups and members" has been reached.
```

The limits are controlled by the following commands in the advanced privilege level:

```
cluster::*> unix-user max-limit
    modify show
```

Default local users

When you create an SVM by using `vserver` setup or System Manager, default local UNIX users and groups are created, along with default UIDs and GIDs.

The following shows these users and groups:

```
cluster::> vserver services unix-user show -vserver vs0
               User            User   Group  Full
Vserver        Name            ID     ID     Name
-------------- --------------- ------ ------ --------------------------------
```

```
nfs            nobody          65535  65535  -
nfs            pcuser          65534  65534  -
nfs            root            0      0      -

cluster::> vserver services unix-group show -vserver vs0
Vserver        Name                ID
-------------- ------------------- ----------
nfs            daemon              1
nfs            nobody              65535
nfs            pcuser              65534
nfs            root                0
```

When you use file-only mode, be sure that the preceding users exist in the files that are being used to manage the cluster. After file-only is enabled, the default users are removed if the uploaded file does not include them.

Diag secd versus vserver security access-check

Secd refers to the user authentication application that resides in the system shell of ONTAP. This application has interacted with domain controllers, LDAP servers, DNS, and so on, since the early days of ONTAP running in cluster mode. Throughout the years and ONTAP releases, the role of secd has changed a bit, and more operations have been moved to other areas; for example, LDAP functionality was moved to the FreeBSD `libc` modules.

NetApp has made these changes so that name service caches can be retained at an SVM level and become a global cache that is used regardless of the node in the cluster where a request arrived. Secd historically used localized caches on each node in versions earlier than ONTAP 9.3, which sometimes left cache differences across a cluster. For more information about global name service caches, see TR-4668: Name Services Best Practices Guide.

In addition to the global cache, new commands were created to accomplish several goals, including to:

- Simplify name service queries.
- Provide a command that did not require diag privileges to run (but could still use node-level queries as needed for troubleshooting).
- Remove the node requirement for running the command.

In ONTAP 9.6 and later, a new set of commands was introduced that mimics the name lookup capabilities of `diag secd` commands. When possible, you should use these commands instead of `diag secd`.

```
cluster::*> vserver services access-check ?
  authentication>             *Check Authentication Information
  dns>                        *Check DNS Lookups
  name-mapping>               *Check Name Mapping Operations
  server-discovery>           *Check Server Discovery Information
```

LDAP query examples

The following examples show what LDAP queries look like.

LDAP user attribute dump example: Active Directory

A PowerShell query returns a series of attribute values that you can use to figure out the appropriate LDAP schema template to apply to your configuration. The following example shows a user dump from Active Directory LDAP with filters applied to `–Properties` to make it easier to find the attributes that are needed.

```
PS C:\Users\Administrator> Get-ADUser -Identity prof1 -Properties
Name,gecos,gidNumber,HomeDirectory,ObjectClass,sAMAccountName,uid,uidNumber,unixHomeDirectory


DistinguishedName : CN=prof1,CN=Users,DC=NTAP,DC=local
```

```
Enabled             : True
gecos               : Prof1
gidNumber           : 1101
GivenName           : prof1
HomeDirectory       :
Name                : prof1
ObjectClass         : user
ObjectGUID          : 0973b3f1-da85-499c-80b4-a210e0d0fb2f
SamAccountName      : prof1
SID                 : S-1-5-21-3552729481-4032800560-2279794651-1110
Surname             :
uid                 : {prof1}
uidNumber           : 1100
unixHomeDirectory : /home/prof1
UserPrincipalName : prof1@NTAP.LOCAL
```

Keep in mind that PowerShell queries work only with versions of Windows that support them. For older Windows versions or for Linux/UNIX-based LDAP servers, you can use `ldapsearch` commands.

LDAP user attribute dump example: ldapsearch

For common `ldapsearch` examples, see Examples of Common LDAP Searches.

The following output is from an `ldapsearch` query:

```
# ldapsearch -D "cn=Directory Manager" -W -p 389 -h 10.193.67.222 -b "dc=centos-ldap,dc=local" -s
sub "(uid=ipa-user)"
Enter LDAP Password:
# extended LDIF
#
# LDAPv3
# base <dc=centos-ldap,dc=local> with scope subtree
# filter: (uid=ipa-user)
# requesting: ALL
#

# ipa-user, users, compat, centos-ldap.local
dn: uid=ipa-user,cn=users,cn=compat,dc=centos-ldap,dc=local
objectClass: posixAccount
objectClass: ipaOverrideTarget
objectClass: top
gecos: IPA User
cn: IPA User
uidNumber: 1971600003
gidNumber: 1971600000
loginShell: /bin/sh
homeDirectory: /home/ipa-user
ipaAnchorUUID:: OklQQTpjZW50b3MtbGRhcC5sb2NhbDplMDQwZWU0Mi00ODRjLTExZWEtOWE3ZC
 0wMDUwNTY5ZWM0N2Q=
uid: ipa-user

# ipa-user, users, accounts, centos-ldap.local
dn: uid=ipa-user,cn=users,cn=accounts,dc=centos-ldap,dc=local
givenName: IPA
sn: User
uid: ipa-user
cn: IPA User
displayName: IPA User
initials: IU
gecos: IPA User
krbPrincipalName: ipa-user@CENTOS-LDAP.LOCAL
gidNumber: 1971600000
userClass: user
objectClass: top
objectClass: person
objectClass: organizationalperson
objectClass: inetorgperson
objectClass: inetuser
objectClass: posixaccount
```

```
objectClass: krbprincipalaux
objectClass: krbticketpolicyaux
objectClass: ipaobject
objectClass: ipasshuser
objectClass: ipauser
objectClass: ipaSshGroupOfPubKeys
objectClass: mepOriginEntry
loginShell: /bin/sh
homeDirectory: /home/ipa-user
mail: ipa-user@centos-ldap.local
krbCanonicalName: ipa-user@CENTOS-LDAP.LOCAL
userPassword:: e2NyeXB0fSQ2JEdYJGtVd2k5RWhSS216WThSUXd2WXd6TlcwYXM1eEZQVjEyaTl
 CNVBOWmEzLnNvWExuUUZtbVRDdW9qdFovSDlkcXQ2dmpVQkhTNFYySUZLWlpFNVBrOWMu
ipaUniqueID: e040ee42-484c-11ea-9a7d-0050569ec47d
krbPrincipalKey:: MIHeoAMCAQGhAwIBAaIDAgEDowMCAQGkgccwgcQwaKAbMBmgAwIBBKESBBB7
 THspfXM9YGZpJ3lrKXtSoUkwR6ADAgESoUAEPiAANeN6Uh1meVExph7lENHLlCq26i8B4To8XooBv
 XDw8MEGNTzEDqlCDI03zyZgTsLaPAaoTR44pIHBqN4AMFigGzAZoAMCAQShEgQQX3UgejBoUURoYk
 8lXnQgUaE5MDegAwIBEaEwBC4QAPUeyAwJ3gYB99nPbnGG8ZsMuuB963O3GLmaJzCOiydzaBcLfvT
 Bz3mN82Ye
uidNumber: 1971600003
krbPasswordExpiration: 20200206144442Z
krbLastPwdChange: 20200206144442Z
krbExtraData:: AAJaJjxecm9vdC9hZG1pbkBDRU5UT1MtTERBUC5MT0NBTAA=
mepManagedEntry: cn=ipa-user,cn=groups,cn=accounts,dc=centos-ldap,dc=local
memberOf: cn=ipausers,cn=groups,cn=accounts,dc=centos-ldap,dc=local
memberOf: cn=trust admins,cn=groups,cn=accounts,dc=centos-ldap,dc=local
memberOf: cn=ontap-ldap,cn=groups,cn=accounts,dc=centos-ldap,dc=local
krbTicketFlags: 128
krbLoginFailedCount: 0
```

Sample credential dump

The following command fetches all the information about a user from the configured name services and protocol services. This command is especially valuable when you are troubleshooting name mapping and permissions issues in ONTAP in multiprotocol environments. Keep in mind that this command works only when CIFS/SMB is configured, because there must be Active Directory communication to fetch Windows credentials.

```
cluster::*> diag secd authentication show-creds -node ontap9-tme-8040-01 -vserver DEMO -unix-
user-name prof1 -list-id true -list-name true

 UNIX UID: 1100 (prof1) <> Windows User: S-1-5-21-3552729481-4032800560-2279794651-1110
(NTAP\prof1 (Windows Domain User))

 GID: 1101 (ProfGroup)
 Supplementary GIDs:
  1101  (ProfGroup)
  1201  (group1)
  1202  (group2)
  1203  (group3)
  1220  (sharedgroup)

 Primary Group SID: S-1-5-21-3552729481-4032800560-2279794651-513   NTAP\DomainUsers (Windows
Domain group)

 Windows Membership:
  S-1-5-21-3552729481-4032800560-2279794651-1106   NTAP\group2 (Windows Domain group)
  S-1-5-21-3552729481-4032800560-2279794651-513   NTAP\DomainUsers (Windows Domain group)
  S-1-5-21-3552729481-4032800560-2279794651-1122   NTAP\sharedgroup (Windows Domain group)
  S-1-5-21-3552729481-4032800560-2279794651-1105   NTAP\group1 (Windows Domain group)
  S-1-5-21-3552729481-4032800560-2279794651-1107   NTAP\group3 (Windows Domain group)
  S-1-5-21-3552729481-4032800560-2279794651-1111   NTAP\ProfGroup (Windows Domain group)
  S-1-18-2   Service asserted identity (Windows Well known group)
  S-1-5-32-551   BUILTIN\Backup Operators (Windows Alias)
  S-1-5-32-545   BUILTIN\Users (Windows Alias)
 User is also a member of Everyone, Authenticated Users, and Network Users

 Privileges (0x2086):
  SeBackupPrivilege
  SeRestorePrivilege
  SeChangeNotifyPrivilege
```

LDAP schema templates

The following shows the available schema templates in ONTAP. This output came from an ONTAP system that was running ONTAP 9.6.

AD-IDMU

```
                                    Schema Template: AD-IDMU
                                            Comment: Schema based on Active Directory Identity
Management for UNIX (read-only)
                RFC 2307 posixAccount Object Class: User
                  RFC 2307 posixGroup Object Class: Group
                 RFC 2307 nisNetgroup Object Class: nisNetgroup
                            RFC 2307 uid Attribute: uid
                      RFC 2307 uidNumber Attribute: uidNumber
                      RFC 2307 gidNumber Attribute: gidNumber
                RFC 2307 cn (for Groups) Attribute: cn
             RFC 2307 cn (for Netgroups) Attribute: name
                   RFC 2307 userPassword Attribute: unixUserPassword
                          RFC 2307 gecos Attribute: name
                  RFC 2307 homeDirectory Attribute: unixHomeDirectory
                     RFC 2307 loginShell Attribute: loginShell
                      RFC 2307 memberUid Attribute: memberUid
              RFC 2307 memberNisNetgroup Attribute: memberNisNetgroup
              RFC 2307 nisNetgroupTriple Attribute: nisNetgroupTriple
              Enable Support for Draft RFC 2307bis: false
       RFC 2307bis groupOfUniqueNames Object Class: groupOfUniqueNames
                RFC 2307bis uniqueMember Attribute: uniqueMember
Data ONTAP Name Mapping windowsToUnix Object Class: User
  Data ONTAP Name Mapping windowsAccount Attribute: msDS-PrincipalName
   Data ONTAP Name Mapping windowsToUnix Attribute: sAMAccountName
   No Domain Prefix for windowsToUnix Name Mapping: true
                               Vserver Owns Schema: true
 Maximum groups supported when RFC 2307bis enabled: 256
                   RFC 2307 nisObject Object Class: nisObject
                     RFC 2307 nisMapName Attribute: nisMapName
                    RFC 2307 nisMapEntry Attribute: nisMapEntry
```

AD-SFU

```
                                    Schema Template: AD-SFU
                                            Comment: Schema based on Active Directory Services for
UNIX (read-only)
                RFC 2307 posixAccount Object Class: User
                  RFC 2307 posixGroup Object Class: Group
                 RFC 2307 nisNetgroup Object Class: msSFU30NisNetGroup
                            RFC 2307 uid Attribute: sAMAccountName
                      RFC 2307 uidNumber Attribute: msSFU30UidNumber
                      RFC 2307 gidNumber Attribute: msSFU30GidNumber
                RFC 2307 cn (for Groups) Attribute: cn
             RFC 2307 cn (for Netgroups) Attribute: name
                   RFC 2307 userPassword Attribute: msSFU30Password
                          RFC 2307 gecos Attribute: name
                  RFC 2307 homeDirectory Attribute: msSFU30HomeDirectory
                     RFC 2307 loginShell Attribute: msSFU30LoginShell
                      RFC 2307 memberUid Attribute: msSFU30MemberUid
              RFC 2307 memberNisNetgroup Attribute: msSFU30MemberNisNetgroup
              RFC 2307 nisNetgroupTriple Attribute: msSFU30MemberOfNisNetgroup
              Enable Support for Draft RFC 2307bis: false
       RFC 2307bis groupOfUniqueNames Object Class: groupOfUniqueNames
                RFC 2307bis uniqueMember Attribute: uniqueMember
Data ONTAP Name Mapping windowsToUnix Object Class: User
  Data ONTAP Name Mapping windowsAccount Attribute: windowsAccount
   Data ONTAP Name Mapping windowsToUnix Attribute: windowsAccount
   No Domain Prefix for windowsToUnix Name Mapping: false
```

```
                         Vserver Owns Schema: true
 Maximum groups supported when RFC 2307bis enabled: 256
               RFC 2307 nisObject Object Class: msSFU30NisObject
                 RFC 2307 nisMapName Attribute: msSFU30NisMapName
                RFC 2307 nisMapEntry Attribute: msSFU30NisMapEntry
```

MS-AD-BIS

```
                                   Schema Template: MS-AD-BIS
                                           Comment: Schema based on Active Directory Identity
Management for UNIX (read-only)
                RFC 2307 posixAccount Object Class: User
                  RFC 2307 posixGroup Object Class: Group
                 RFC 2307 nisNetgroup Object Class: nisNetgroup
                            RFC 2307 uid Attribute: uid
                      RFC 2307 uidNumber Attribute: uidNumber
                      RFC 2307 gidNumber Attribute: gidNumber
                RFC 2307 cn (for Groups) Attribute: cn
             RFC 2307 cn (for Netgroups) Attribute: name
                   RFC 2307 userPassword Attribute: unixUserPassword
                          RFC 2307 gecos Attribute: name
                  RFC 2307 homeDirectory Attribute: unixHomeDirectory
                     RFC 2307 loginShell Attribute: loginShell
                      RFC 2307 memberUid Attribute: memberUid
              RFC 2307 memberNisNetgroup Attribute: memberNisNetgroup
              RFC 2307 nisNetgroupTriple Attribute: nisNetgroupTriple
              Enable Support for Draft RFC 2307bis: true
       RFC 2307bis groupOfUniqueNames Object Class: group
                RFC 2307bis uniqueMember Attribute: Member
Data ONTAP Name Mapping windowsToUnix Object Class: User
  Data ONTAP Name Mapping windowsAccount Attribute: sAMAccountName
   Data ONTAP Name Mapping windowsToUnix Attribute: sAMAccountName
   No Domain Prefix for windowsToUnix Name Mapping: true
                               Vserver Owns Schema: true
 Maximum groups supported when RFC 2307bis enabled: 256
                   RFC 2307 nisObject Object Class: nisObject
                     RFC 2307 nisMapName Attribute: nisMapName
                    RFC 2307 nisMapEntry Attribute: nisMapEntry
```

RFC 2307

```
                                   Schema Template: RFC-2307
                                           Comment: Schema based on RFC 2307 (read-only)
                RFC 2307 posixAccount Object Class: posixAccount
                  RFC 2307 posixGroup Object Class: posixGroup
                 RFC 2307 nisNetgroup Object Class: nisNetgroup
                            RFC 2307 uid Attribute: uid
                      RFC 2307 uidNumber Attribute: uidNumber
                      RFC 2307 gidNumber Attribute: gidNumber
                RFC 2307 cn (for Groups) Attribute: cn
             RFC 2307 cn (for Netgroups) Attribute: cn
                   RFC 2307 userPassword Attribute: userPassword
                          RFC 2307 gecos Attribute: gecos
                  RFC 2307 homeDirectory Attribute: homeDirectory
                     RFC 2307 loginShell Attribute: loginShell
                      RFC 2307 memberUid Attribute: memberUid
              RFC 2307 memberNisNetgroup Attribute: memberNisNetgroup
              RFC 2307 nisNetgroupTriple Attribute: nisNetgroupTriple
              Enable Support for Draft RFC 2307bis: false
       RFC 2307bis groupOfUniqueNames Object Class: groupOfUniqueNames
                RFC 2307bis uniqueMember Attribute: uniqueMember
Data ONTAP Name Mapping windowsToUnix Object Class: posixAccount
  Data ONTAP Name Mapping windowsAccount Attribute: windowsAccount
   Data ONTAP Name Mapping windowsToUnix Attribute: windowsAccount
   No Domain Prefix for windowsToUnix Name Mapping: false
                               Vserver Owns Schema: true
 Maximum groups supported when RFC 2307bis enabled: 256
                   RFC 2307 nisObject Object Class: nisObject
                     RFC 2307 nisMapName Attribute: nisMapName
                    RFC 2307 nisMapEntry Attribute: nisMapEntry
```

Sample LDAP client configuration

The following configuration is from an LDAP client pointing to Active Directory LDAP servers running Windows 2012.

Active Directory LDAP client

```
                                   Vserver: DEMO
                 Client Configuration Name: DEMO
                          LDAP Server List: -
             (DEPRECATED)-LDAP Server List: -
                   Active Directory Domain: NTAP.LOCAL
        Preferred Active Directory Servers: -
Bind Using the Vserver's CIFS Credentials: true
                           Schema Template: DEMO
                          LDAP Server Port: 389
                       Query Timeout (sec): 3
         Minimum Bind Authentication Level: sasl
                            Bind DN (User): ldap-user
                                   Base DN:
                         Base Search Scope: subtree
                                   User DN: -
                         User Search Scope: subtree
                                  Group DN: -
                        Group Search Scope: subtree
                               Netgroup DN: -
                     Netgroup Search Scope: subtree
                Vserver Owns Configuration: true
       Use start-tls Over LDAP Connections: false
            Enable Netgroup-By-Host Lookup: false
                       Netgroup-By-Host DN: -
                    Netgroup-By-Host Scope: subtree
                   Client Session Security: none
                     LDAP Referral Chasing: false
                   Group Membership Filter: -
```

The following configuration is from an LDAP client pointing to Red Hat Directory Server.

RHEL Directory Server LDAP client

```
                 Client Configuration Name: centos7.ntap2016.local
                          LDAP Server List: centos7.ntap2016.local
             (DEPRECATED)-LDAP Server List: -
                   Active Directory Domain: -
        Preferred Active Directory Servers: -
Bind Using the Vserver's CIFS Credentials: false
                           Schema Template: RFC-2307
                          LDAP Server Port: 389
                       Query Timeout (sec): 3
         Minimum Bind Authentication Level: simple
                            Bind DN (User): cn=ldapadm,dc=ntap2016,dc=local
                                   Base DN: dc=ntap2016,dc=local
                         Base Search Scope: subtree
                                   User DN: -
                         User Search Scope: subtree
                                  Group DN: -
                        Group Search Scope: subtree
                               Netgroup DN: -
                     Netgroup Search Scope: subtree
                Vserver Owns Configuration: false
       Use start-tls Over LDAP Connections: false
            Enable Netgroup-By-Host Lookup: false
                       Netgroup-By-Host DN: -
                    Netgroup-By-Host Scope: subtree
                   Client Session Security: none
                     LDAP Referral Chasing: false
                   Group Membership Filter: -
```

LDAP traffic as seen from a packet trace

This section explains LDAP communication between an ONTAP SVM LDAP client and an LDAP server that runs Windows Active Directory. In this trace, `getxxbyyy` was run on the cluster for a specific user named `prof1`.

```
cluster::*> getxxbyyy getpwbyname -node node1 -vserver DEMO -username prof1 -show-source true -
use-cache false
  (vserver services name-service getxxbyyy getpwbyname)
Source used for lookup: LDAP
pw_name: prof1
pw_passwd:
pw_uid: 1100
pw_gid: 1101
pw_gecos:
pw_dir:
pw_shell: /bin/sh
```

Following is the LDAP client configuration:

```
cluster::*> ldap client show -client-config DEMO

                                  Vserver: DEMO
                Client Configuration Name: DEMO
                         LDAP Server List: -
            (DEPRECATED)-LDAP Server List: -
                  Active Directory Domain: ntap.local
       Preferred Active Directory Servers: -
Bind Using the Vserver's CIFS Credentials: true
                          Schema Template: DEMO
                         LDAP Server Port: 389
                      Query Timeout (sec): 3
        Minimum Bind Authentication Level: sasl
                           Bind DN (User): administrator
                                  Base DN: DC=NTAP,DC=local
                        Base Search Scope: subtree
                                  User DN: CN=Users,DC=NTAP,DC=local
                        User Search Scope: subtree
                                 Group DN: -
                       Group Search Scope: subtree
                              Netgroup DN: -
                    Netgroup Search Scope: subtree
                Vserver Owns Configuration: true
      Use start-tls Over LDAP Connections: false
           Enable Netgroup-By-Host Lookup: true
                      Netgroup-By-Host DN: -
                   Netgroup-By-Host Scope: subtree
                  Client Session Security: none
                    LDAP Referral Chasing: false
                  Group Membership Filter: -
```

The first steps in the trace were DNS record lookups for the LDAP SRV record. It is based on the `-ad-domain` setting that was used in the client configuration.

```
10.193.67.237  10.193.67.236  DNS     81      Standard query 0xcbec SRV _ldap._tcp.ntap.local
```

That request was successful, so another DNS request was made for the SRV record of the `Default-First-Site-Name`.

```
10.193.67.236  10.193.67.237  DNS     134     Standard query response 0xcbec SRV
_ldap._tcp.ntap.local SRV 0 100 389 oneway.ntap.local A 10.193.67.236

10.193.67.237  10.193.67.236  DNS     112     Standard query 0x0075 SRV _ldap._tcp.Default-First-
Site-Name._sites.ntap.local

10.193.67.236  10.193.67.237  DNS     165     Standard query response 0x0075 SRV
_ldap._tcp.Default-First-Site-Name._sites.ntap.local SRV 0 100 389 oneway.ntap.local A
10.193.67.236
```

Next, the LDAP port that is specified in the client configuration is tested through a regular TCP packet to confirm it is open and listening.

```
10.193.67.237  10.193.67.236  TCP    74     14802 → 389 [SYN] Seq=0 Win=65535 Len=0 MSS=8960
WS=256 SACK_PERM=1 TSval=890800619 TSecr=0
10.193.67.236  10.193.67.237  TCP    74     389 → 14802 [SYN, ACK] Seq=0 Ack=1 Win=8192 Len=0
MSS=1460 WS=256 SACK_PERM=1 TSval=252542599 TSecr=890800619
```

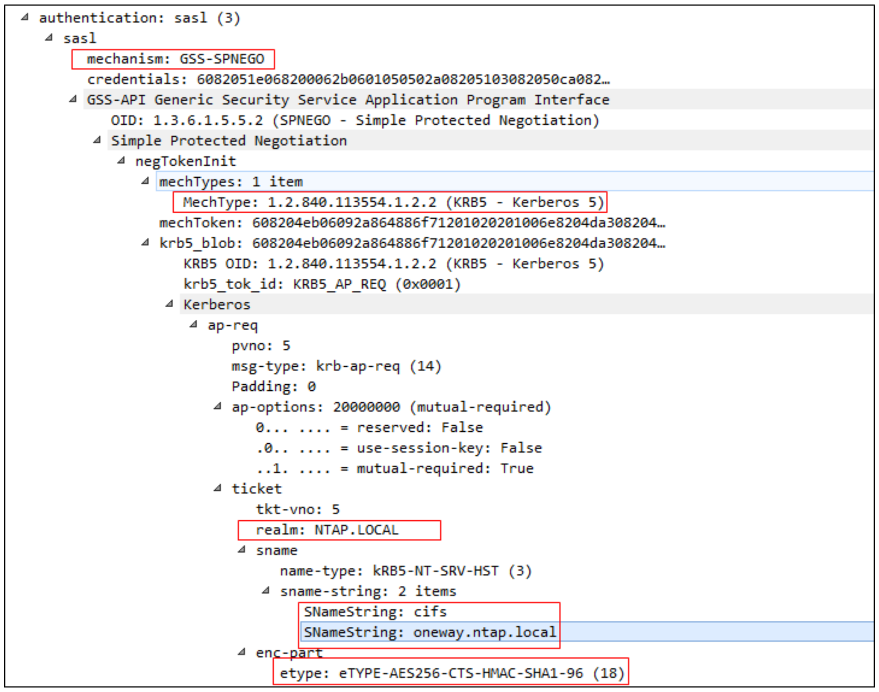
Next, a TCP packet is sent to open the port to perform the LDAP communication.

```
10.193.67.237  10.193.67.236  TCP    66     14802 → 389 [ACK] Seq=1 Ack=1 Win=65792 Len=0
TSval=890800619 TSecr=252542599
```

Then the LDAP bind occurs.

```
10.193.67.237  10.193.67.236  LDAP   1416   bindRequest(1) "<ROOT>" sasl
```

Because the LDAP client option is set as `-bind-as-cifs-server true`, the bind request uses the CIFS machine account and Kerberos authentication. You can see it in the packet details.

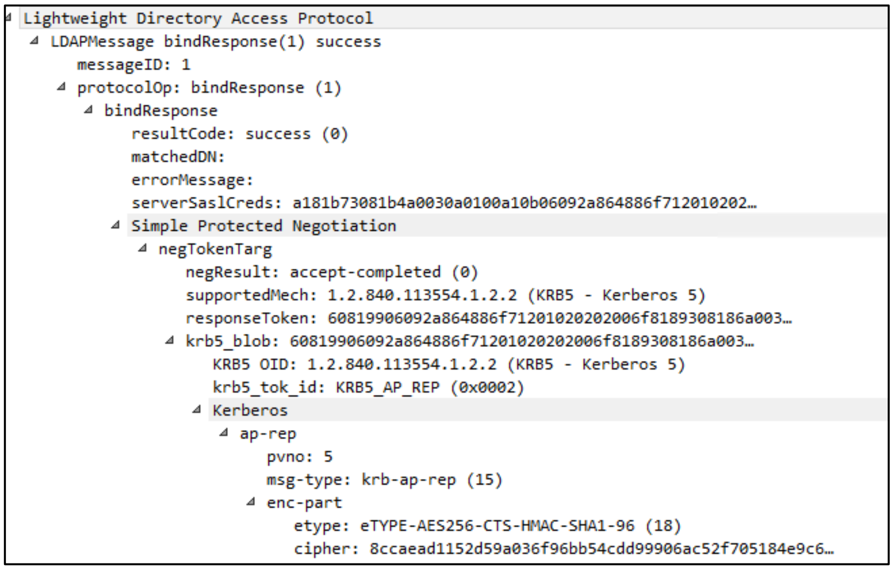


```
◢ authentication: sasl (3)
  ◢ sasl
      mechanism: GSS-SPNEGO
      credentials: 6082051e068200062b0601050502a08205103082050ca082…
    ◢ GSS-API Generic Security Service Application Program Interface
        OID: 1.3.6.1.5.5.2 (SPNEGO - Simple Protected Negotiation)
      ◢ Simple Protected Negotiation
        ◢ negTokenInit
          ◢ mechTypes: 1 item
              MechType: 1.2.840.113554.1.2.2 (KRB5 - Kerberos 5)
            mechToken: 608204eb06092a864886f71201020201006e8204da308204…
          ◢ krb5_blob: 608204eb06092a864886f71201020201006e8204da308204…
              KRB5 OID: 1.2.840.113554.1.2.2 (KRB5 - Kerberos 5)
              krb5_tok_id: KRB5_AP_REQ (0x0001)
            ◢ Kerberos
              ◢ ap-req
                  pvno: 5
                  msg-type: krb-ap-req (14)
                  Padding: 0
                ◢ ap-options: 20000000 (mutual-required)
                    0... .... = reserved: False
                    .0.. .... = use-session-key: False
                    ..1. .... = mutual-required: True
                ◢ ticket
                    tkt-vno: 5
                    realm: NTAP.LOCAL
                  ◢ sname
                      name-type: kRB5-NT-SRV-HST (3)
                    ◢ sname-string: 2 items
                        SNameString: cifs
                        SNameString: oneway.ntap.local
                  ◢ enc-part
                      etype: eTYPE-AES256-CTS-HMAC-SHA1-96 (18)
```

Kerberos is used here because the CIFS machine account named `DEMO` has a valid DNS A record and reverse name-lookup record. If for any reason you cannot use Kerberos, you fall back to NTLM.

The next packet shows that the bind is successful with Kerberos.

```
10.193.67.236  10.193.67.237  LDAP   278    bindResponse(1) success
```



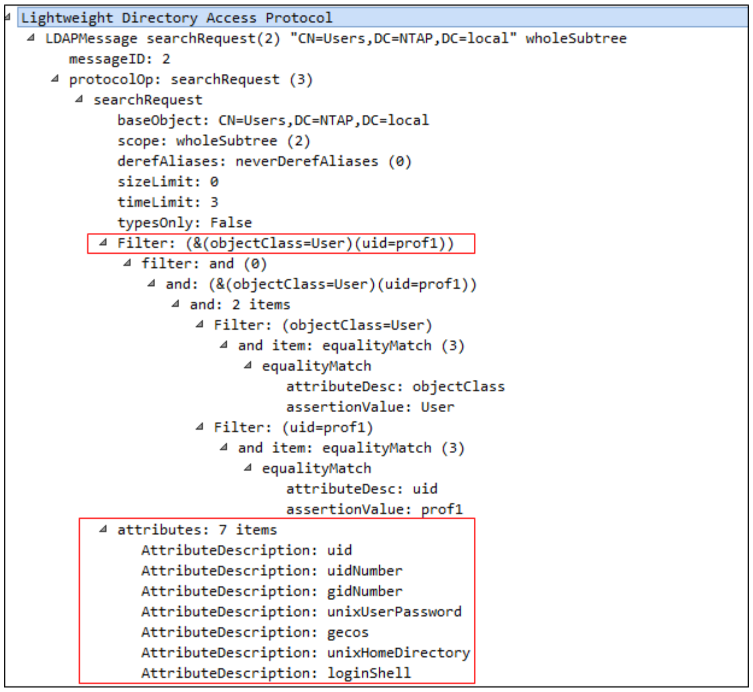
```
◢ Lightweight Directory Access Protocol
  ◢ LDAPMessage bindResponse(1) success
      messageID: 1
    ◢ protocolOp: bindResponse (1)
      ◢ bindResponse
          resultCode: success (0)
          matchedDN:
          errorMessage:
          serverSaslCreds: a181b73081b4a0030a0100a10b06092a864886f712010202…
        ◢ Simple Protected Negotiation
          ◢ negTokenTarg
              negResult: accept-completed (0)
              supportedMech: 1.2.840.113554.1.2.2 (KRB5 - Kerberos 5)
              responseToken: 60819906092a864886f71201020202006f8189308186a003…
            ◢ krb5_blob: 60819906092a864886f71201020202006f8189308186a003…
                KRB5 OID: 1.2.840.113554.1.2.2 (KRB5 - Kerberos 5)
                krb5_tok_id: KRB5_AP_REP (0x0002)
              ◢ Kerberos
                ◢ ap-rep
                    pvno: 5
                    msg-type: krb-ap-rep (15)
                  ◢ enc-part
                      etype: eTYPE-AES256-CTS-HMAC-SHA1-96 (18)
                      cipher: 8ccaead1152d59a036f96bb54cdd99906ac52f705184e9c6…
```

Now the LDAP search can be performed. Because it is a user request and `-user-dn` has been populated with a value, it is used for the search. If no user DN was provided, you fall back to the value that was set in `-base-dn`.

```
10.193.67.237  10.193.67.236  LDAP   239    searchRequest(2) "CN=Users,DC=NTAP,DC=local"
wholeSubtree
```

The LDAP `searchRequest` packet gives you a lot of information about the filters that were used in the search. If this LDAP request was using TLS or SSL, then it would be encrypted and you could not see the values unless you decrypted the trace.

In the following example, you can see that the user `objectClass` was used to search for the UID `prof1`. You can also see that ONTAP asked for seven different attributes in the search. You can use this information to troubleshoot search requests and to build your own LDAP search filters for use with third-party tools such `ldapsearch` or Ldp.

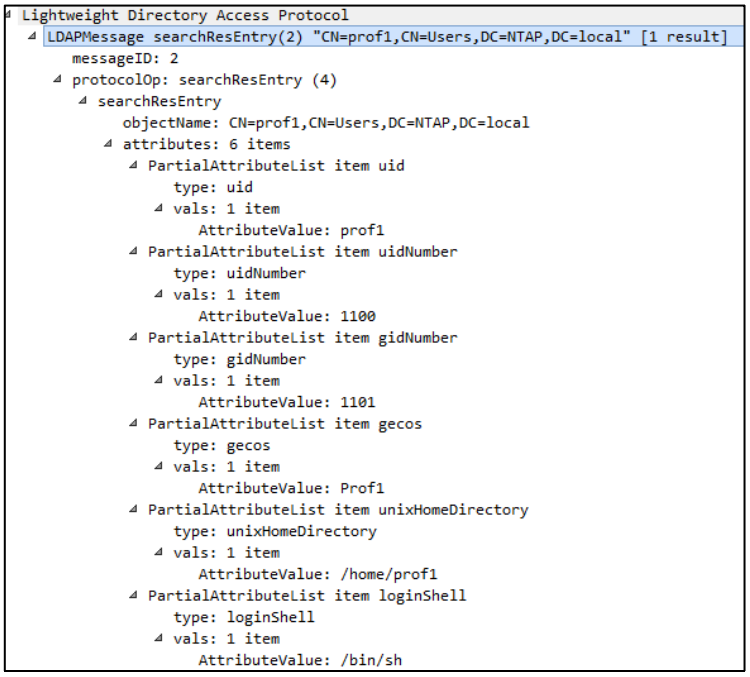


```
◢ Lightweight Directory Access Protocol
  ◢ LDAPMessage searchRequest(2) "CN=Users,DC=NTAP,DC=local" wholeSubtree
      messageID: 2
    ◢ protocolOp: searchRequest (3)
      ◢ searchRequest
          baseObject: CN=Users,DC=NTAP,DC=local
          scope: wholeSubtree (2)
          derefAliases: neverDerefAliases (0)
          sizeLimit: 0
          timeLimit: 3
          typesOnly: False
        ◢ Filter: (&(objectClass=User)(uid=prof1))
          ◢ filter: and (0)
            ◢ and: (&(objectClass=User)(uid=prof1))
              ◢ and: 2 items
                ◢ Filter: (objectClass=User)
                  ◢ and item: equalityMatch (3)
                    ◢ equalityMatch
                        attributeDesc: objectClass
                        assertionValue: User
                ◢ Filter: (uid=prof1)
                  ◢ and item: equalityMatch (3)
                    ◢ equalityMatch
                        attributeDesc: uid
                        assertionValue: prof1
        ◢ attributes: 7 items
            AttributeDescription: uid
            AttributeDescription: uidNumber
            AttributeDescription: gidNumber
            AttributeDescription: unixUserPassword
            AttributeDescription: gecos
            AttributeDescription: unixHomeDirectory
            AttributeDescription: loginShell
```

The LDAP `searchRequest` replies with the requested information and shows that one result was returned.

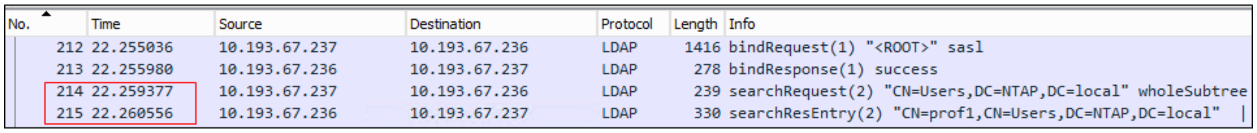
```
10.193.67.236  10.193.67.237  LDAP   330    searchResEntry(2)
"CN=prof1,CN=Users,DC=NTAP,DC=local"  | searchResDone(2) success  [1 result]
```

In the trace details, you see the same output as from the `getXXbyXX` command from the ONTAP CLI.



```
◢ Lightweight Directory Access Protocol
  ◢ LDAPMessage searchResEntry(2) "CN=prof1,CN=Users,DC=NTAP,DC=local" [1 result]
      messageID: 2
    ◢ protocolOp: searchResEntry (4)
      ◢ searchResEntry
          objectName: CN=prof1,CN=Users,DC=NTAP,DC=local
        ◢ attributes: 6 items
          ◢ PartialAttributeList item uid
              type: uid
            ◢ vals: 1 item
                AttributeValue: prof1
          ◢ PartialAttributeList item uidNumber
              type: uidNumber
            ◢ vals: 1 item
                AttributeValue: 1100
          ◢ PartialAttributeList item gidNumber
              type: gidNumber
            ◢ vals: 1 item
                AttributeValue: 1101
          ◢ PartialAttributeList item gecos
              type: gecos
            ◢ vals: 1 item
                AttributeValue: Prof1
          ◢ PartialAttributeList item unixHomeDirectory
              type: unixHomeDirectory
            ◢ vals: 1 item
                AttributeValue: /home/prof1
          ◢ PartialAttributeList item loginShell
              type: loginShell
            ◢ vals: 1 item
                AttributeValue: /bin/sh
```

In addition to viewing the LDAP search filters, you also can see how long the `searchRequest` took. Each packet is marked with a timestamp. In this case, you can see that the request returned in less than a second:



```
No.   Time       Source         Destination    Protocol Length Info
  212 22.255036  10.193.67.237  10.193.67.236  LDAP       1416 bindRequest(1) "<ROOT>" sasl
  213 22.255980  10.193.67.236  10.193.67.237  LDAP        278 bindResponse(1) success
  214 22.259377  10.193.67.237  10.193.67.236  LDAP        239 searchRequest(2) "CN=Users,DC=NTAP,DC=local" wholeSubtree
  215 22.260556  10.193.67.236  10.193.67.237  LDAP        330 searchResEntry(2) "CN=prof1,CN=Users,DC=NTAP,DC=local"
```

Having timestamp information helps you determine whether LDAP issues are occurring because of the configured LDAP timeout value in the LDAP client configuration.

Finally, when the request is finished, ONTAP closes the port request.

```
10.193.67.237  10.193.67.236  TCP     66      14802 → 389 [ACK] Seq=1524 Ack=477 Win=65792 Len=0
TSval=890800725 TSecr=252542599
```

Contact us

Let us know how we can improve this technical report. Contact us at docfeedback@netapp.com. Include TECHNICAL REPORT 4835 in the subject line.

Acknowledgments

Special thanks to Oliver Brakmann for providing a method to create `bind-dn` users in FreeIPA that are not the Directory Manager.

Where to find additional information

- TR-4067: ONTAP NFS Best Practice and Implementation Guide
  www.netapp.com/us/media/tr-4067.pdf
- TR-4523: DNS Load Balancing in ONTAP
  www.netapp.com/us/media/tr-4523.pdf
- TR-4616: NFS Kerberos in ONTAP with Microsoft Active Directory
  www.netapp.com/us/media/tr-4616.pdf
- TR-4668: Name Services Best Practices Guide (ONTAP 9.3 and later)
  www.netapp.com/us/media/tr-4668.pdf
- ONTAP 9 Documentation Center
  https://docs.netapp.com/ontap-9/index.jsp
- ONTAP and ONTAP System Manager Documentation Resources
  https://www.netapp.com/us/documentation/ontap-and-oncommand-system-manager.aspx

Version history

Version	Date	Document version history
Version 1.0	May 2020	Initial version.
Version 1.1	February 2021	Minor revisions.

Refer to the Interoperability Matrix Tool (IMT) on the NetApp Support site to validate that the exact product and feature versions described in this document are supported for your specific environment. The NetApp IMT defines the product components and versions that can be used to construct configurations that are supported by NetApp. Specific results depend on each customer's installation in accordance with published specifications.

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