IBM System Storage N series
Data ONTAP 7.3 Network Management Guide

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Contents

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About this guide

You can use your product more effectively when you understand this document's intended audience and the conventions that this document uses to present information.

This guide describes how to configure and manage network interfaces, virtual interfaces (vifs), virtual LANs (VLANs), routing, IPsec, and SNMP on storage systems that run Data ONTAP. This guide also describes host-name resolution and SNMP.

This guide describes all storage system models; however, some models do not support all the networking interfaces. See the hardware guide for your storage system to identify which interfaces are supported on your system.

Note: In this document, the term *gateway* describes IBM N series storage systems that have been ordered with gateway functionality. Gateways support various types of storage, and they are used with third-party disk storage systems—for example, disk storage systems from IBM, HP®, Hitachi Data Systems®, and EMC®. In this case, disk storage for customer data and the RAID controller functionality is provided by the back-end disk storage system. A gateway might also be used with disk storage expansion units specifically designed for the IBM N series models.

The term *filer* describes IBM N series storage systems that either contain internal disk storage or attach to disk storage expansion units specifically designed for the IBM N series storage systems. Filer storage systems do not support using third-party disk storage systems.

Next topics

Audience

This document is written with certain assumptions about your technical knowledge and experience.

This document is for systems administrators who are familiar with operating systems that run on storage system clients such as UNIX, MAC OSX, and Windows. It also assumes that you are familiar

with how Network File System (NFS), Common Internet File System (CIFS), and HyperText Transfer Protocol (HTTP) are used for file sharing or transfers.

Supported features

IBM® System Storage™ N series storage systems are driven by NetApp® Data ONTAP® software. Some features described in the product software documentation are neither offered nor supported by IBM. Please contact your local IBM representative or reseller for further details. Information about supported features can also be found at the following Web site:

www.ibm.com/storage/support/nas/

A listing of currently available N series products and features can be found at the following Web site:

www.ibm.com/storage/nas/

Getting information, help, and services

If you need help, service, or technical assistance or just want more information about IBM products, you will find a wide variety of sources available from IBM to assist you. This section contains information about where to go for additional information about IBM and IBM products, what to do if you experience a problem with your IBM N series product, and whom to call for service, if it is necessary.

Next topics

Before you call

Before you call, make sure that you have taken these steps to try to solve the problem yourself:

- Check all cables to make sure that they are connected properly.
- Check the power switches to make sure that the system is turned on.
- Use the troubleshooting information in your system documentation and use the diagnostic tools that come with your system.

Using the documentation

Information about N series hardware products is available in printed documents and a documentation CD that comes with your system. The same documentation is available as PDF files on the IBM NAS support Web site:

www.ibm.com/storage/support/nas/

Data ONTAP software publications are available as PDF files on the IBM NAS support Web site:

www.ibm.com/storage/support/nas/

Web sites

IBM maintains pages on the World Wide Web where you can get the latest technical information and download device drivers and updates.

- For NAS product information, go to the following Web site:
  www.ibm.com/storage/nas/
- For NAS support information, go to the following Web site:
  www.ibm.com/storage/support/nas/
- For AutoSupport information, go to the following Web site:
  www.ibm.com/storage/support/nas/
- For the latest version of publications, go to the following Web site:
  www.ibm.com/storage/support/nas/

Accessing online technical support

For online Technical Support for your IBM N series product, visit the following Web site:

www.ibm.com/storage/support/nas/

Hardware service and support

You can receive hardware service through IBM Integrated Technology Services. Visit the following Web site for support telephone numbers:

www.ibm.com/planetwide/

Supported servers and operating systems

IBM N series products attach to many servers and many operating systems. To determine the latest supported attachments, follow the link to the Interoperability Matrices from the following Web site:

www.ibm.com/storage/support/nas/

Firmware updates

As with all devices, it is recommended that you run the latest level of firmware, which can be downloaded by visiting the following Web site:

www.ibm.com/storage/support/nas/

Verify that the latest level of firmware is installed on your machine before contacting IBM for technical support. See the *Data ONTAP Upgrade Guide* for your version of Data ONTAP for more information on updating firmware.

Accessing Data ONTAP man pages

You can use the Data ONTAP manual (man) pages to access technical information.

About this task

Data ONTAP manual pages are available for the following types of information. They are grouped into sections according to standard UNIX naming conventions.

Types of information	Man page section
Commands	1
Special files	4
File formats and conventions	5
System management and services	8

Step

1. View man pages in the following ways:
   - Enter the following command at the storage system command line:

     `man command_or_file_name`
   - Click the manual pages button on the main Data ONTAP navigational page in the FilerView user interface.
   - Use the *Commands: Manual Page Reference*, Volumes 1 and 2

     Note: All Data ONTAP man pages are stored on the storage system in files whose names are prefixed with the string "na_" to distinguish them from client man pages. The prefixed names are used to distinguish storage system man pages from other man pages and sometimes appear in the NAME field of the man page, but the prefixes are not part of the command, file, or services.

Terminology

To understand the concepts in this document, you might need to know how certain terms are used.

Storage terms

storage controller Refers to the component of a storage system that runs the Data ONTAP operating system and controls its disk subsystem. Storage controllers are also sometimes called *controllers*, *storage appliances*, *appliances*, *storage engines*, *heads*, *CPU modules*, or *controller modules*.

storage system Refers to the hardware device running Data ONTAP that receives data from and sends data to native disk shelves, third-party storage, or both. Storage systems that run Data ONTAP are sometimes referred to as *filers*, *appliances*, *storage appliances*, *gateways*, or *systems*.

> **Note:** The term *gateway* describes IBM N series storage systems that have been ordered with gateway functionality. Gateways support various types of storage, and they are used with third-party disk storage systems—for example, disk storage systems from IBM, HP®, Hitachi Data Systems®, and EMC®. In this case, disk storage for customer data and the RAID controller functionality is provided by the back-end disk storage system. A gateway might also be used with disk storage expansion units specifically designed for the IBM N series models.
>
> The term *filer* describes IBM N series storage systems that either contain internal disk storage or attach to disk storage expansion units specifically designed for the IBM N series storage systems. Filer storage systems do not support using third-party disk storage systems.

vif Refers to a single virtual interface that is created by grouping together multiple physical interfaces.

Cluster and high-availability terms

active/active configuration In the Data ONTAP 7.2 and 7.3 release families, refers to a pair of storage systems (sometimes called *nodes*) configured to serve data for each other if one of the two systems stops functioning. Also sometimes referred to as *active/active pairs*. In the Data ONTAP 7.1 release family, this functionality is referred to as a *cluster*.

cluster In the Data ONTAP 7.1 release family, refers to a pair of storage systems (sometimes called *nodes*) configured to serve data for each other if one of the two systems stops functioning. In the Data ONTAP 7.3 and 7.2 release families, this functionality is referred to as an *active/active configuration*.

Where to enter commands

You can use your product more effectively when you understand how this document uses command conventions to present information.

You can perform common administrator tasks in one or more of the following ways:

- You can enter commands either at the system console or from any client computer that can obtain access to the storage system using a Telnet or Secure Shell (SSH) session.
  In examples that illustrate command execution, the command syntax and output shown might differ from what you enter or see displayed, depending on your version of the operating system.
- You can use the FilerView graphical user interface.
  For information about accessing your system with FilerView, see the *Data ONTAP System Administration Guide*.
- You can enter Windows, ESX, HP-UX, AIX, Linux, and Solaris commands at the applicable client console.
  In examples that illustrate command execution, the command syntax and output shown might differ from what you enter or see displayed, depending on your version of the operating system.
- You can use the client graphical user interface.
  Your product documentation provides details about how to use the graphical user interface.
- You can enter commands either at the switch console or from any client that can obtain access to the switch using a Telnet session.
  In examples that illustrate command execution, the command syntax and output shown might differ from what you enter or see displayed, depending on your version of the operating system.

Keyboard and formatting conventions

You can use your product more effectively when you understand how this document uses keyboard and formatting conventions to present information.

Keyboard conventions

Convention	What it means
The IBM NAS support site	Refers to *http://www.ibm.com/storage/support/nas/*.

Convention	What it means
Enter, *enter*	• Used to refer to the key that generates a carriage return; the key is named Return on some keyboards. • Used to mean pressing one or more keys on the keyboard and then pressing the Enter key, or clicking in a field in a graphical interface and then typing information into the field.
hyphen (-)	Used to separate individual keys. For example, Ctrl-D means holding down the Ctrl key while pressing the D key.
type	Used to mean pressing one or more keys on the keyboard.

Formatting conventions

Convention	What it means
Italic font	• Words or characters that require special attention. • Placeholders for information that you must supply. For example, if the guide says to enter the `arp -d` *`hostname`* command, you enter the characters "arp -d" followed by the actual name of the host. • Book titles in cross-references.
`Monospaced` font	• Command names, option names, keywords, and daemon names. • Information displayed on the system console or other computer monitors. • Contents of files. • File, path, and directory names.
`Bold monospaced` font	Words or characters you type. What you type is always shown in lowercase letters, unless your program is case-sensitive and uppercase letters are necessary for it to work properly.

Special messages

This document might contain the following types of messages to alert you to conditions that you need to be aware of.

Note: A note contains important information that helps you install or operate the system efficiently.

Attention: An attention notice contains instructions that you must follow to avoid a system crash, loss of data, or damage to the equipment.

How to send your comments

Your feedback is important in helping us provide the most accurate and high-quality information. If you have comments or suggestions for improving this document, send us your comments by e-mail to *starpubs@us.ibm.com*. Be sure to include the following:

- Exact publication title
- Publication form number (for example, GC26-1234-02)
- Page, table, or illustration numbers
- A detailed description of any information that should be changed

Network interfaces on your storage system

Your storage system supports physical network interfaces, such as Ethernet and Gigabit Ethernet interfaces, and virtual network interfaces, such as virtual interface (vif) and virtual local area network (VLAN). Each of these network interface types has its own naming convention.

Your storage system supports the following types of physical network interfaces:

- 10/100/1000 Ethernet
- Gigabit Ethernet (GbE)
- 10 Gigabit Ethernet

In addition, some storage system models include a physical network interface named e0M. The e0M interface is used only for Data ONTAP management activities, such as for running a Telnet, SSH, or RSH session.

Next topics

Network interface naming on page 23
Maximum number of network interfaces on page 25
The e0M interface on page 26
How to use the RLM or BMC to manage Data ONTAP remotely on page 27

Related concepts

Network interface configuration on page 39
How vifs work in Data ONTAP on page 107
How VLANs work on page 93

Network interface naming

Network interface names are based on whether the interface is a physical or virtual network interface. Physical interfaces are assigned names based on the slot number of the adapter. Vif names are user specified. VLANs are named by combining the interface name and VLAN ID.

Physical interfaces are automatically assigned names based on the slot where the network adapter is installed. Because physical interfaces are Ethernet interfaces, they are identified by a name consisting of "e," the slot number of the adapter, and the port on the adapter (if multi-port adapter). A multiport adapter has letters or numbers imprinted next to its ports.

- e<*slot_number*> if the adapter or slot has only one port
- e<*slot_number*><*port_letter*> if the adapter or slot has multiple ports

Vif names are user specified. A vif's name should meet the following criteria:

- It must begin with a letter.
- It must not contain any spaces.
- It must not contain more than 15 characters.
- It must not already be in use for a vif.

VLAN interface names are in the following format:

- *<physical_interface_name>-<vlan_ID>*
- *<vif_name>-<vlan_ID>*

The following table lists interface types, interface name formats, and example of names that use these identifiers.

Interface type	Interface name format	Examples of names
Physical interface on a single-port adapter or slot	e*<slot_number>*	e0 e1
Physical interface on a multiple-port adapter or slot	e*<slot_number><port_letter>*	e0a e0b e0c e0d e1a e1b
Vif	Any user-specified string that meets certain criteria	web_vif vif1
VLAN	*<physical_interface_name>-<vlan-ID>* or *<vif_name>-<vlan_ID>*	e8-2 vif1-3

Host names

When you run the `setup` command on a storage system for the first time, Data ONTAP creates a host name for each installed interface by appending the interface name to the host name of the storage system.

The following table shows examples of host names appended with the interface names.

Interface type	Host name
Single-port Ethernet interface in slot 0	toaster-e0

Interface type	Host name
Quad-port Ethernet interface in slot 1	toaster-e1a toaster-e1b toaster-e1c toaster-e1d

Maximum number of network interfaces

Beginning with Data ONTAP 7.3, storage systems can accommodate from 256 to 1,024 network interfaces per system, depending on the storage system model, system memory, and whether they are in an active/active configuration.

You should run the `sysconfig` command and check the Memory size field displayed for the slot 0 system board of the storage system to determine your storage system memory.

The number of physical interfaces depends on the storage system model. Each storage system can support up to 16 vifs. The maximum number of VLANs that can be supported equals the maximum number of network interfaces shown in the following table minus the total number of physical interfaces, vifs, vh, and loopback interfaces supported by the storage system.

The maximum number of network interfaces that each system can support is shown in the following table. The total number of interfaces can include physical, vif, VLAN, vh, and loopback interfaces.

Storage system memory	Maximum number of network interfaces
2 GB or less	128
2 GB or less in an active/active configuration	256
6 GB or less	256
6 GB or less in an active/active configuration	512
More than 6 GB	512
More than 6 GB in an active/active configuration	1,024

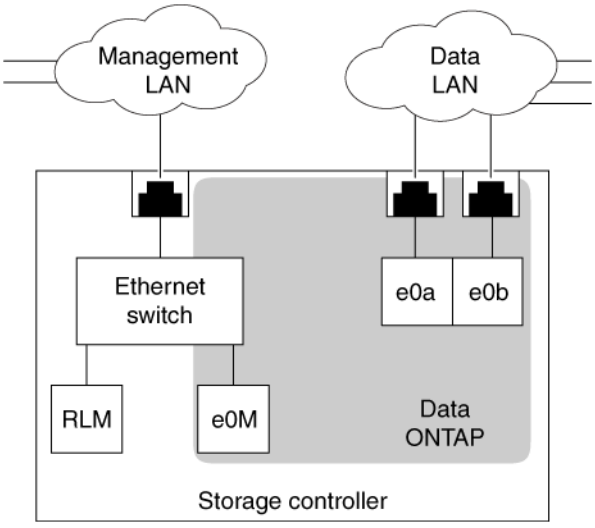
Related references

Network interface statistics on page 183

The e0M interface

Some storage system models include an interface named e0M. The e0M interface is dedicated to Data ONTAP management activities. It enables you to separate management traffic from data traffic on your storage system for security and throughput benefits.

On a storage system that includes the e0M interface, the Ethernet port that is indicated by a wrench icon on the rear of the chassis connects to an internal Ethernet switch. The internal Ethernet switch then provides connectivity to the e0M interface and the Remote LAN Module (RLM). The following diagram illustrates the connections.



When you set up a system that includes the e0M interface, the Data ONTAP setup script informs you that, for environments that use dedicated LANs to isolate management traffic from data traffic, e0M is the preferred interface for the management LAN. The setup script then prompts you to configure e0M. The e0M configuration is separate from the RLM configuration. Both configurations require unique IP addresses to allow the Ethernet switch to direct traffic to either the e0M interface or the RLM. For information about how to set up the e0M interface, see the *Data ONTAP Software Setup Guide*.

The e0M interface does not support vifs, VLANs, and jumbo frames.

After you have set up the e0M interface, you can use it to access the storage system with the following protocols, if they have been enabled:

- Telnet
- RSH
- HTTP or HTTPS
- SSH

- SNMP

How to use the RLM or BMC to manage Data ONTAP remotely

You can manage your storage system locally from an Ethernet connection by using any network interface. However, to manage your storage system remotely, the system should have a Remote LAN Module (RLM) or Baseboard Management Controller (BMC). These provide remote platform management capabilities, including remote access, monitoring, troubleshooting, and alerting features.

If your data center configuration has management traffic and data traffic on separate networks, you can configure the RLM or the BMC on the management network.

With the RLM, you can remotely access the storage system in the following ways:

- Through the serial console
  The RLM is directly connected to the storage system through the serial console. You use the Data ONTAP CLI to administer the storage system and the RLM.
- Through an Ethernet connection using a secure shell client application
  You use the RLM CLI to monitor and troubleshoot the storage system.

With the BMC, you can access the storage system in the following ways:

- Through the serial console
  You use the Data ONTAP CLI to administer the storage system and the BMC.
- Through an Ethernet connection by using a secure shell client application
  You use the BMC CLI to monitor and troubleshoot the storage system.

For more information about the RLM and the BMC, see the *Data ONTAP System Administration Guide*.

Next topics

Ways to configure the RLM on page 27
Ways to configure the BMC on page 28

Ways to configure the RLM

Before using the RLM, you must configure it for your storage system and network. You can configure the RLM when setting up a new storage system with RLM already installed, after setting up a new storage system with RLM already installed, or when adding an RLM to an existing storage system.

You can configure the RLM by using one of the following methods:

- Initializing a storage system that has the RLM pre-installed

When the storage system setup process is complete, the rlm setup command runs automatically. For more information about the entire setup process, see the *Data ONTAP Software Setup Guide*.

- Running the Data ONTAP `setup` script
  The `setup` script ends by initiating the `rlm setup` command.
- Running the Data ONTAP `rlm setup` command
  For information about using the `rlm setup` command to configure the RLM, see the *Data ONTAP System Administration Guide*.

When the `rlm setup` script is initiated, you are prompted to enter network and mail host information.

Ways to configure the BMC

Before using the BMC, you must configure it for your storage system and network. You can configure the BMC when setting up a new storage system with BMC already installed or after setting up a new storage system with BMC already installed.

You can configure the BMC by using one of the following methods:

- Initializing a storage system that has the BMC
  When the storage system setup process is complete, the `bmc setup` command runs automatically. For more information about the entire setup process, see the *Data ONTAP Software Setup Guide*.
- Running the Data ONTAP `setup` script
  The `setup` script ends by initiating the `bmc setup` command.
- Running the Data ONTAP `bmc setup` command
  For information about using the `bmc setup` command to configure the BMC, see the *Data ONTAP System Administration Guide*.

When the `bmc setup` script is initiated, you are prompted to enter network and mail host information.

Standards and characteristics of Ethernet frames

Frame size and Maximum Transmission Unit (MTU) size are the two important characteristics of an Ethernet frame. The standard Ethernet (IEEE 802.3) frame size is 1,518 bytes. The MTU size specifies the maximum number of bytes of data that can be encapsulated in an Ethernet frame.

The frame size of a standard Ethernet frame (defined by RFC 894) is the sum of the Ethernet header (14 bytes), the payload (IP packet, usually 1,500 bytes), and the Frame Check Sequence (FCS) field (4 bytes). You can change the default frame size on Gigabit Ethernet network interfaces.

The MTU size specifies the maximum payload that can be encapsulated in an Ethernet frame. For example, the MTU size of a standard Ethernet frame is 1,500 bytes; this is the default for storage systems. However, a jumbo frame, with an MTU size of 9,000 bytes, can also be configured.

Next topics

What jumbo frames are on page 29
Flow control on page 30

What jumbo frames are

Jumbo frames are larger than standard frames and require fewer frames. Therefore, you can reduce the CPU processing overhead by using jumbo frames with your network interfaces. Particularly, by using jumbo frames with a Gigabit or 10 Gigabit Ethernet infrastructure, you can significantly improve performance, depending on the network traffic.

Jumbo frames are packets that are longer than the standard Ethernet (IEEE 802.3) frame size of 1,518 bytes. The frame size definition for jumbo frames is vendor-specific because jumbo frames are not part of the IEEE standard. The most commonly used jumbo frame size is 9,018 bytes.

Jumbo frames can be used for all Gigabit and 10 Gigabit Ethernet interfaces that are supported on your storage system. The interfaces must be operating at or above 1,000 Mbps.

You can set up jumbo frames on your storage system in the following two ways:

- During initial setup, the `setup` command prompts you to configure jumbo frames if you have an interface that supports jumbo frames on your storage system.
- If your system is already running, you can enable jumbo frames by setting the MTU size on an interface.

Next topics

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Guidelines to configure clients for jumbo frames on page 30

Network interface requirements for jumbo frames

Before you enable jumbo frames on your storage system, jumbo frames must be enabled for the switch ports, client interfaces, and intermediate routers on the network. If your storage system and the client are on different subnets, the next-hop router must be configured for jumbo frames.

Guidelines to configure clients for jumbo frames

When configuring clients for jumbo frames, you should verify certain configurations, such as the TCP window size of the client and the MTU size of the client, storage system, and any intermediate subnet.

The guidelines for configuring clients for jumbo frames are as follows:

- Configure jumbo frames on the client and on your storage system.
  Find how to configure jumbo frames on your client by checking the network adapter documentation for your client.
- Enlarge the client's TCP window size.
  The minimum value for the client's window size should be two times the MTU size, minus 40, and the maximum value can be the highest value your system allows. Typically, the maximum value you can set for your client's TCP window is 65,535. If your storage system is configured to support jumbo frames and the client is not, the communication between the storage system and the client occurs at the client's frame size.
- Configure the storage system and UDP clients to have the same MTU size.
  User Datagram Protocol (UDP) systems do not negotiate the MTU size. If your storage system and clients do not have the same MTU size, the storage system might send packets that the clients cannot receive.
- Check the MTU size of any intermediate subnets if your storage system and the client are on different subnets.
  If the storage system and the client (both configured to use jumbo frames) are on different subnets and an intermediate subnet does not support jumbo frames, the intermediate router fragments the IP packets and the advantages of using jumbo frames are lost.

Related tasks

Specifying an MTU size for a network interface on page 43

Flow control

Flow control enables you to manage the flow of frames between two directly connected link-partners. Flow control can reduce or eliminate dropped packets due to overrun.

To achieve flow control, you can specify a flow control option that causes packets called Pause frames to be used as needed. For example, link-partner A sends a Pause On frame to link-partner B when its receive buffers are nearly full. Link-partner B suspends transmission until it receives a Pause Off frame from link-partner A or a specified timeout threshold is reached.

Support for IPv6

Starting with Data ONTAP 7.3.1, Internet Protocol version 6 (IPv6) is supported on your storage system's network. IPv6 increases the IP address size from 32 bits (in IPv4) to 128 bits. This larger address space provides expanded routing and addressing capabilities.

Data ONTAP 7.3 and earlier used IPv4 for all the addressing and networking requirements. However, IPv4 has many limitations, such as limited address space and security. To address these limitations, the Internet Engineering Task Force (IETF) developed a new version of IP, called IPv6.

You can enable the IPv6 option and configure IPv6 addresses on the network interfaces of the storage system. IPv6 addresses can also be automatically configured.

Next topics

Ways to configure IPv6 addresses

IPv6 addresses can be configured on the network interfaces of your storage system, either manually or automatically. The configuration of an IPv6 address depends on the type and scope of the address.

Next topics

IPv6 address types

There are three types of IPv6 addresses: unicast, anycast, and multicast.

Unicast address	This address identifies a single interface. A data packet sent to a unicast address is delivered only to the interface that is identified by that address.
Anycast address	This address identifies a set of interfaces. A data packet sent to an anycast address is delivered to the nearest interface (according to the routing protocols' measure of distance) that is identified by that address. **Note:** Anycast address is not supported in Data ONTAP.

Multicast address	This address identifies a set of interfaces. A data packet sent to a multicast address is delivered to all the interfaces that are identified by that address. **Note:** In IPv6, multicast addresses replace broadcast addresses.

IPv6 address scopes

IPv6 addresses fall under three scopes: global, link-local, and unique local.

Global address	This address has an unlimited scope.
Link-local	This address has a link-only scope that can be used to reach neighboring nodes that are attached to the same link. This address is automatically assigned to a network interface.
Unique local address	The address scope is limited to a local site or local set of sites. These addresses cannot be routed on the global Internet.

IPv6 address states

Before and after an IPv6 address is assigned, it goes through various states, such as tentative address, duplicate address, preferred address, and so on. These address states are applicable to both manually and automatically configured addresses.

An IPv6 address can have one or more of the following states:

Tentative address	An address whose uniqueness on a link is being verified. When an address is configured on a network interface (either manually or automatically), the address is initially in the tentative state. Such an address is not considered to be assigned to an interface. An interface discards received packets addressed to a tentative address, but accepts Neighbor Discovery packets related to Duplicate Address Detection (DAD) for the tentative address.
Duplicate address	If DAD finds that an address is not unique, it is moved to the duplicate state. Such an address cannot be used for sending and receiving data.
Preferred address	An address used to send and receive data packets from and to a network interface without any restriction on the upper layer protocols.
Deprecated address	A preferred address becomes deprecated when its preferred lifetime expires. The use of this address is discouraged, but not prohibited.
Valid address	A uniquely verified address that you can assign to a network interface for sending and receiving data. A valid address can be a preferred or deprecated address.
Invalid address	A network interface address that can no longer send or receive data packets. A valid address becomes invalid when its valid lifetime expires. An invalid address is removed from the network interface.

How to transition from IPv4 to IPv6

A transition mechanism enables IPv6 hosts and routers to be compatible with IPv4 hosts and routers. Starting with Data ONTAP 7.3.1, a dual stack mechanism is used for transitioning from IPv4 to IPv6.

In the dual stack mechanism, the following modes are supported:

- Only IPv4 mode: In this mode, IPv6 is not enabled.
- Only IPv6 mode: In this mode, IPv6 is enabled and IPv4 addresses are not configured on any interface.
- IPv6/IPv4 mode: In this mode, IPv6 is enabled and both IPv4 and IPv6 addresses are configured on the network interfaces.

Attention: In the "Only IPv6 mode," address lookup can return both IPv4 and IPv6 addresses. If you use an IPv4 address to set up communication in the "Only IPv6 mode," the communication fails. Therefore, you should have at least one IPv4 address configured in a network interface and then use the "IPv6/IPv4 mode."

Data ONTAP does not support the following IPv6 transition mechanisms (defined in RFC 2893):

- Configured tunneling of IPv6 over IPv4
- IPv4-mapped IPv6 addresses
- Automatic tunneling of IPv6 over IPv4

Enabling or disabling IPv6

You can enable IPv6 on all the interfaces of your storage system either during setup or when the storage system is in operation. You can disable IPv6 on your storage system if you want to revert to IPv4 addressing.

About this task

- You can enable IPv6 during initial system configuration when the `setup` command is run for the first time. If you want to enable IPv6 later, you can rerun the `setup` command or configure IPv6 manually. For more information about the `setup` command, see the *Data ONTAP Software Setup Guide*.
- You can enable IPv6 only for the entire storage system, but not for a network interface or a vFiler unit.

Step

1. To enable or disable IPv6 when the storage system is in operation (not during setup), enter the following command:

`options ip.v6.enable {on|off}`

`on`—Enables IPv6

`off`—Disables IPv6

After you finish

If you have enabled IPv6 when the storage system is in operation, you must manually restart all server applications, except CIFS, FTP, and HTTP, to run over IPv6. For CIFS, FTP, and HTTP to work over IPv6, you must enable their individual IPv6 options. For more information about the protocols supported over IPv6, see the *Data ONTAP File Access and Protocols Management Guide*.

Note: If the applications are running only over IPv4, you do not need to restart the applications.

Types of address autoconfiguration

IPv6 defines both a stateful and a stateless address autoconfiguration mechanism. Data ONTAP 7.3.1 and later supports IPv6 stateless address autoconfiguration.

The Neighbor Discovery protocol is one of the protocols that facilitates address autoconfiguration.

Next topics

What stateless address autoconfiguration is on page 34

Enabling or disabling router-advertised messages on page 35

Related concepts

What Neighbor Discovery does on page 35

What stateless address autoconfiguration is

The stateless address autoconfiguration mechanism allows a host to generate its own addresses by using a combination of locally available information and router-advertised information. The stateless address autoconfiguration requires minimal manual configuration of hosts and routers.

Data ONTAP supports the following two types of autoconfigured IPv6 addresses:

- Autoconfigured address based on the router-advertised prefix: This address is a combination of the network prefix, which is router-advertised, and the network interface identifier.
- Autoconfigured link-local address: In the absence of routers, a host can generate only link-local addresses. Link-local addresses allow communication between hosts and routers that are on the same link.

RFC 2462 describes address autoconfiguration.

Enabling or disabling router-advertised messages

RA messages help in autoconfiguring addresses that have global scope and in learning routes and prefixes. If, due to security reasons, you do not want the MAC address of the network interfaces to be viewed by any external network, you can disable RA address autoconfiguration.

About this task

You can use the `ip.v6.ra_enable` option to enable or disable router-advertised (RA) messages.

- By default, the `ip.v6.ra_enable` option is set to `on`.
- You can enable the RA option only for the entire storage system; you cannot enable it for a network interface.
- Disabling the RA option does not remove the existing autoconfigured addresses and the routes learned.
- When the RA option is disabled, the RA message is dropped. Therefore, no default route is learned, the default router failover is disabled, and link MTU updates are stopped.

Step

1. To enable or disable RA address autoconfiguration, enter the following command:

   `options ip.v6.ra_enable {on|off}`

   `on`—Enables RA address autoconfiguration

   `off`—Disables RA address autoconfiguration

What Neighbor Discovery does

The Neighbor Discovery (ND) protocol enables hosts and routers to discover the presence of neighboring IPv6 hosts and routers. The ND protocol also helps in identifying the link-layer address of hosts and routers and in performing Duplicate Address Detection (DAD).

The ND protocol replaces the IPv4 protocols, such as Address Resolution Protocol (ARP), Internet Control Message Protocol (ICMP) Router Discovery, and ICMP Redirect.

The various ND mechanisms for enabling interaction between nodes that are on the same link, as described in RFC 2461, are described below:.

Router discovery	How hosts find routers that reside on an attached link.
Prefix discovery	How hosts discover the set of address prefixes that define which destinations are on-link for an attached link.
Parameter discovery	How hosts discover operating parameters such as link MTU and default hop limit for outgoing packets.

Address autoconfiguration	How hosts and routers automatically configure an address for an interface.
Address resolution	How hosts and routers determine the link-local address of a neighbor by using the IPv6 address of the neighbor.
Next-hop determination	How hosts and routers determine the IPv6 address of a neighbor to which a packet should be sent, by using the destination address. The next hop can be either the destination address or a router address.
Neighbor Unreachability Detection	How hosts and routers determine that a neighbor is no longer reachable.
Duplicate Address Detection	How hosts and routers determine that an address considered for use is not already in use by a neighbor.
Redirect	How a router informs a host of a better first-hop router to reach a particular destination.

ND message types

There are five types of ND messages: Router Solicitation, Router Advertisement, Neighbor Solicitation, Neighbor Advertisement, and Redirect. You can specify various ND options in an ND message.

Router Advertisement and Router Solicitation messages facilitate host-router discovery functions. Neighbor Solicitation and Neighbor Advertisement messages facilitate exchange of information between neighboring hosts on the same network. The Redirect message is used to inform a host of a better route for sending data packets to a particular destination. All the ND message types use the Internet Control Message Protocol version 6 (ICMPv6) message structure.

The ND options that can be specified in an ND message are the source link-layer address, target link-layer address, prefix information, MTU, and redirected header. These ND options provide additional information such as MAC addresses, on-link network prefixes, on-link MTU information, and redirection data.

Note: Data ONTAP supports a maximum of 10 options in an ND message.

How DAD works with Data ONTAP

Before assigning unicast addresses to an interface, Duplicate Address Detection (DAD) is performed on the addresses to ensure that the addresses configured on a link are unique. DAD is performed on all unicast addresses (both manually and automatically configured). When the DAD procedure fails for an address, the address is not configured.

DAD prevents multiple nodes from using the same address simultaneously. DAD is performed on all unicast addresses of a network interface, provided the value of the `dad_attempts` option for that interface is greater than zero.

To check the uniqueness of an address, a node sends Neighbor Solicitation messages, each separated by an interval of 1 second. The number of Neighbor Solicitation messages sent is equal to the value of the `dad_attempts` option for the network interface.

An address on which the DAD procedure is applied remains in the tentative state until the procedure has been successfully completed. The target address of the Neighbor Solicitation message is set to the address that is being checked and remains in the tentative state. If the node receives a valid Neighbor Advertisement message with the tentative address as target, the tentative address is not unique. The tentative address is marked duplicated and cannot be used for any data communication.

If DAD fails for a link-local address, the network interface is configured to the `down` status.

If a node does not receive a Neighbor Advertisement message after sending the Neighbor Solicitation messages for a tentative address, the address is considered unique. When an address is determined to be unique, it is assigned to the network interface.

Example: Duplicated unicast address

The following example shows DAD failure for a unicast address, where the address state changes from tentative to duplicated.

```
system1> ifconfig e0b 2001:0db8::99
system1> ifconfig e0b
e0b: flags=0x2508866<BROADCAST,RUNNING,MULTICAST,TCPCKSUM> mtu 1500
inet6 2001:0db8::99 prefixlen 64 tentative
ether 00:a0:98:08:64:07 (auto-1000t-fd-cfg_down) flowcontrol full
```

```
system1> Wed Aug 6 09:24:44 GMT [system1:netif.linkUp:info]: Ethernet
e0b: Link up.
Wed Aug 6 09:24:44 GMT [system1:netinet6.nbr.dad.dtcDupAdr:error]:
e0b: DAD detected duplicate IPv6
address 2001:0db8::99: %d NS, 0 NA.
Wed Aug 6 09:24:44 GMT [system1:netinet6.nbr.dad.complete:error]:
e0b: DAD complete for 2001:0db8::99- duplicate found.
Wed Aug 6 09:24:44 GMT [system1:netinet6.nbr.manl.intvtnReq:error]:
e0b: Manual intervention required.
Wed Aug 6 09:24:45 GMT [system1:netinet6.nbr.dadStrc.notFnd1:error]:
nd6_dad_timer: DAD structure is not found.
system1> ifconfig e0b
e0b: flags=0x2d48867<UP,BROADCAST,RUNNING,MULTICAST,TCPCKSUM,LINK_UP>
mtu 1500
inet6 2001:0db8::99 prefixlen 64 duplicated
inet6 fe80::2a0:98ff:fe08:6407 prefixlen 64 scopeid 0x2 autoconf
ether 00:a0:98:08:64:07 (auto-1000t-fd-up) flowcontrol full
```

Example: Duplicated link-local address

The following example shows DAD failure for a link-local address, where the network interface is configured to the `down` status.

```
system1> ifconfig e0b up
system1> Tue Jul 22 16:46:38 GMT [system1: netif.linkUp:info]:
```

```
Ethernet e0b: Link up.
Tue Jul 22 16:46:39 GMT [system1: netinet6.nbr.dad.dtcDupAdr:error]:
e0b: DAD detected duplicate IPv6 address
fe80:0002::02a0:98ff:fe08:6407: %d NS, 0 NA.
Tue Jul 22 16:46:39 GMT [system1: netinet6.nbr.dad.complete:error]:
e0b: DAD complete for fe80:0002::02a0:98ff:fe08:6407 - duplicate
found.
Tue Jul 22 16:46:39 GMT [system1: netinet6.nbr.manl.intvtnReq:error]:
e0b: Manual intervention required.
Tue Jul 22 16:46:39 GMT [system1: netif.linkInfo:info]: Ethernet e0b:
Link configured down.
Tue Jul 22 16:46:40 GMT [system1:
netinet6.nbr.dadStrc.notFnd1:error]: nd6_dad_timer: DAD structure is
not found.
```

```
system1> ifconfig -a
e0a: flags=0x2508866<BROADCAST,RUNNING,MULTICAST,TCPCKSUM> mtu 1500
        ether 00:a0:98:08:64:06 (auto-1000t-fd-cfg_down) flowcontrol
full
e0b: flags=0x2508866<BROADCAST,RUNNING,MULTICAST,TCPCKSUM> mtu 1500
        ether 00:a0:98:08:64:07 (auto-1000t-fd-cfg_down) flowcontrol
full
e0c: flags=0x2508866<BROADCAST,RUNNING,MULTICAST,TCPCKSUM> mtu 1500
        ether 00:a0:98:08:64:08 (auto-1000t-fd-cfg_down) flowcontrol
full
e0d: flags=0x2508866<BROADCAST,RUNNING,MULTICAST,TCPCKSUM> mtu 1500
        ether 00:a0:98:08:64:09 (auto-1000t-fd-cfg_down) flowcontrol
full
e0e: flags=0x2508866<BROADCAST,RUNNING,MULTICAST,TCPCKSUM> mtu 1500
        ether 00:a0:98:08:64:0a (auto-1000t-fd-cfg_down) flowcontrol
full
e0f: flags=0x2508866<BROADCAST,RUNNING,MULTICAST,TCPCKSUM> mtu 1500
        ether 00:a0:98:08:64:0b (auto-1000t-fd-cfg_down) flowcontrol
full
lo:
flags=0x1948049<UP,LOOPBACK,RUNNING,MULTICAST,TCPCKSUM,LINK_UP,UDPCKSU
M> mtu 8160
        inet 127.0.0.1 netmask 0xff000000 broadcast 127.0.0.1
        inet6 fe80::1 prefixlen 64 scopeid 0x7 autoconf
        inet6 ::1 prefixlen 128
        ether 00:00:00:00:00:00 (VIA Provider)
```

Related tasks

Specifying the number of DAD attempts on page 48

Network interface configuration

Configuring network interfaces involves assigning IP addresses, setting network parameters and hardware-dependent values, specifying network interfaces, and viewing your storage system's network configuration.

When you configure network interfaces, you can do any or all of the following:

- Assign an IP address to a network interface.
- Set parameters such as network mask, broadcast address, and prefix length.

  Note: If IPv6 is enabled on your storage system, you can set only the prefix length. IPv6 does not have a network mask and does not support broadcast addresses.
- Set hardware-dependent values such as media type, MTU size, and flow control.
- Specify whether the interface should be attached to a network with firewall security protection.
- Specify whether the network interface must be registered with Windows Internet Name Services (WINS), if CIFS is running and at least one WINS server has been configured.
- Specify the IP address of an interface or specify the interface name on an active/active configuration partner for takeover mode.

  Note: When using IPv6 in an active/active configuration, you can specify only the partner interface name (and not the IP address) on the active/active configuration for takeover mode.
- View the current configuration of a specific interface or all interfaces that exist on your storage system.

Next topics

Configuring network interfaces on page 39
Creating or removing aliases on page 49
Changing the status of an interface on page 50
Viewing or modifying interface settings with FilerView on page 50
Blocking or unblocking protocols from network interfaces on page 51
Network interface information you can view on page 52

Related concepts

Network interfaces on your storage system on page 23

Configuring network interfaces

You can configure network interfaces either during system setup or when the storage system is operating. When the storage system is operating, you can use the `ifconfig` command to assign or modify configuration values of your network interfaces.

During system setup, you can configure the IP addresses for the network interfaces. An `ifconfig` command is included in the `/etc/rc` file of the root volume for each network interface that you

configured during the system setup. After your storage system has been set up, the `ifconfig` commands in the `/etc/rc` file are used to configure the network interfaces on subsequent storage system reboots.

You can use the `ifconfig` command to change values of parameters for a network interface when your storage system is operating. However, such changes are not automatically included in the `/etc/rc` file. If you want your configuration modifications to be persistent after a reboot, you must include the `ifconfig` command values in the `/etc/rc` file.

Next topics

Configuring an IP address for a network interface

You can configure IP addresses for your network interface during system setup. To configure the IP addresses later, you should use the `ifconfig` command. You can configure both IPv4 and IPv6 addresses for a network interface.

About this task

- Network configuration changes made by using the `ifconfig` command are not automatically included in the `/etc/rc` file. To make the configuration changes persistent after reboots, include the `ifconfig` command in the `/etc/rc` file.
- When you configure an IP address, your storage system creates a network mask based on the class of the address (Class A, B, C, or D) by default.

Step

1. To configure an IP address for a network interface, enter the following command:

   `ifconfig` *`interface_name IP_address`*

interface_name is the name of the network interface.

IP_address is the IP address that you want to assign to the network interface.

Example

To configure a quad-port Ethernet interface e3a to use the IPv4 address 192.0.2.10, enter the following command:

```
ifconfig e3a 192.0.2.10
```

To configure a quad-port Ethernet interface e3a to use the IPv6 address 2001:0db8:35ab:0:8a2e:0:0370:85, enter the following command:

```
ifconfig e3a 2001:0db8:35ab:0:8a2e:0:0370:85
```

Related tasks

Specifying a subnet mask for a network interface on page 41

Specifying a subnet mask for a network interface

You must specify a subnet mask if you have created subnets that do not match the class boundary of the IPv4 address of the network interface. You can specify a subnet mask for a network interface by using the `ifconfig` command. IPv6 does not support subnet masks.

About this task

Data ONTAP allows you to configure a 32-bit subnet mask with all bits equal to 1.

Step

1. To specify a subnet mask, enter the following command:

   ```
   ifconfig interface_name netmask mask
   ```

   interface_name is the name of the network interface.

   mask is the subnet mask.

   Example

   To configure a 24-bit mask for the interface e3a that you have already configured, enter the following command:

   ```
   ifconfig e3a netmask 255.255.255.0
   ```

Related tasks

Configuring an IP address for a network interface on page 40

Specifying the prefix length for a network interface

Prefix length specifies the number of bits in the IP address that are to be used as the subnet mask. You can specify the prefix length for a network interface by using the `ifconfig` command.

About this task

For an IPv4 address, the prefix length must be less than or equal to 32 bits. For an IPv6 address, the prefix length must be less than or equal to 128 bits. The default value of the prefix length for an IPv6 address is 64 bits.

Step

1. To specify the prefix length, enter the following command:

   ifconfig *interface_name ip_address* prefixlen *length*

   ip_address is the IP address assigned to the network interface.

   length is the prefix length for the network interface.

   #### Example

   To configure a prefix length of 24 bits, enter the following command:

   ifconfig e0a 192.0.2.16 prefixlen 24

   To configure a prefix length of 64 bits for an IPv6 address, enter the following command:

   ifconfig e3a 2001:0db8:35ab:0:8a2e:0:0370:85 prefixlen 64

Specifying a broadcast address

You can use a broadcast address to send a message to all the machines on a subnet. You can specify a broadcast address by using the `ifconfig` command.

About this task

IPv6 does not support broadcast addresses.

Step

1. To specify a broadcast address, enter the following command:

   ifconfig *interface_name* broadcast *address*

   interface_name is the name of the network interface.

   address is the broadcast address.

Example

To set a broadcast address of 192.0.2.25 for the network 192.0.2.10 with subnet mask 255.255.255.0, enter the following command:

```
ifconfig e3a broadcast 192.0.2.25
```

Specifying a media type for a network interface

You can specify a media type for configuring the speed and duplex of a network interface by using the `ifconfig` command.

Step

1. To specify a media type, enter the following command:

   `ifconfig` ***`interface_name`*** **`mediatype`** ***`type`***

   `interface_name` is the name of the network interface.

   `type` specifies the Ethernet media type used. The possible values are `tp`, `tp-fd`, `100tx`, `100tx-fd`, `auto`, or `10g-sr`.

   For more information, see the na_ifconfig(1) man page.

   Example

   To configure the interface e2a as a 100Base-TX full-duplex interface, enter the following command:

   ```
   ifconfig e2a mediatype 100tx-fd
   ```

Specifying an MTU size for a network interface

The maximum transmission unit (MTU) size is used to specify the jumbo frame size on Gigabit Ethernet interfaces. You can specify the MTU size for transmission between your storage system and its client by using the `ifconfig` command.

Step

1. To specify an MTU size, enter the following command:

   `ifconfig` ***`interface_name`*** **`mtusize`** ***`size`***

   `interface_name` is the name of the network interface.

   `size` is the MTU to be used for the network interface.

   Example

   To specify an MTU size of 9000 for Gigabit Ethernet interface e8, enter the following command:

   ```
   ifconfig e8 mtusize 9000
   ```

Related concepts

Standards and characteristics of Ethernet frames on page 29
What jumbo frames are on page 29
Guidelines to configure clients for jumbo frames on page 30

Specifying the flow control type for a network interface

You can specify the flow control type for a network interface to manage the flow of frames between two directly connected link-partners by using the `ifconfig` command. You can configure flow control on interfaces operating at or above 1,000 Mbps.

About this task

The configured flow control setting is advertised during autonegotiation. If autonegotiation succeeds, the operational flow control setting is determined based on the negotiated speed and the value advertised by the other device. If autonegotiation fails, the configured flow control setting is used.

You can also use the `ifstat` command to view the operational flow control setting.

Step

1. To specify the flow control type, enter the following command:

   `ifconfig` ***`interface_name`*** **`flowcontrol`** ***`value`***

   `interface_name` is the name of the network interface.

   `value` is the flow control type. You can specify the following values for the `flowcontrol` option:

none	No flow control
receive	Able to receive flow control frames
send	Able to send flow control frames
full	Able to send and receive flow control frames

   The default flow control type is `full`.

   Example

   To turn off flow control on interface e8, enter the following command:

   ```
   ifconfig e8 flowcontrol none
   ```

Related concepts

Flow control on page 30

Specifying whether a network interface is trusted

You can specify whether a network interface is trustworthy or untrustworthy. When you specify an interface as untrusted (untrustworthy), any packets received on the interface are likely to be dropped.

For example, if you run a `ping` command on an untrusted interface, the interface drops any ICMP response packet received.

Step

1. To specify a network interface as trusted or untrusted, enter the following command:

   `ifconfig` *`interface_name`* `{trusted|untrusted}`

   `interface_name` is the name of the network interface.

   `trusted` specifies that the network interface is trustworthy.

   `untrusted` specifies that the network interface is untrustworthy.

   #### Example

   To specify that the network attached to interface e8 is not trustworthy for firewall security, enter the following command:

   `ifconfig e8 untrusted`

Specifying the partner IP address in an active/active configuration

In an active/active configuration, you can assign a partner IP address to a network interface. The network interface takes over this IP address when a failover occurs. You can use the `ifconfig` command to specify the partner IP address.

About this task

You can specify only an IPv4 address for takeover in an active/active configuration.

Step

1. To assign the partner IP address, enter the following command:

   `ifconfig` *`interface_name`* `partner` *`address`*

   `interface_name` is the name of the network interface.

   `address` is the partner IP address.

   #### Example

   To specify the IP address on the partner interface that takes over the interface e8 in case of a failover, enter the following command:

   `ifconfig e8 partner 192.0.2.10`

Related tasks

Specifying the partner interface in an active/active configuration on page 46

Specifying the partner interface in an active/active configuration

In an active/active configuration, you can assign the name of a partner interface. The partner interface takes over the network interface when a failover occurs. You can specify the partner interface by using the `ifconfig` command.

About this task

When using IPv6, you must specify the partner interface, and not an IP address.

Step

1. To specify a partner interface name, enter the following command:

   `ifconfig` *`interface_name`* `partner` *`partner_interface`*

   `interface_name` is the name of the network interface.

   `partner_interface` is the name of the partner network interface.

   Example
   To specify e3 as the interface for the active/active configuration partner that takes over the interface e8 when e8 fails, enter the following command:

   ```
   ifconfig e8 partner e3
   ```

Related tasks

Specifying the partner IP address in an active/active configuration on page 45

Enabling or disabling automatic takeover for a network interface

You can enable or disable negotiated failover for a network interface to trigger automatic takeover if the interface experiences a persistent failure. You can use the `nfo` option of the `ifconfig` command to enable or disable negotiated failover.

Before you begin

You must enable takeover on interface failures by entering the following command:

```
options cf.takeover.on_network_interface_failure enable
```

About this task

- You must include the `nfo` option in the `/etc/rc` file for it to persist across reboots.
- You can specify the `nfo` option for a vif. However, you cannot specify the `nfo` option for any underlying physical interface of the vif.

Step

1. To enable or disable negotiated failover, enter the following command:

   ifconfig *interface_name* {nfo|-nfo}

   interface_name is the name of the network interface.

   nfo—Enables negotiated failover

   -nfo—Disables negotiated failover

   Example
   To enable negotiated failover on the interface e8 of an active/active configuration, enter the following command:

   ifconfig e8 nfo

Removing a primary IP address from a network interface

You can remove a primary IP address from a network interface to disconnect the network interface from the network or reconfigure the network interface.

Before you begin

Ensure that you remove all the manually configured alias addresses for the interface.

Step

1. To remove a primary IP address, enter the following command:

   ifconfig *interface_name* 0

   interface_name is the name of the network interface.

   Alternatively, to remove a primary IPv4 address, you can use the following command:

   ifconfig *interface_name* 0.0.0.0

   Example

   To remove the primary address of the interface e3, enter the following command:

   ifconfig e3 0

   Note: To remove a primary IPv6 address, you can use either of these commands:

   - **ifconfig *interface_name* 0::0**
   - **ifconfig *interface_name* inet6 0**

Related tasks

Creating or removing aliases on page 49

Specifying the number of DAD attempts

To check the uniqueness of an IPv6 address, a node sends Neighbor Solicitation messages. You can use the `ifconfig` command to specify the number of consecutive Neighbor Solicitation messages (`dad_attempts`) to be sent while performing DAD on a tentative address before it can be configured.

Before you begin

IPv6 must be enabled on the storage system.

About this task

A value of zero for the `dad_attempts` option indicates that DAD is not performed on the tentative addresses. A value of one for the `dad_attempts` option indicates a single transmission with no follow-up retransmission and so on.

Step

1. Enter the following command:

   `ifconfig` *`interface_name`* `dad_attempts` *`value`*

   `interface_name` is the name of the interface

   `value` is the total number of consecutive Neighbor Solicitation messages sent while performing DAD on a tentative address. The default value is 2.

   You can set the `dad_attempts` *`value`* from 0 to 15 for physical interfaces and from 0 to 7 for vifs and VLANs.

   Note: A `dad_attempts` *`value`* that is greater than 13 does not work in certain scenarios. Therefore, it is best to set the `dad_attempts` *`value`* to less than 13.

Example

You can configure the interface e0a for sending four consecutive Neighbor Solicitation messages by using the following command:

`ifconfig e0a dad_attempts 4`

The following is the output of the `ifconfig` command:

```
ifconfig e0a
e0a: flags=0x2d48867<UP,BROADCAST,RUNNING,MULTICAST,TCPCKSUM> mtu 1500
dad_attempts 4
inet6 fe80::2a0:98ff:fe06:c8f6 prefixlen 64 scopeid 0x3 autoconf
tentative
ether 00:a0:98:06:c8:f6 (auto-1000t-fd-up) flowcontrol full
```

Related concepts

How DAD works with Data ONTAP on page 36

Viewing network interface settings

To verify the network connectivity and diagnose any issues, you can view the network interface settings, such as interface status, IP address, and other network parameters. You can view the settings of all interfaces or a specific interface by using the `ifconfig` command.

Step

1. Depending on the network interface settings that you want to view, complete the following step:

If you want to view...	Enter the following command...
All interfaces	**`ifconfig -a`**
A specific interface	**`ifconfig`** ***`interface_name`***

Related tasks

Viewing or modifying interface settings with FilerView on page 50

Creating or removing aliases

You can create or remove an alias if you are changing the IP address of an interface. You should use the `alias` command to create an alias IP address, and use the `-alias` command to remove an alias IP address.

About this task

- The alias addresses are lost when the storage system reboots. If you want to make these changes persistent, include the `ifconfig` commands, which are used for configuring the alias addresses, in the `/etc/rc` file for the root volume.
- You cannot use FilerView to manage aliases.
- For IPv4 addresses, you can add an alias address only if a primary address for the interface exists.

  Note: For IPv6 addresses, the link-local and autoconfigured addresses are automatically added as alias addresses even without a primary address configured for an interface.

Step

1. To create or remove an alias, enter the following command:

   `ifconfig` ***`interface_name`*** **`[-]alias`** ***`address`***

Example

The following example creates the alias IP address 192.0.2.30 for the interface e0 (already configured with IP address 192.0.2.21):

```
ifconfig e0 alias 192.0.2.30
```

The following example removes the 192.0.2.30 alias for the interface e0 specified in the previous example:

```
ifconfig e0 -alias 192.0.2.30
```

Changing the status of an interface

You must make an interface inactive before performing tasks such as upgrading an interface, disabling a failed interface, or troubleshooting connectivity issues. You must again make the interface active after you complete the task. You can make an interface active or inactive by using the `ifconfig` command.

About this task

If you have enabled IPv6 on your storage system, you can bring up the interface without a valid address configured because a link-local address is created automatically for the interface. However, if the `/etc/rc` file contains an entry to keep a network interface in down status, a link-local address is not created.

Step

1. To change the status of an interface, enter the following command:

   ifconfig *interface* {up|down}

   `up`—makes the interface active

   `down`—makes the interface inactive

Viewing or modifying interface settings with FilerView

You can use FilerView to view or modify the settings of all interfaces or a specific interface. The changes made by using FilerView are automatically written to the `/etc/rc` file.

Steps

1. From the list on the left pane, click **Network > Manage Interfaces**.
2. Depending on whether you want to view or modify the configuration settings, perform the following step:

If you want to...	Then...
View interface configuration details	Click **Show All Interface Details**.
Modify an interface configuration	Select an interface and click **Modify**.

Blocking or unblocking protocols from network interfaces

You can use the `interface.blocked.protocol` option to block specified network protocols, including CIFS, iSCSI, FTP, or NFS, on selected network interfaces. You can also unblock a protocol from a network interface.

Step

1. To block or unblock protocols from network interfaces, perform one of the following steps:

If you want to...	Enter the following command...
Block a protocol from multiple network interfaces	**options interface.blocked.*protocol_name interface_name,interface_name, ...interface_name*** *protocol_name* is the protocol that you want to block. *interface_name* is the interface on which you want to block the protocol. **Note:** To block multiple protocols from a single interface, you must repeat the command for each protocol.
Unblock a protocol	**options interface.blocked.*protocol_name* ""**

Example

To block the interface e9 from using the CIFS protocol, enter the following command:

```
options interface.blocked.cifs e9
```

To block the CIFS protocol from the interfaces e0a and e0b, enter the following command:

```
options interface.blocked.cifs e0a,e0b
```

To block NFS, CIFS, and FTP from the interface e0a, enter the following commands:

```
options interface.blocked.nfs e0a
```

```
options interface.blocked.cifs e0a
```

```
options interface.blocked.ftpd e0a
```

To unblock CIFS from all the network interfaces, enter the following command:

```
options interface.blocked.cifs ""
```

Network interface information you can view

You can view the status and performance statistics of your network interfaces, such as packets sent and received, cumulative or continuous packet traffic, collisions and other errors, active sockets, memory buffer, protocol-specific statistics, routing tables.

Data ONTAP provides the following commands that you can use to view network interface information:

Command	Information displayed
`ifconfig -a`	• Interface status (up or down) • Configuration parameters
`ifstat`	• Packets sent and received • Collisions and other errors • Negotiated media type settings between storage system interfaces and link partners
`netstat`	• Active sockets for each protocol • Memory buffer (mbuf) pool usage • Protocol-specific statistics for all protocols or a single protocol • Cumulative or continuous packet traffic for all interfaces or a single interface • Routing tables

For more information, see the man pages for these commands.

You can also use FilerView to view interface and routing information.

Next topics

Viewing statistics of all active TCP connections on page 53
Viewing or clearing network interface statistics on page 54
Viewing network interface information with FilerView on page 57

Viewing statistics of all active TCP connections

You can view the mapping network context of each TCP connection and the number of bytes of data sent and received over each TCP connection by using the `netstat` command.

Step

1. Depending on the statistics that you want to view, perform the following step:

If you want to view the...	Enter the following command...
Mapping context of each TCP connection	**`netstat -aM`**
Number of bytes of data sent and received over each TCP connection	**`netstat -aB`**

Example

The following example shows the output of the `netstat -aM` command:

```
system1> netstat -aM
Active TCP connections (including servers)
Ctx  Local Address         Remote Address         Swind Send-Q  Rwind Recv-Q State
 lg  *.443                 *.*                        0      0      0      0 LISTEN
 lg  *.22                  *.*                        0      0      0      0 LISTEN
 lg  *.10568               *.*                        0      0      0      0 LISTEN
 lg  *.10569               *.*                        0      0      0      0 LISTEN
 lg  *.10567               *.*                        0      0      0      0 LISTEN
 lg  *.10571               *.*                        0      0      0      0 LISTEN
 lg  *.8514                *.*                        0      0      0      0 LISTEN
 lg  *.514                 *.*                        0      0      0      0 LISTEN
 lg  *.23                  *.*                        0      0      0      0 LISTEN
 lg  *.8023                *.*                        0      0      0      0 LISTEN
 lg  *.4047                *.*                        0      0      0      0 LISTEN
 lg  *.4045                *.*                        0      0      0      0 LISTEN
 lg  *.4046                *.*                        0      0      0      0 LISTEN
 lg  *.2049                *.*                        0      0      0      0 LISTEN
 lg  *.111                 *.*                        0      0      0      0 LISTEN
 lg  *.28073               *.*                        0      0      0      0 LISTEN
 lg  *.32243               *.*                        0      0      0      0 LISTEN
 lg  *.22899               *.*                        0      0      0      0 LISTEN
  1  192.168.1.72.2049     192.168.1.36.800       33952    328  26280      0 ESTABLISHED
 lg  *.2049                *.*                        0      0      0      0 LISTEN

Active UDP sockets (including servers)
Local Address         Remote Address        Send-Q Recv-Q
*.10570               *.*                        0      0
*.69                  *.*                        0      0
*.161                 *.*                        0      0
*.4049                *.*                        0      0
*.4047                *.*                        0      0
*.4045                *.*                        0      0
*.4046                *.*                        0      0
*.2049                *.*                        0      0
*.111                 *.*                        0      0
*.21566               *.*                        0      0
*.520                 *.*                        0      0
```

The following example shows the output of the `netstat -aB` command:

```
netstat -aB
Active TCP connections (including servers)
Local Address         Remote Address         Swind Send-Q  Rwind Recv-Q State
Sent   Rcvd
```

```
localhost-20.1023     localhost-10.671       65535      0   8760      0 ESTABLISHED
0       0
localhost-20.8514     localhost-10.626       66608      1   8760      0 ESTABLISHED
1      44
localhost-20.18576    localhost-10.7951      66608      0   8760      0 ESTABLISHED
9284    606K
*.10568               *.*                        0      0      0      0 LISTEN
0       0
*.10569               *.*                        0      0      0      0 LISTEN
0       0
*.10567               *.*                        0      0      0      0 LISTEN
0       0
*.22                  *.*                        0      0      0      0 LISTEN
0       0
*.443                 *.*                        0      0      0      0 LISTEN
0       0
*.8514                *.*                        0      0      0      0 LISTEN
0       0
*.514                 *.*                        0      0      0      0 LISTEN
0       0
*.23                  *.*                        0      0      0      0 LISTEN
0       0
*.8023                *.*                        0      0      0      0 LISTEN
0       0
*.32243               *.*                        0      0      0      0 LISTEN
0       0
*.22899               *.*                        0      0      0      0 LISTEN
0       0

Active UDP sockets (including servers)
Local Address         Remote Address        Send-Q Recv-Q
*.10570               *.*                        0      0
*.69                  *.*                        0      0
*.161                 *.*                        0      0
```

Viewing or clearing network interface statistics

You can use the `ifstat` command to view the cumulative statistics of packets received and sent on a specified interface or on all interfaces. You can also use the `ifstat` command to clear the statistics.

About this task

- The `ifstat` command displays the cumulative network interface statistics that are gathered either from the time of the last reboot or from the last time you cleared them.
- If you use the `ifstat` command on a storage system that is part of an active/active configuration, the resulting information pertains only to the storage system on which the command was run. The information does not include statistics for the partner node in an active/active configuration.
- In an active/active configuration in takeover mode, the `ifstat` command displays the combined statistics of the packets processed by the network interface on the local node and those on the partner node.

  Because the statistics displayed by the `ifstat` command are cumulative, a giveback does not cause the statistics to zero out.

Step

1. Depending on the statistics that you want to view, perform the following step:

If you want to...	Enter the following command...
View the network interface statistics of all interfaces	**ifstat -a**
View the network interface statistics of a specific interface	**ifstat *interface_name*** *interface_name* is the name of the network interface.
Clear the network interface statistics of a network interface	**ifstat -z *interface_name***

The output of the `ifstat` command depends on the type of interface. For example, Ethernet or Gigabit Ethernet interfaces generate different types of statistics.

Example of showing the network interface statistics before and after clearing them

To view the statistics of the network interface e0a, enter the following command:

ifstat e0a

An output similar to the following is displayed.

```
system1> ifstat e0a

-- interface  e0a  (8 days, 20 hours, 10 minutes, 27 seconds) --

RECEIVE
 Frames/second:      13  | Bytes/second:      800  | Errors/
minute:       0
 Discards/minute:     0  | Total frames:      897k | Total bytes:
62415k
 Total errors:        0  | Total discards:      0  | Multi/
broadcast:   734k
 No buffers:          0  | Non-primary u/c:     0  | Tag
drop:            0
 Vlan tag drop:       0  | Vlan untag drop:     0  | CRC
errors:          0
 Runt frames:         0  | Fragment:            0  | Long
frames:         0
 Jabber:              0  | Alignment errors:    0  | Bus
overruns:        0
 Queue overflows:     0  | Xon:                 0  |
Xoff:                0
 Jumbo:               0  | Reset:               0  |
Reset1:              0
 Reset2:              0
TRANSMIT
 Frames/second:       2  | Bytes/second:      110  | Errors/
minute:       0
 Discards/minute:     0  | Total frames:      153k | Total bytes:
24129k
 Total errors:        0  | Total discards:      0  | Multi/
broadcast:  9478
```

```
 Queue overflows:     0  | No buffers:          0  | Max
collisions:      0
 Single collision:    0  | Multi collisions:    0  | Late
collisions:     0
 Timeout:             0  | Xon:                 0  |
Xoff:                0
 Jumbo:               0
LINK_INFO
 Current state:      up  | Up to downs:         0  |
Auto:               on
 Speed:           1000m  | Duplex:           full  |
Flowcontrol:      none
```

The following command clears and reinitializes the statistics for the network interface e0a:
ifstat -z e0a

The following sample output shows the network interface statistics for the network interface e0a immediately after the statistics are cleared.

```
system1> ifstat e0a

-- interface  e0a  (0 hours, 0 minutes, 8 seconds) --

RECEIVE
 Frames/second:       1  | Bytes/second:       32  | Errors/
minute:       0
 Discards/minute:     0  | Total frames:        7  | Total
bytes:       448
 Total errors:        0  | Total discards:      0  | Multi/
broadcast:     0
 No buffers:          0  | Non-primary u/c:     0  | Tag
drop:          0
 Vlan tag drop:       0  | Vlan untag drop:     0  | CRC
errors:          0
 Runt frames:         0  | Fragment:            0  | Long
frames:         0
 Jabber:              0  | Alignment errors:    0  | Bus
overruns:        0
 Queue overflows:     0  | Xon:                 0  |
Xoff:                0
 Jumbo:               0  | Reset:               0  |
Reset1:              0
 Reset2:              0
TRANSMIT
 Frames/second:       1  | Bytes/second:       17  | Errors/
minute:       0
 Discards/minute:     0  | Total frames:        4  | Total
bytes:       361
 Total errors:        0  | Total discards:      0  | Multi/
broadcast:     0
 Queue overflows:     0  | No buffers:          0  | Max
collisions:      0
 Single collision:    0  | Multi collisions:    0  | Late
collisions:     0
 Timeout:             0  | Xon:                 0  |
Xoff:                0
 Jumbo:               0
```

```
LINK_INFO
 Current state:       up | Up to downs:         0  |
Auto:                  on
 Speed:            1000m | Duplex:            full |
Flowcontrol:       none
```

Related references

Statistics for Gigabit Ethernet controller IV - VI and G20 interfaces on page 183

Statistics for the BGE 10/100/1000 Ethernet interface on page 193

Viewing network interface information with FilerView

You can view network interface statistics, such as MTU size, incoming and outgoing packets on each interface, by using the Network Report in FilerView. You can also view routing information including the routing tables by using the Network Report.

About this task

The Network Report in FilerView provides the same information that you get by running the `netstat -l`, `routed status`, and `netstat -rn` commands.

Step

1. From the list on the left pane, click **Network > Report**.

   The Network Report displays the interface statistics and routing tables.

How routing in Data ONTAP works

You can have Data ONTAP route its own outbound packets to network interfaces. Although your storage system can have multiple network interfaces, it does not function as a router. However, it can route its outbound packets.

Data ONTAP uses two routing mechanisms:

Fast path	Data ONTAP uses this mechanism to route NFS packets over UDP and to route all TCP traffic.
Routing table	To route IP traffic that does not use fast path, Data ONTAP uses the information available in the local routing table. The routing table contains the routes that have been established and are currently in use, as well as the default route specification.

Next topics

What fast path is

Fast path is an alternative routing mechanism to the routing table, in which the responses to incoming network traffic are sent back by using the same interface as the incoming traffic. It provides advantages such as load balancing between multiple network interfaces and improved storage system performance.

Fast path is enabled automatically on your storage system; however, you can disable it.

Note: Fast path is supported over IPv6.

Using fast path provides the following advantages:

- Load balancing between multiple network interfaces on the same subnet.
  Load balancing is achieved by sending responses on the same interface of your storage system that receives the incoming requests.
- Increased storage system performance by skipping routing table lookups.

How fast path works with NFS-over-UDP

NFS-over-UDP traffic uses fast path only when sending a reply to a request. The reply packet is sent out on the same network interface that received the request packet.

For example, a storage system named toaster uses the toaster-e1 interface to send reply packets in response to NFS-over-UDP requests received on the toaster-e1 interface.

How fast path works with TCP

Data ONTAP can use fast path on every TCP packet transmitted except the first SYN packet (if Data ONTAP initiates a connection). The network interface that is used to transmit a packet is the same interface that received the last packet.

For TCP connections, if Data ONTAP detects that using fast path in a network setup is not optimal, fast path is turned off automatically.

How fast path affects Telnet sessions and the ping utility

If fast path is enabled and the default router stops working, you cannot use the `ping` utility to communicate with your storage system. However, the Telnet sessions to your storage system can still be established from a non-local subnet. This happens because the `ping` utility uses routing table lookups.

Fast path not compatible with asymmetric routing

If fast path is enabled on your storage system in an asymmetric network, the destination MAC address of the response packet will be that of the router that forwarded the incoming packet. However, in asymmetric networks, the router that forwards packets to your storage system is not the router that forwards packets sent by the storage system. In such scenarios, you must disable fast path.

Related tasks

Enabling or disabling fast path on page 64

Similarities and differences between fast path over IPv4 and IPv6

Starting with Data ONTAP 7.3.3, fast path is supported over IPv6. Fast path over IPv4 and IPv6 provide improved storage system performance. However, fast path over IPv6 does not provide load balancing between multiple interfaces like IPv4 does.

Similarities between fast path over IPv4 and IPv6

Fast path over IPv4 and IPv6 provide improved system performance because of the following reasons:

- When fast path is enabled, TCP checksum computation is automatically offloaded to the network interfaces.

  Note: Only specific NICs support this functionality.

- Route lookup to the final destination is skipped when fast path is enabled.

Differences between fast path over IPv4 and IPv6

Fast path over IPv4 provides load balancing between multiple network interfaces on the same subnet because responses are sent on the same network interface that receives the incoming requests. IPv4 uses the same source IPv4 address and the source MAC address of the incoming packet in the destination packet.

Fast path over IPv6 does not provide load balancing because it uses the default gateway of the incoming interface as the destination. Fast path over IPv6 always performs an NDP lookup to find the MAC address of the next hop. Therefore, the responses might not be sent on the same interface that receives the request.

How to manage the routing table

You can manage the routing table automatically by using the `routed` daemon, or manually by using the `route` command.

Next topics

What the routed daemon does

The `routed` daemon performs several functions automatically and can be configured to perform several additional functions. The `routed` daemon is enabled by default.

The `routed` daemon performs the following functions by default:

- Deletes redirected routes after a specified period
- Performs router discovery with ICMP Router Discovery Protocol (IRDP)
  This is useful only if there is no static default route.
- Listens for Routing Information Protocol (RIP) packets
- Migrates routes to alternate interfaces when multiple interfaces are available on the same subnet

The `routed` daemon can also be configured to perform the following functions:

- Control RIP and IRDP behavior
- Generate RIP response messages that update a host route on your storage system
- Recognize distant gateways identified in the `/etc/gateways` file

Note: The `routed` daemon supports only IPv4.

For more information about the `routed` daemon, see the na_routed(1) man page.

When the routed daemon should be turned off

In some circumstances, you should turn off the `routed` daemon. For example, you should turn it off if you have multiple interfaces on the same subnet and you want to direct network traffic to specific interfaces.

If you want to direct traffic to specific interfaces, you must turn off the `routed` daemon, because the daemon sees all interfaces on a subnet as equivalent.

You can safely turn off the `routed` daemon if the following conditions are true:

- You do not use RIP or router discovery.
- You have a single router per subnet or a network in which redirects are not sent.
- You can manage your routing table directly.

Note: Unless you have specific routing needs and understand network routing configuration, you are advised to always keep the `routed` daemon on. Turning off the `routed` daemon might cause unexpected routing behavior.

Related tasks

Enabling or disabling the routed daemon from the command-line interface on page 64
Enabling or disabling the routed daemon with FilerView on page 65

How dynamic routing works for IPv6

IPv6 routing table entries are created by default when you enable IPv6. Additional entries are added dynamically in the routing table on receiving Router Advertisement and ICMP redirect messages.

Storage systems populate a default router list and a prefix list, based on the information in the Router Advertisement messages. The default router list is used to select a router for off-link destinations, and the prefix list is used to determine whether a destination address is on-link.

Related tasks

Enabling or disabling IPv6 on page 33

Routing tables in a vFiler unit environment

If you enable the MultiStore license, Data ONTAP disables the `routed` daemon. Therefore, routing tables in a vFiler unit environment must be managed manually with the `route` command.

All vFiler units in an IPspace share a routing table. Therefore, any commands that display or manipulate the routing table apply to all vFiler units in that IPspace.

Circumstances that might alter the routing table

Certain events can cause the routing table to be modified. You should check the routing table after these events occur to be sure that it is still configured as required.

The routing table might be modified in the following circumstances:

- A new interface is configured with the `ifconfig` command and there are no existing entries for the new network number in the routing table.
- You use the `route add` command to add an entry to the routing table.
- Your storage system receives an ICMP/ICMPv6 redirect packet, which notifies the storage system of a better first-hop router for a particular destination.

  Note: Your storage system ignores ICMP/ICMPv6 redirect packets if the `ip.icmp_ignore_redirect.enable` option is turned on.
- Your storage system is rebooted after the default route in the `/etc/rc` file is modified.
- The default route is added to the routing table on receiving an IPv6 Router Advertisement message.

Specifying the default route

The default route entry routes to destinations that are not listed in the routing table. You can specify the default route in Data ONTAP either during initial setup or by modifying the `/etc/rc` file.

About this task

If IPv6 is enabled on your storage system, the default route is automatically generated.

Steps

1. Open the `/etc/rc` file in the root volume by using a text editor.
2. Add the following command to the `/etc/rc` file:

   `route add default` ***`route_IP`***

   `route_IP` is the IP address of the default route

   Example
   The following example shows the default route being set in the `/etc/rc` file by using the `route add` command:

```
hostname sys1
ifconfig e0 192.0.2.21 netmask 255.255.255.0 mediatype 100tx-fd
route add default 192.0.2.1 1
routed on
```

How to enable or disable routing mechanisms

Both the fast path mechanism and the `routed` daemon are enabled by default in Data ONTAP. You can enable or disable these routing mechanisms using the command-line interface or FilerView.

If you disable both fast path and the `routed` daemon, you must configure routing manually.

Next topics

Enabling or disabling fast path on page 64
Enabling or disabling the routed daemon from the command-line interface on page 64
Enabling or disabling the routed daemon with FilerView on page 65

Enabling or disabling fast path

Fast path provides advantages such as load balancing and improved storage system performance. You can enable or disable fast path by using the `options ip.fastpath.enable` command.

Step

1. Enter the following command from the command-line interface:

   `options ip.fastpath.enable {on|off}`

   `on`—Enables fast path

   `off`—Disables fast path

   Note: You can use the `-x` option with the `netstat` command to check if the fast path mechanism is enabled.

Related concepts

What fast path is on page 59

Enabling or disabling the routed daemon from the command-line interface

You can manage the routing table automatically by using the routed daemon. You can turn on or turn off the routed daemon by using the `routed` command.

About this task

You must add the `routed` command to the `/etc/rc` file for the routed daemon behavior to persist across storage system reboots.

Step

1. To enable or disable the routed daemon, enter the following command:

`routed {on|off}`

`on`—Turns on the routed daemon

`off`—Turns off the routed daemon

Related concepts

What the routed daemon does on page 61
When the routed daemon should be turned off on page 62

Related references

The routed daemon on page 211

Enabling or disabling the routed daemon with FilerView

You can use FilerView to turn on or turn off the `routed` daemon.

Steps

1. From the list on the left pane, click **Network > Configure**.
2. Select **Yes** (for on) or **No** (for off) from the Routed Enabled drop-down list.
3. Click **Apply**.

Related concepts

What the routed daemon does on page 61
When the routed daemon should be turned off on page 62

Related references

The routed daemon on page 211

How to view the routing table and default route information

You can view the routing table of the storage system and default route information relating to your route's destinations, their gateways, how much each route is used, and the interface used by each route. Flags showing route status information are also displayed.

Next topics

Viewing the routing table from the command-line interface on page 66
Viewing the default route information from the command-line interface on page 67
Viewing the routing table and routing information by using FilerView on page 68

Viewing the routing table from the command-line interface

You can view information such as default route and the routes for specific destination addresses. If you have enabled the IPv6 option, the routing table displays both the IPv4 and IPv6 information.

Step

1. To view the Data ONTAP routing table, enter one of the following commands:
   - **`netstat -rn`**
   - **`route -s`**

Example for interpreting the routing table

The output of the `netstat -rn` command is as follows:

```
netstat -rn
Routing tables

Internet:
Destination
Gateway                                     Flags
Refs                Use     Interface
default
192.0.2.1                   UGS
3                     21397    e0a
127.0.0.1
127.0.0.1
UH                                 0
0             lo
192.0.2/24                link#11
UC                                 0
0          e0a
192.0.2.1                     0:d0:d3:0:30:0
UHL                              1
0          e0a
192.0.2.23              0:1:30:b8:30:c0
UHL                              0
0             e0a
192.0.2.24              0:1:30:b8:2e:c0
UHL                              0
0             e0a

Internet v6:
Destination      Gateway            Flags     Refs     Use  Interface
default          fe80::21b:2bff:fed7:ec00%e1a UG 0        0  e1a
::1              ::1                UH          0        0  lo
2001:0db8::/64   link#3             UC          0        0  e1a
2001:0db8:b255:4213::/64 link#3                    UC
0        0  e1a
```

```
2001:0db8:b255:4213::1 link#3                                    UHL
0        0  e1a
```

In this example, the destination can be a host 192.0.2.1, a network 192.0.2/24, or the default route. If the destination is a subnet on a network, the network number is followed by a forward slash (/) and a number that describes the network mask for that network.

The IPv6 routing table also has the same network parameters except that the network mask is replaced by the prefix length for that network.

Routing table flags

The following table describes the Flags column in the `netstat -rn` output.

Flag	Description
U	Up—Route is valid
G	Gateway—Route is to a gateway router rather than to a directly connected network or host
H	Host name—Route is to a host rather than to a network, where the destination address is a complete address
R	Reject—Set by ARP when an entry expires (for example, the IP address could not be resolved into a MAC address)
D	Dynamic—Route added by a route redirect or RIP (if routed is enabled)
M	Modified—Route modified by a route redirect
C	Cloning—A new route is cloned from this entry when it is used
L	Link—Link-level information, such as the Ethernet MAC address, is present
S	Static—Route added with the `route` command

Viewing the default route information from the command-line interface

You can view default route information such as whether the `routed` daemon is turned on or off, default route information, and routing protocols. You can view the default route information by using the `routed status` command.

Step

1. Enter the following command:

   `routed status`

   Note: You can also view the default route by using the `netstat -rn` or `route -s` commands.

Example

The output of the `routed status` command is as follows:

```
routed status
RIP snooping is on
Gateway                 Metric  State   Time Last Heard
example-gateway.com        1     ALIVE   Wed Mar 18 13:58:56 IST 2009
0 free gateway entries, 1 used
```

In the `routed status` command output, metric is the route property that is used to determine the preferred route. The route with the lowest metric is the preferred route. You should always use a metric greater than 0 when adding default routes.

Viewing the routing table and routing information by using FilerView

You can view the routing table, routing information, and routing protocols by using FilerView. You can view information such as default route and the routes for specific destination addresses.

Step

1. From the list on the left pane, click **Network > Report**.

   The Routing section of the Network Report shows the default route and protocols in effect, as well as routing tables.

Modifying the routing table

You might want to add or delete routes in your routing table depending on the changes in your network. You can use the `route` command to modify the routing table. You cannot modify the routing table using FilerView.

Step

1. Depending on whether you want to add or delete a route from the routing table, perform the following step:

If you want to...	Enter the following command...
Add a route	**route add *destination* [*gateway metric*]** *destination* is the IP address or host name of the destination for which the route is being added or deleted. *gateway* is the gateway for the specified *destination*. *metric* indicates the number of hops to the *destination*. The value of *metric* should be greater than zero when the route to the destination is through the *gateway*. The value of *metric* is zero when the *destination* is on a directly-attached network.
Delete a route	**route delete *destination* [*gateway metric*]** **Attention:** You must not delete a cloned route (denoted by the C flag) from the routing table; if you do, the network connectivity to that subnet is lost. If you have deleted a cloned route, you must add the route again to the routing table in either of the following ways: • Bring the interface that connects to the particular subnet first to the down state and then to the up state. You can change the state of the interface by using the ifconfig command. • Delete and reconfigure the IP address on the interface that connects to the particular subnet.

For more information about the route command and options, see the na_route(1) man page.

Example

To add a destination with the IP address 192.0.2.25 to the routing table, enter the following command:

```
route add 192.0.2.25 gateway.com 1
```

You can verify that the route to this destination is added to the routing table by using the netstat -rn or route -sn command, as shown in the following output:

```
system1> netstat -rn
Routing tables

Internet:
Destination      Gateway            Flags     Refs     Use  Interface
default          192.0.2.1          UGS          4   184855  e0a
127.0.0.1        127.0.0.1          UH           0        0  lo
192.0.2/24       link#11            UC           2     1238  e0a
192.0.2.1        0:d0:d3:0:30:0     UHL          0       40  e0a
192.0.2.23       0:1:30:b8:30:c0    UHL          1        0  e0a
192.0.2.25       192.0.2.1          UHL          0     1285  lo
```

In this example, the subnet route, 192.0.2, is a cloned route.

Related tasks

Changing the status of an interface on page 50

Related references

Routing table flags on page 67

How to maintain host-name information

Data ONTAP relies on correct resolution of host names to provide basic connectivity for storage systems on the network. If you are unable to access the storage system data or establish sessions, there might be problems with host-name resolution on your storage system or on a name server.

Host-name information can be maintained in one or all of the following ways in Data ONTAP:

- In the `/etc/hosts` file on your storage system's default volume
- On a Domain Name System (DNS) server
- On a Network Information Service (NIS) server

If you use more than one of the resources for host-name resolution, the order in which they are used is determined by the `/etc/nsswitch.conf` file.

Next topics

How the /etc/hosts file works

Data ONTAP uses the `/etc/hosts` file to resolve host names to IP addresses. You need to keep the `/etc/hosts` file up-to-date. Changes to the `/etc/hosts` file take effect immediately.

When Data ONTAP is first installed, the `/etc/hosts` file is automatically created with default entries for the following interfaces:

- localhost
- All interfaces on your storage system

The `/etc/hosts` file resolves the host names for the storage system on which it is configured. This file cannot be used by other systems for name resolution.

For more information about file formats, see the na_hosts(5) man page.

You can add IP address and host name entries in the `/etc/hosts` file in the following two ways:

- Locally—You can add entries by using the command-line interface or FilerView.

- Remotely—If the file has many entries and you have access to an NIS makefile master, you can use the NIS makefile master to create the `/etc/hosts` file. This method prevents errors that might be caused by editing the file manually.

Next topics

Adding a host name in the /etc/hosts file on page 72
Hard limits for the /etc/hosts file on page 73
Editing the /etc/hosts file with FilerView on page 73
Changing the host name of a storage system on page 73

Adding a host name in the /etc/hosts file

You can add the host name and aliases of the storage system in the `/etc/hosts` file. You can use the `setup` command to rewrite the `/etc/hosts` file.

About this task

During setup, if you enable IPv6 on the storage system and configure IPv6 addresses for your network interfaces, these IPv6 addresses are also added to the `/etc/hosts` file.

Step

1. From a workstation that has access to your storage system, edit the `/etc/hosts` file. Add the following line to the `/etc/hosts` file:

   IP_address host_name aliases

   IP_address is the IP address of the host.

   host_name is the name of the host.

   aliases are the alias names for the host.

   #### Example

   To add a host name, myhost, with an IP address 192.0.2.16, add the following line in the `/etc/hosts` file:

   192.0.2.16 myhost newhost myhost-e0a

   newhost and myhost-e0a are the alias names for myhost.

   The following is a sample `/etc/hosts` file:

```
#Auto-generated by setup Tue Apr 21 17:41:40 IST 2009
127.0.0.1 localhost
192.0.2.16         myhost myhost-e0a
# 0.0.0.0       myhost-e0b
# 0.0.0.0       myhost-e0c
# 0.0.0.0       myhost-e0d
```

The following is a sample `/etc/hosts` file in which an IPv6 address is also configured for the interface e0a:

```
#Auto-generated by setup Tue Apr 21 17:41:40 IST 2009
127.0.0.1 localhost
192.0.2.16         myhost myhost-e0a
2001:0db8::95   myhost myhost-e0a
# 0.0.0.0       myhost-e0b
# 0.0.0.0       myhost-e0c
# 0.0.0.0       myhost-e0d
```

Hard limits for the /etc/hosts file

You need to be aware of the hard limits on the line size and number of aliases when you edit the `/etc/hosts` file.

The hard limits are as follows:

- Maximum line size is 1022 characters.
  The line size limit includes the end of line character. You can enter up to 1021 characters per line.
- Maximum number of aliases is 34.

Note: There is no limit on file size.

Editing the /etc/hosts file with FilerView

You can add entries to the local `/etc/hosts` file if the number of entries is small.

Steps

1. In FilerView, click **Network** in the list on the left pane.
2. In the list under Network, click **Manage Hosts File**.
3. Click in the hosts window, then click **Insert**.
4. Complete the fields in the **Create a New /etc/hosts Line** window for each host you want to add and click **OK**.
5. Click **Apply** in the **Manage Hosts File** window.

Changing the host name of a storage system

You can change the host name of a storage system by editing the `/etc/hosts` file, and then using the `hostname` command.

Steps

1. Edit the `/etc/hosts` file to include the new host name of the storage system.

2. Enter the following command to specify a new name for the host:

   hostname ***new_name***

   new_name is the new host name of the storage system.

3. Reboot the storage system.

   Attention: Ensure that you complete both steps before rebooting the storage system. If you skip Step 2 and then reboot the storage system, any manual or scheduled SnapMirror operations might fail. Use the `hostname` command to specify the correct name before any SnapMirror operations are initiated.

How to configure DNS to maintain host information

You can maintain host information centrally using DNS. With DNS, you do not have to update the `/etc/hosts` file every time you add a new host to the network. You can configure your storage system to use one or more DNS servers either during the setup procedure or later.

If you have several storage systems on your network, maintaining host information centrally saves you from updating the `/etc/hosts` file on each storage system every time you add or delete a host.

If you configure DNS during the setup procedure, your storage system's DNS domain name and name server addresses are configured in one of the following ways:

- Automatically if you use Dynamic Host Configuration Protocol (DHCP) to configure onboard interfaces. Automatic configuration is possible only if all the DHCP-configured DNS server addresses are IPv4 addresses.
- Manually if you do not use DHCP—you must enter the values when prompted. A maximum of three name server IP addresses can be specified for a DNS server.

  Note: You can configure IPv4 and IPv6 addresses as DNS server addresses.

If you configure DNS later, you must take the following actions:

- Specify DNS name servers.
- Specify the DNS domain name of your storage system.
- Enable DNS on your storage system.

You can enable DNS and set DNS configuration values in either of the following ways:

- Using FilerView
- Using the command-line interface

If you want to use primarily DNS for host-name resolution, you should specify it ahead of other methods in the hosts section of the `/etc/nsswitch.conf` file.

Correct host-name resolution depends on correctly configuring of the DNS server. If you experience problems with host-name resolution or data availability, check the DNS server in addition to local networking.

For more information about storage system DNS resolution of host names, see the na_dns(1) and na_dns(8) man pages.

Next topics

Configuring DNS from the command-line interface on page 75
How DNS resolves host names on page 76
DNS name caching on page 77
DNS information you can view on page 77

Related concepts

How the /etc/hosts file works on page 71

Configuring DNS from the command-line interface

You can configure your storage system to use one or more DNS servers for host-name resolution. You can configure DNS by first creating or editing the `/etc/resolv.conf` file, then specifying the DNS domain name, and finally enabling DNS through the command-line interface.

Steps

1. Depending on whether you want to create or edit the `/etc/resolv.conf` file, perform the following step:

If you are...	Then...
Creating the `/etc/resolv.conf` file	By using a text editor, create the `/etc/resolv.conf` file in the root volume. The file can consist of up to three lines, each specifying a name server host in the following format. **`nameserver` *`ip_address`*** *`ip_address`* is the IP address of the DNS name server. The IP address can be an IPv4 or an IPv6 address. **Note:** If an IPv6 link-local address is specified as a DNS name server, the address must be appended with `%`*`interface_name`*. The appended *`interface_name`* is the name of the interface on the storage system that is connected to the same link as the specified DNS name server. For example: **`nameserver 2001:0db8:85a3:0:0:8a2e:0370:99`** e0a is the interface on the storage system that is connected to the same link as the DNS name server with the IPv6 address 2001:0db8:85a3:0:0:8a2e:0370:99.

If you are...	Then...
Editing the `/etc/resolv.conf` file	From a workstation that has access to the root volume of your storage system, edit the `/etc/resolv.conf` file using a text editor.

2. Enter the following command to specify the DNS domain name:

   `options dns.domainname` ***`domain`***

   `domain` is the new domain name, which follows the host name of your storage system in the fully qualified domain name.

3. Enter the following command to enable DNS:

   `options dns.enable {on|off}`

   `on`—Enables DNS

   `off`—Disables DNS

Hard limits for the /etc/resolv.conf file

You need to be aware of the hard limits for name servers, domain name, and search domains when you create or edit the `/etc/resolv.conf` file.

The hard limits for the `/etc/resolv.conf` file are as follows:

- Maximum line size is 256.
- Maximum number of name servers is 3.
- Maximum domain name length is 256 characters.
- Maximum search domains limit is 6.

  Note: You should use only tab or space to separate host names in the search domain list.

- Total number of characters for all search domains is 256.

Note: There is no limit on file size.

How DNS resolves host names

DNS uses certain records for resolving a domain name to an IP address. To determine a host name based on the IP address, DNS uses the reverse lookup.

For resolving IPv4 addresses, DNS uses the A record. The A record can store a 32-bit address and can resolve IPv4 addresses. To resolve IPv6 addresses, DNS uses the AAAA record. The AAAA record can store a 128-bit address and can resolve IPv6 addresses.

IPv4 reverse DNS lookups use the `in-addr.arpa` domain. An IPv4 address is represented in the in-addr.arpa domain by a sequence of bytes, represented as decimal numbers, in reverse order. The numbers are separated by dots and end with the suffix `.in-addr.arpa`.

IPv6 reverse DNS lookups use the `ip6.arpa` domain. An IPv6 address is represented as a name in the `ip6.arpa` domain by a sequence of nibbles, represented as hexadecimal digits, in reverse order. These nibbles are separated by dots and end with the suffix `.ip6.arpa`.

The following table shows sample IPv4 and IPv6 addresses and their reverse DNS lookups:

IP address	Reverse lookup domain name
192.0.2.10	10.2.0.192.in-addr.arpa
2001:0db8:85a3:0:0:8a2e:0370:99	9.9.0.0.0.7.3.0.e.2.a.8.0.0.0.0.0.0.0.0.3.a.5.8.8.b.d. 0.1.0.0.2.ip6.arpa

DNS name caching

DNS name caching speeds up the process whereby the DNS name resolver converts host names into IP addresses. The DNS name cache stores DNS requests so that they can be easily and quickly found when needed. DNS name caching is enabled by default.

Name caching improves DNS performance during a name server failover and reduces the time needed for an active/active configuration takeover and giveback.

You can disable DNS name caching by using the `dns.cache.enable` option, but doing so might have an adverse performance impact. The `dns flush` command removes all entries from the DNS name cache. However, the command has no effect if DNS name caching is not enabled.

For more information about the `dns flush` command and the `dns.cache.enable` option, see the na_ dns(1) man page.

DNS information you can view

You can view information about whether DNS and DNS name caching are enabled, configured name servers, state of these name servers (whether up or down), configured DNS domain name, DNS name cache statistics, and performance statistics for each name server.

The `dns info` command displays the status of the DNS resolver. If DNS is enabled, the command displays the following information:

- Whether DNS is enabled
- Whether DNS name caching is enabled
- Caching statistics
  - Cache hits: Number of DNS requests that were found in the cache
  - Cache misses: Number of DNS requests that were not found in the cache and that required a DNS query to the name server
  - Cache entries: Number of entries currently in the DNS name cache
  - Expired cache entries
  - Number of cache replacements
- Details about each name server that was polled by your storage system:

  - IP address of the DNS server
  - State of the name server, displayed as "UP," "DOWN," or "NO INFO"
  - Date of the last DNS request to that name server
  - Average time in milliseconds for a DNS query
  - Number of DNS queries made
  - Number of DNS queries that resulted in errors
- Default DNS domain name of the storage system
- Search domains of the storage system

The search domains are domain suffixes that are used to convert unqualified domain names into fully qualified domain names (FQDN). The search domains are read from the `/etc/resolv.conf` file.

For more information about the `dns info` command and the resulting display, see the na_ dns(1) man page.

How to use dynamic DNS to update host information

You can use dynamic DNS updates to prevent errors and save time when sending new or changed DNS information to the primary master DNS server for your storage system's zone. Dynamic DNS allows your storage system to automatically send information to the DNS servers as soon as the information changes on the system.

Without dynamic DNS updates, you must manually add DNS information (DNS name and IP address) to the identified DNS servers when a new system is brought online or when existing DNS information changes. This process is slow and error-prone. During disaster recovery, manual configuration can result in a long downtime.

For example, if you want to change the IP address on interface e0 of *`storagesystem1`*, you can simply configure e0 with the new IP address. The storage system *`storagesystem1`* automatically sends its updated information to the primary master DNS server.

Note: Data ONTAP supports a maximum of 64 Dynamic Domain Name Server (DDNS) aliases.

Next topics

How dynamic DNS updates work in Data ONTAP on page 79
Support for dynamic DNS updates in Data ONTAP on page 79
Enabling or disabling dynamic DNS updates on page 80
Disabling the transmission of DNS updates for an IP address on page 80
Changing the time-to-live setting for DNS entries on page 81

How dynamic DNS updates work in Data ONTAP

If dynamic DNS updates are enabled on your storage system, Data ONTAP periodically sends updates to the primary master DNS server for its zone. Updates are also sent if any DNS information changes on your system.

Your storage system finds the primary master DNS server for its zone by querying the DNS servers configured in your storage system's `/etc/resolv.conf` file. The primary master DNS server might be different from the ones configured in your storage system's `/etc/resolv.conf` file.

By default, periodic updates are sent every 12 hours. A time-to-live (TTL) value is assigned to every DNS update sent from your storage system. The TTL value defines the time for which a DNS entry is valid on the DNS server. By default, the TTL value is set to 24 hours, and you can change it.

When your storage system sends an update to the DNS server, it waits up to five minutes to receive an acknowledgement of the update from the server. If it does not receive an acknowledgement, the storage system sends the update again. This time, the storage system doubles the waiting interval (to 10 minutes), before sending the update. The storage system continues to double the waiting interval with each retry until a waiting interval of 160 minutes or TTL/2, whichever is less, is reached.

Support for dynamic DNS updates in Data ONTAP

When you use dynamic DNS updates in Data ONTAP, you must be aware of certain conditions, such as the types of systems and network interfaces that support dynamic DNS, secure updates, and behavior of vFiler units with dynamic DNS.

The following conditions apply to dynamic DNS updates:

- By default, dynamic DNS updates are disabled in Data ONTAP.
- Dynamic DNS updates are supported on UNIX and Windows systems.
- On Windows DNS servers, secure dynamic DNS updates can be used to prevent malicious updates on the DNS servers. Kerberos is used to authenticate updates.

  Even if secure dynamic DNS updates are enabled, your storage system initially tries sending updates in clear text. If the DNS server is configured to accept only secure updates, the updates sent in clear text are rejected. Upon rejection, the storage system sends secure DNS updates.
- For secure dynamic DNS updates, your storage system must have CIFS running and must be using Windows Domain authentication.
- Dynamic DNS updates can be sent for the following:
  - Physical interfaces
  - vif and VLAN interfaces
  - vFiler units
- You cannot set TTL values for individual vFiler units. All vFiler units inherit the TTL value that is set for vfiler0, which is the default vFiler unit and is the same as the physical storage system.
- DHCP addresses cannot be dynamically updated.
- In a takeover situation, the hosting storage system is responsible for sending DNS updates for IP addresses for which it is responding.

- For both manual and autoconfigured global IPv6 unicast addresses, the dynamic DNS update is sent after Duplicate Address Detection is performed. For IPv6 addresses of any other type and scope, your storage system does not send any dynamic DNS update.

Enabling or disabling dynamic DNS updates

Dynamic DNS allows your storage system to automatically send information to the DNS servers as soon as the information changes on the system. By default, dynamic DNS is disabled on the storage system. You can enable dynamic DNS on your storage system by using the `options dns.update.enable` command.

Step

1. Enter the following command:

   `options dns.update.enable {on|off|secure}`

   `on`—Enables dynamic DNS updates

   `off`—Disables dynamic DNS updates

   `secure`—Enables secure dynamic DNS updates

   Note: Secure dynamic DNS updates are supported for Windows DNS servers only.

Disabling the transmission of DNS updates for an IP address

You can disable the transmission of dynamic DNS updates for an IP address by using the `ifconfig` command.

About this task

You should not disable dynamic DNS updates for an interface that is part of a vif.

You can also disable dynamic DNS updates for an IPv6 address.

Step

1. Enter the following command:

   `ifconfig` ***`interface_name`*** **`no_ddns`** ***`IP_address`***

   `interface_name` is the name of the interface.

   `IP_address` is the IP address of the interface.

   Example

   Use the following command to ensure that dynamic DNS updates are not sent from the interface e0a:

   `ifconfig e0a no_ddns 192.0.2.30`

The following output shows the output of the `ifconfig` command after the dynamic DNS is disabled for the interface:

```
ifconfig e0a
e0a: flags=0x2d48867<UP,BROADCAST,RUNNING,MULTICAST,TCPCKSUM> mtu 1500
inet 192.0.2.30 netmask 0xff000000 broadcast 10.255.255.255 noddns
ether 00:a0:98:07:66:02 (auto-1000t-fd-up) flowcontrol full
```

The `ifconfig` command output shows the "noddns" keyword that indicates that dynamic DNS updates are disabled for this IP address.

Changing the time-to-live setting for DNS entries

You can change the time-to-live setting for DNS entries by using the `options dns.update.ttl` command.

Step

1. Enter the following command:

   `options dns.update.ttl` ***`time`***

   `time` can be set in seconds (**`s`**), minutes (**`m`**), or hours (**`h`**), with a minimum value of 600 seconds and a maximum value of 24 hours.

   Example

   To set the TTL to two hours, enter the following command:

   `options dns.update.ttl 2h`

Related concepts

How dynamic DNS updates work in Data ONTAP on page 79

How to use NIS to maintain host information

NIS enables you to centrally maintain host information. In addition, NIS enables you to maintain user information.

NIS provides the following methods for resolving the storage system's host name:

- Using the `/etc/hosts` file on the NIS server
  You can download the `/etc/hosts` file on the NIS server o your storage system's default volume for local host-name lookup.
- Using a hosts map that is maintained as a database on the NIS server
  The storage system uses the hosts map to query during a host lookup request across the network.
- Using the ipnodes map that is maintained as a database on the NIS server
  The ipnodes map is used for host lookup when IPv6 is enabled on your storage system.

  Note: The ipnodes database is supported only on Solaris NIS servers. To resolve a host name to an address, your storage system (with IPv6 enabled) first looks in the ipnodes database. If

the IP address is not present in the ipnodes database, the application looks in the hosts database. However, if IPv6 is not enabled, then your storage system looks only in the hosts database and does not refer the ipnodes database.

Next topics

How using NIS slaves can improve performance on page 82
How an NIS master is selected on page 83
Creating /etc/hosts from the NIS master on page 83
Guidelines for using NIS slaves on page 83
NIS administrative commands on page 84

How using NIS slaves can improve performance

Host-name resolution by using a hosts map can have a performance impact because each query for the hosts map is sent across the network to the NIS server. You can improve the performance of your storage system by downloading the maps and listening for updates from the NIS master server.

The NIS slave improves performance by establishing contact with an NIS master server and performing the following two tasks:

- Downloading the maps from the NIS master server
  You can download the maps from the NIS master server to the NIS slave by running the `yppush` command from the NIS server. You can also download the maps by disabling and then enabling the NIS slave from your storage system. After the maps are downloaded, they are stored in the `/etc/yp/nis_domain_name` directory. The NIS slave then services all the NIS requests from your storage system by using these maps. The NIS slave checks the NIS master every 45 minutes for any changes to the maps. If there are changes, they are downloaded.
- Listening for updates from the NIS master
  When the maps on the NIS master are changed, the NIS master administrator can optionally notify all slaves. Therefore, in addition to periodically checking for updates from the NIS master, the NIS slave also listens for updates from the master.

You cannot configure the NIS slave during the setup procedure. To configure the NIS slave after the setup procedure is complete, you need to enable NIS slave by setting `options nis.slave.enable` to `on`.

Note: The NIS slave does not respond to remote NIS client requests and therefore cannot be used by other NIS clients for name lookups.

Related concepts

Guidelines for using NIS slaves on page 83

Related tasks

Enabling an NIS slave on your storage system on page 87

How an NIS master is selected

If you enable the NIS slave on your storage system, the NIS servers listed with the `nis.servers` option are contacted to determine the master NIS server.

The NIS master can be different from the servers that are listed with the `nis.servers` option. In such a case, the servers listed with the `nis.servers` option inform the slave about the master server.

The NIS slave on your storage system can contact the master only if any one of the following conditions is true:

- The NIS server has an entry in the ipnodes map for the master.
- The NIS server has an entry in the hosts map for the master.
- The `/etc/hosts` file on your storage system is able to resolve the IP address of the master.

Creating /etc/hosts from the NIS master

You can create a host file remotely and modify the NIS master to install the host file in the `/etc` directory. This method is useful if you have many entries in your host file.

Steps

1. On the NIS server, open the NIS Makefile with a text editor.
2. Locate the section for `hosts.time`.
3. Add the following lines at the end of the `hosts.time` section, replacing *`dirname`* with a directory name of your choice, and *`toaster 1`*, *`toaster2`*, and so on with names of the storage systems:

   ```
   @mntdir=/tmp/dirname_etc_mnt_$$$$;\ if [ ! -d $$mntdir ]; then rm -f $
   $mntdir; \ mkdir $$mntdir; fi;\ for s_system in toaster1 toaster2
   toaster3 ; do \ mount $$s_system:/etc $$mntdir;\ mv $$mntdir/hosts $
   $mntdir/hosts.bak;\ cp /etc/hosts $$mntdir/hosts;\ umount $$mntdir;\
   done;\ rmdir $$mntdir
   ```

4. Save the NIS Makefile.

   The `/etc/hosts` file on your storage system is updated whenever the NIS Makefile is run.

Related concepts

How the /etc/hosts file works on page 71

Guidelines for using NIS slaves

When using an NIS slave, you should follow certain guidelines, such as the available space in the storage system, conditions for enabling DNS, and supported configurations.

The following guidelines apply when using the NIS slave:

- The root volume of your storage system must have sufficient space to download maps for the NIS slave. Typically, the space required in the root volume is same as the size of the maps on the NIS server.
- If the root volume does not have enough space to download maps, the following occurs:
  - An error message is displayed informing you that the space on the disk is not sufficient to download or update the maps from the NIS master.
  - If the maps cannot be downloaded, the NIS slave is disabled. Your storage system switches to using hosts map on the NIS server for name resolution.
  - If the maps cannot be updated, your storage system continues to use the old maps.
- If the NIS master server was started with the `-d` option or if the `hosts.byname` and `hosts.byaddr` maps are generated with the `-b` option, your storage system must have DNS enabled, DNS servers must be configured, and the hosts entry in the `/etc/nsswitch.conf` file must contain DNS as an option to use for host name lookup.

If you have your NIS server configured to perform host name lookups using DNS, or if you use DNS to resolve names that cannot be first resolved using the `hosts.by*` maps, using the NIS slave causes those lookups to fail. This is because when the NIS slave is used, all lookups are performed locally using the downloaded maps. However, if you configure DNS on your storage system, the lookups succeed.

You can use the NIS slave for the following:

- Vifs and VLAN interfaces
- vFiler units
- Active/active configurations

  Note: In an active/active configuration, you should ensure that the `nis.servers` options value is the same on both nodes and that the `/etc/hosts` file on both nodes can resolve the name of the NIS master server.

Related concepts

How using NIS slaves can improve performance on page 82

NIS administrative commands

You can use the NIS administrative commands to view the NIS server information.

Data ONTAP supports the standard NIS administrative commands listed in the following table. For more information, see each command's man page.

Command	Function
`ypcat`	Prints an entire NIS map.
`ypgroup`	Displays the NIS group cache entries.
`ypmatch`	Looks up specific entries in an NIS map.

Command	Function
`ypwhich`	Returns the name of the current NIS server.

How to configure NIS with Data ONTAP interfaces

You can configure your storage system to use one or more NIS servers either during the setup procedure or later using the Data ONTAP command-line interface or FilerView.

If you want to use NIS primarily for host-name resolution, specify it ahead of other methods in the hosts map in the `/etc/nsswitch.conf` file.

To configure NIS, you need to do all of the following:

- Specify the NIS server to which your storage system should bind.
- Specify the NIS domain name of your storage system.
- Enable NIS on your storage system.

Correct host-name resolution depends on correctly configuring the NIS server. If you experience problems with host-name resolution or data availability, check the NIS server in addition to local networking.

For more information about your NIS client, see the na_nis(1) and na_nis(8) man pages.

Next topics

Enabling or disabling NIS using the command-line interface on page 85
Specifying the NIS domain name on page 86
Specifying NIS servers to bind to your storage system on page 86
Enabling an NIS slave on your storage system on page 87

Enabling or disabling NIS using the command-line interface

You can enable or disable NIS on your storage system for host-name resolution.

Step

1. Enter the following command:

   `options nis.enable {on|off}`

   `on`—Enables NIS

   `off`—Disables NIS

Specifying the NIS domain name

You can specify the NIS domain name to which your storage system belongs.

Step

1. Enter the following command:

   options nis.domainname *domain*

   domain is the NIS domain name to which your storage system belongs. For example, typical NIS domain names might be `sales` or `marketing`. The NIS domain name is usually not the same as the DNS domain name.

Specifying NIS servers to bind to your storage system

You can specify an ordered list of NIS servers to which you want your storage system to bind. The list should begin with the closest NIS server (closest in network terms) and end with the farthest one.

About this task

Keep the following in mind before performing the binding procedure:

- Using the NIS broadcast feature can incur security risks.
- You can specify NIS servers by IP address or host name. If host names are used, ensure that each host name and its IP address are listed in the `/etc/hosts` file of your storage system. Otherwise, the binding with the host name fails.
- You can only specify IPv4 addresses or server names that resolve to IPv4 addresses by using the `/etc/hosts` file on your storage system.

Step

1. Enter the following command to specify the NIS servers and their order:

   options nis.servers *ip_address, server_name,*[*]

   The asterisk (*) specifies that broadcast (for IPv4) and multicast (for IPv6) is used to bind to NIS servers if the servers in the list are not responding. The '*' is the default value. If you do not specify the broadcast or multicast option, and none of the listed servers is responding, NIS services are disrupted until one of the preferred servers responds.

Example

The following command lists two servers and uses the default broadcast (multicast for IPv6) option:

```
options nis.servers 192.0.2.1,nisserver-1,*
```

Your storage system first tries to bind to 192.0.2.1. If the binding fails, the storage system tries to bind to nisserver-1. If this binding also fails, the storage system binds to any server that

responds to the broadcast or multicast. However, the storage system continues to poll the preferred servers. When one of the preferred server is found, the storage system binds to the preferred server.

The following command lists an NIS server with an IPv6 address and uses the default multicast option:

```
options nis.servers 2001:0db8:85a3:0:0:8a2e:0370:99,*
```

Related concepts

How an NIS master is selected on page 83

Enabling an NIS slave on your storage system

You can enable an NIS slave on your storage system to reduce traffic over your network.

About this task

If you enable IPv6 on your storage system, your storage system can have multiple addresses configured for it in the host-name database. These addresses appear in the host-name lookup, depending on the following conditions:

- If you disable the NIS slave, you can obtain all the addresses from either the hosts database or the ipnodes database in the NIS server.
- If you disable the NIS slave, your storage system reverts to the original configuration, in which it contacts an NIS server to resolve host names.
- If you enable the NIS slave, only the last address from the list of addresses available in the `/etc/hosts` file is stored for a host name in the host database downloaded to your system.
- If you enable the NIS slave, a maximum of three addresses are stored for a host name in the ipnodes database downloaded to your system. At least one address from each address family is stored.

Step

1. To enable or disable an NIS slave on your storage system, enter the following command:

   ```
   options nis.slave.enable {on|off}
   ```

Related concepts

How using NIS slaves can improve performance on page 82
Guidelines for using NIS slaves on page 83

What NIS information you can view

You can view information about NIS master and slave servers, netgroup caches, and performance statistics.

The `nis info` command displays the following types of NIS information:

- NIS domain name
- Last time the local group cache was updated
- Information about each NIS server that was polled by your storage system:
  - IP address of the NIS server
  - Type of NIS server
  - State of the NIS server
  - Whether your storage system is bound to the NIS server
  - Time of polling
- Information about the NIS netgroup cache:
  - Status of the cache
  - Status of the "*.*" entry in the cache
  - Status of the "*.nisdomain" entry in the cache
- Whether an NIS slave is enabled
- NIS master server
- Last time the NIS map was checked by the NIS slave
- NIS performance statistics:
  - Number of YP lookup network retransmission
  - Total time spent in YP lookups
  - Number of network retransmission
  - Minimum time spent in a YP lookup
  - Maximum time spent in a YP lookup
  - Average time spent in a YP lookup
- Response statistics for the three most recent YP lookups

For more information about the `nis info` command and resulting display, see the na_nis(1) man page.

Viewing NIS performance statistics

You can use the `nis info` command to view NIS performance statistics for your storage system.

Step

1. Enter the following command to view NIS information:

`nis info`

Example

The following example shows the statistics provided by the `nis info` command.

```
system1*> nis info
NIS domain is lab.example.com
    NIS group cache has been disabled

     IP Address    Type State Bound   Last Polled
Client
calls Became Active
-------------------------------------------------------------------
-----------------------------
    192.0.2.12 PREF ALIVE YES     Mon Jan 23 23:11:14
GMT 2008 0 Fri Jan 20 22:25:47 GMT 2008

                   NIS Performance Statistics:
                Number of YP Lookups: 153
                Total time spent in YP Lookups: 684 ms, 656 us
                Number of network re-transmissions: 0
                Minimum time spent in a YP Lookup: 0 ms, 1 us
                Maximum time spent in a YP Lookup: 469 ms, 991 us
                Average time spent in YP Lookups: 4 ms, 474 us

                   3 Most Recent Lookups:
               [0] Lookup time: 0 ms, 1 us Number of network re-
transmissions: 0
               [1] Lookup time: 5 ms, 993 us Number of network re-
transmissions: 0
               [2] Lookup time: 0 ms, 1 us Number of network re-
transmissions: 0
NIS netgroup (*.* and *.nisdomain) cache status:
uninitialized
         *.* eCode: 0
         *.nisdomain eCode: 0
   NIS Slave disabled
```

Configuring DNS and NIS with FilerView

You can configure DNS and NIS for host-name resolution by using FilerView. You can also configure the host-name service configuration file (`/etc/nsswitch.conf`) with FilerView.

Steps

1. Click **Network** in the list on the left pane.
2. In the list under Network, click **Configure Host Name Resolution (DNS & NIS)**.

   The **Host Name Resolution Policy Wizard** is displayed.

3. Click **Next** and complete the steps in the **Host Name Resolution Policy Wizard** to set or modify the DNS and NIS configuration values.

   You can perform the following tasks by using the **Host Name Resolution Policy Wizard**:

   - Enable DNS and NIS
   - Enter a DNS domain name
   - Specify the dynamic DNS update interval
   - Enable dynamic DNS
   - Use DNS cache
   - Specify IP addresses of DNS servers (maximum of three IP addresses)
   - Specify the domain search list
   - Specify a NIS domain name
   - Specify NIS servers
   - Enable NIS domain search
   - Enable NIS slave
   - Enable local caching of NIS group files
   - Specify the schedule to update the local cache of NIS group files
   - Define the search order for hosts, password, shadow, group, and netgroup information

Related concepts

How to configure DNS to maintain host information on page 74
DNS name caching on page 77
How to use dynamic DNS to update host information on page 78
How to configure NIS with Data ONTAP interfaces on page 85
Guidelines for using NIS slaves on page 83
How to change the host-name search order on page 90

How to change the host-name search order

If you use more than one method for host-name resolution, you must specify the order in which each name resolution service is used. This order is specified in the `/etc/nsswitch.conf` file in your storage system's root volume. You can change this order at any time.

Data ONTAP creates a default `/etc/nsswitch.conf` file when you run the `setup` command on your storage system. The contents of the default file are as follows:

```
hosts: files nis dns

passwd: files nis ldap

netgroup: files nis ldap

group: files nis ldap
```

```
shadow: files nis
```

Note: Only the hosts entry in the `/etc/nsswitch.conf` file pertains to host-name resolution. For information about other entries, see the *Data ONTAP System Administration Guide* and the na_nsswitch.conf(5) man page.

By default, the host information is searched in the following order:

- `/etc/hosts` file
- NIS
- DNS

You can change the host-name resolution order in either of the following ways:

- By using FilerView
- By editing the `/etc/nsswitch.conf` file

Next topics

Changing the host-name search order with FilerView on page 91
Changing the host-name search order on page 91

Changing the host-name search order with FilerView

You can use FilerView to change the order in which Data ONTAP searches for host information.

Steps

1. From the list on the left pane, click **Network**.
2. In the list under Network, click **Manage DNS** and **NIS Name Service**.
3. In the Name Service section, select the desired values from the **Hosts** drop-down list.

Changing the host-name search order

You can change the order in which Data ONTAP searches for host information by editing the `/etc/nsswitch.conf` file.

Steps

1. If the `/etc/nsswitch.conf` file does not exist in the root volume of the storage system, create it.
2. Edit the file, entering each line in the following format:

   `hosts:` ***`service`***

   `service` is one or more of the following: `files`, `dns`, `nis`.

3. Save the file.

Example

To change the resolution order to use NIS exclusively, change the hosts line to read as follows:

```
hosts: nis
```

How VLANs work

VLANs provide logical segmentation of networks by creating separate broadcast domains. A VLAN can span multiple physical network segments. The end-stations belonging to a VLAN are related by function or application.

For example, end-stations in a VLAN might be grouped by departments, such as engineering and accounting, or by projects, such as release1 and release2. Because physical proximity of the end-stations is not essential in a VLAN, you can disperse the end-stations geographically and still contain the broadcast domain in a switched network.

Next topics

VLAN membership

An end-station must become a member of a VLAN before it can share the broadcast domain with other end-stations on that VLAN. The switch ports can be configured to belong to one or more VLANs (static registration), or end-stations can register their VLAN membership dynamically, with VLAN-aware switches.

VLAN membership can be based on one of the following:

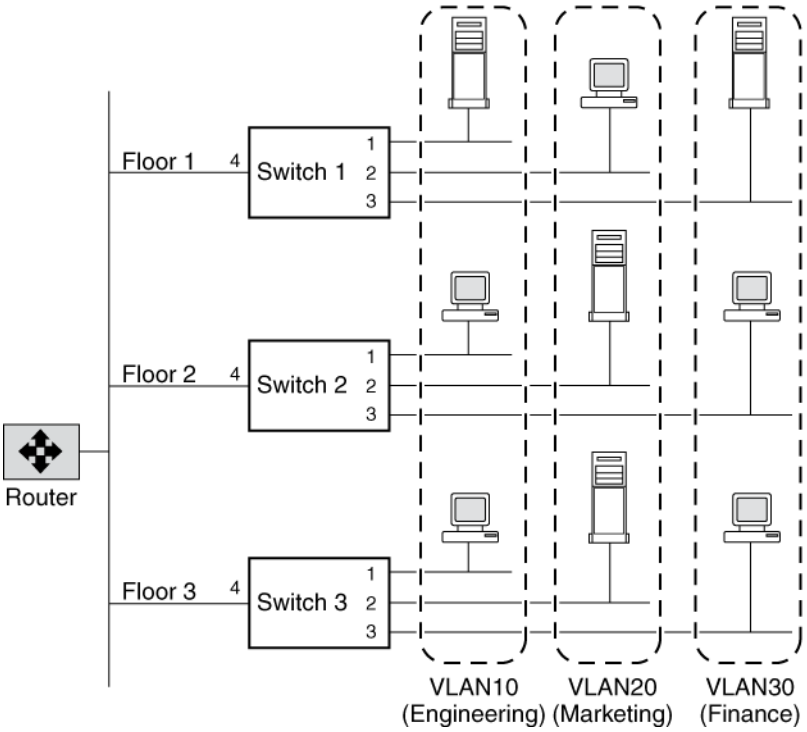
- Switch ports
- End-station MAC addresses
- Protocol

In Data ONTAP, VLAN membership is based on switch ports. With port-based VLANs, ports on the same or different switches can be grouped to create a VLAN. As a result, multiple VLANs can exist on a single switch.

How VLAN membership affects communication

Any broadcast or multicast packets originating from a member of a VLAN are confined only among the members of that VLAN. Communication between VLANs, therefore, must go through a router.

The following figure illustrates how communication occurs between geographically dispersed VLAN members.



In this figure, VLAN 10 (Engineering), VLAN 20 (Marketing), and VLAN 30 (Finance) span three floors of a building. If a member of VLAN 10 on Floor 1 wants to communicate with a member of VLAN 10 on Floor 3, the communication occurs without going through the router, and packet flooding is limited to port 1 of Switch 2 and Switch 3 even if the destination MAC address to Switch 2 and Switch 3 is not known.

Related concepts

VLAN membership on page 93

GARP VLAN Registration Protocol

GARP VLAN Registration Protocol (GVRP) uses Generic Attribute Registration Protocol (GARP) to allow end-stations on a network to *dynamically* register their VLAN membership with GVRP-aware switches. Similarly, these switches dynamically register with other GVRP-aware switches on the network, thus creating a VLAN topology across the network.

GVRP provides dynamic registration of VLAN membership; therefore, members can be added or removed from a VLAN at any time, saving the overhead of maintaining static VLAN configuration on switch ports. Additionally, VLAN membership information stays current, limiting the broadcast domain of a VLAN only to the active members of that VLAN.

For more information about GVRP and GARP, see IEEE 802.1Q and IEEE 802.1p (incorporated in the 802.1D:1998 edition).

GVRP configuration for VLAN interfaces

By default, GVRP is disabled on all VLAN interfaces in Data ONTAP; however, you can enable it.

After you enable GVRP on an interface, the VLAN interface informs the connecting switch about the VLANs it supports. This information (dynamic registration) is updated periodically. This information is also sent every time an interface comes up after being in the down state or whenever there is a change in the VLAN configuration of the interface.

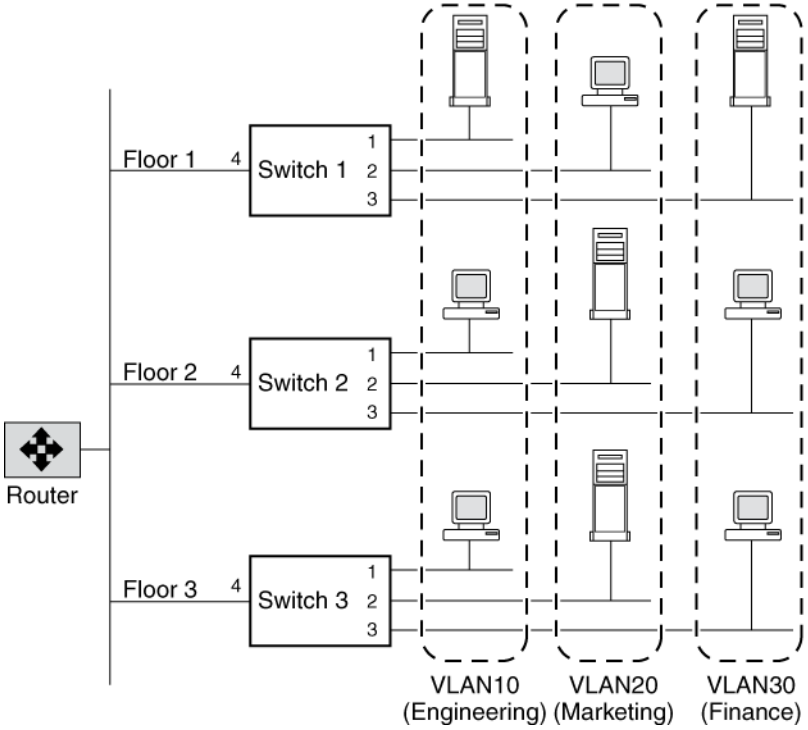
Related tasks

Enabling or disabling GVRP on your VLAN interface on page 103

VLAN tags

A VLAN tag is a unique identifier that indicates the VLAN to which a frame belongs. Generally, a VLAN tag is included in the header of every frame sent by an end-station on a VLAN.

On receiving a tagged frame, the switch inspects the frame header and, based on the VLAN tag, identifies the VLAN. The switch then forwards the frame to the destination in the identified VLAN. If the destination MAC address is unknown, the switch limits the flooding of the frame to ports that belong to the identified VLAN.



For example, in this figure, if a member of VLAN 10 on Floor 1 sends a frame for a member of VLAN 10 on Floor 2, Switch 1 inspects the frame header for the VLAN tag (to determine the VLAN) and the destination MAC address. The destination MAC address is not known to Switch 1. Therefore, the switch forwards the frame to all other ports that belong to VLAN 10, that is, port 4 of Switch 2 and Switch 3. Similarly, Switch 2 and Switch 3 inspect the frame header. If the destination MAC address on VLAN 10 is known to either switch, that switch forwards the frame to the destination. The end-station on Floor 2 then receives the frame.

Advantages of VLANs

VLANs provide a number of advantages such as ease of administration, confinement of broadcast domains, reduced network traffic, and enforcement of security policies.

VLANs provide the following advantages:

- Ease of administration

  VLANs enable logical grouping of end-stations that are physically dispersed on a network. When users on a VLAN move to a new physical location but continue to perform the same job function, the end-stations of those users do not need to be reconfigured. Similarly, if users change their job

function, they need not physically move: changing the VLAN membership of the end-stations to that of the new team makes the users' end-stations local to the resources of the new team.

- Confinement of broadcast domains

  VLANs reduce the need to have routers deployed on a network to contain broadcast traffic. Flooding of a packet is limited to the switch ports that belong to a VLAN.
- Reduction in network traffic

  Confinement of broadcast domains on a network significantly reduces traffic.
- Enforcement of security policies

  By confining the broadcast domains, end-stations on a VLAN are prevented from listening to or receiving broadcasts not intended for them. Moreover, if a router is not connected between the VLANs, the end-stations of a VLAN cannot communicate with the end-stations of the other VLANs.

Prerequisites for setting up VLANs

You must meet certain prerequisites for switches and end-stations before you can set up VLANs in a network.

The following are the prerequisites for setting up VLANs:

- The switches deployed in the network either must comply with IEEE 802.1Q standards or must have a vendor-specific implementation of VLANs.
- For an end-station to support multiple VLANs, it must be able to dynamically register (using GVRP) or must be statically configured to belong to one or more VLANs.

Guidelines for setting up VLANs in Data ONTAP

VLANs in Data ONTAP are implemented in compliance with the IEEE 802.1Q standard.

You should keep these guidelines in mind when setting up VLANs in Data ONTAP:

- You cannot set up VLANs using the `setup` procedure.

  You must use the command-line interface or FilerView to create, change, or delete VLANs.
- You must add the commands to create VLANs on the storage system to the `/etc/rc` file to make the VLANs persistent across reboots.
- You can create any number of VLANs on a NIC (supporting IEEE 802.1Q) on the storage system.

  However, Data ONTAP imposes a limit on the number of interfaces (including physical, vif, VLAN, vh, and loopback interfaces) per storage system.
- You can create VLANs on physical interfaces and vifs.
- You can configure IPv4 and IPv6 addresses on a VLAN interface.

- You can use VLANs to support packets of different Maximum Transmission Unit (MTU) sizes on the same network interface.

  If a network interface is a member of multiple VLANs, you can specify different MTU sizes for individual VLANs.
- You can assign an identification number from 1 to 4094 to a VLAN.
- You must ensure that the interface on your storage system is also a member of its partner's VLANs in an active/active configuration.
- You cannot configure any parameters except `mediatype` for the physical network interface configured to handle VLANs.

Related concepts

Maximum number of network interfaces on page 25

The vlan command syntax

You can use the `vlan` command to create, add interfaces to, delete, modify, and view the statistics of a VLAN.

The following table gives the syntax of the `vlan` command:

Command	Description
`vlan create [-g {on|off}] ifname vlanid_list`	Create a VLAN
`vlan add ifname vlanid_list`	Add an interface to a VLAN
`vlan delete -q ifname [vlanid_list]`	Delete an interface from a VLAN
`vlan modify -g {on|off} ifname`	Enable or disable GVRP on VLAN interfaces
`vlan stat ifname [vlanid_list]`	View the statistics of the network interfaces of a VLAN

For more information about the `vlan` command, see the na_vlan(1) man page.

Note: The VLANs created or changed using the `vlan` command are not persistent across reboots unless the `vlan` commands are added to the `/etc/rc` file.

Creating a VLAN

You can create a VLAN for ease of administration, confinement of broadcast domains, reduced network traffic, and enforcement of security policies. You can use the `vlan create` command to

include an interface in one or more VLANs as specified by the VLAN identifier, enable VLAN tagging, and optionally enable GVRP.

About this task

- By default, GVRP is disabled on VLAN interfaces created by using the `vlan create` command; however, you can enable it with the `-g` option of the `vlan create` command.
- VLANs created by using the `vlan create` command are not persistent across reboots unless the `vlan` commands are added to the `/etc/rc` file.
- A VLAN name should not exceed 15 characters. A VLAN is named by combining the base interface name (physical or vif) and the VLAN identifier. If the resulting VLAN name exceeds 15 characters, the base interface name is truncated and appended to the VLAN identifier with a hyphen (-) in between.
- You should be aware of the limit on the interface name when making an entry in the `/etc/rc` file.

Step

1. Enter the following command:

   `vlan create [-g {on|off}] *ifname vlanid*`

   `-g` enables (`on`) or disables (`off`) GVRP on an interface. By default, GVRP is disabled on the interface.

   `ifname` is the name of the network interface.

   `vlanid` is the VLAN identifier to which the *`ifname`* interface belongs. You can include a list of VLAN identifiers.

Example: Creating and naming of VLAN interfaces

Create VLANs with identifiers 10, 20, and 30 on the interface e4 of a storage system by using the following command:

`vlan create e4 10 20 30`

As a result, VLAN interfaces e4-10, e4-20, and e4-30 are created. The `ifconfig` command output displays e4 as a VLAN interface as follows:

```
ifconfig -a
e0a: flags=0x80e08866<BROADCAST,RUNNING,MULTICAST,VLAN> mtu 1500
ether 00:0c:29:56:54:7e (auto-1000t-fd-up) flowcontrol full
```

The following example displays the truncation of the base interface name when creating a VLAN. To create a VLAN on the vif "reallylongname," enter the following command:

`vlan create reallylongname 100`

> The resulting VLAN name is "reallylongn-100". The base interface name is truncated and the VLAN name is restricted to 15 characters. When you edit the `/etc/rc` file, ensure that you enter the truncated VLAN name.

After you finish

You must configure the VLAN interface by using the `ifconfig` command.

Related concepts

Prerequisites for setting up VLANs on page 97
Guidelines for setting up VLANs in Data ONTAP on page 97

Configuring a VLAN

After you create a VLAN, you must configure it with an IP address. By using the `ifconfig` command, you can configure all the parameters for a VLAN interface in the same way that you configure the parameters for a physical interface.

About this task

You can configure the following parameters for a VLAN:

- IP address (IPv4 and IPv6)
- Network mask
- Prefix length
- Interface status
- Partner

Step

1. Enter the following command:

   `ifconfig` *`ifname-vlanid IP_address`* `netmask` *`mask`*

   `ifname-vlanid` is the VLAN interface name.

   `IP_address` is the IP address for this interface.

   `mask` is the network mask for this interface.

   #### Example

   Create VLANs with identifiers 1760 on the interface e5a of a storage system by using the following command:

   `vlan create e5a 1760`

   Configure the VLAN interface e5a-1760 by using the following command:

```
ifconfig e5a-1760 192.0.2.11 netmask 255.255.255.0
```

To configure the VLAN interface e5a-1760 with an IPv6 address, use the following command:

```
ifconfig e5a-1760 2001:0db8:85a3:0:0:8a2e:0370:99 prefixlen 64
```

Related concepts

Configuring network interfaces on page 39

IPv6 link-local addresses for VLANs

When IPv6 is enabled on your storage system, all VLANs share the same link-local address as the underlying network interface (physical or vif). When VLANs share the same link-local address, there are no address duplication (DAD) issues because link-local addresses cannot be routed and are confined to a LAN.

Related concepts

IPv6 address scopes on page 32

Related tasks

Enabling or disabling IPv6 on page 33

Adding an interface to a VLAN

If a physical interface does not belong to any VLAN, you can use the `vlan create` command to make the interface a member of one or more VLANs. However, if the interface is already a member of a VLAN, you should use the `vlan add` command to add the interface to subsequent VLANs.

About this task

VLANs created using the `vlan add` commands are not persistent across reboots unless the `vlan` commands are added to the `/etc/rc` file.

Step

1. Enter the following command:

   `vlan add` ***`interface_name vlanid`***

   `interface_name` is the name of the network interface.

   `vlanid` is the VLAN identifier to which the interface belongs. You can include a list of VLAN identifiers.

   Example

   Add VLANs with identifiers 40 and 50 on the interface e4 of a storage system by using the following command:

```
vlan add e4 40 50
```

VLAN interfaces e4-40 and e4-50 are created.

After you finish

You must configure the VLAN interface by using the `ifconfig` command.

Related tasks

Configuring a VLAN on page 100
Creating a VLAN on page 98

Deleting VLANs

You can delete a specific VLAN or all VLANs that are configured on a network interface. When you delete all VLANs on an interface, the interface is then available to be configured as a regular physical interface.

Step

1. Enter the following command:

   `vlan delete [-q] interface_name`

If you want to...	Enter the following command:
Delete one or more specific VLANs	**`vlan delete [-q] interface_name vlanid`** **Note:** If you want to delete more than one specific VLAN, you can include a list of VLAN identifiers. For example, to delete the VLAN e4-30, enter the following command: **`vlan delete e4 30`**
Delete all VLANs configured on a network interface	**`vlan delete [-q] interface_name`** For example, to delete all VLANs configured on the interface e4, enter the following command: **`vlan delete e4`**

`interface_name` is the name of the network interface.

`vlanid` is the VLAN identifier to which the *`interface_name`* interface belongs. You can include a list of VLAN identifiers.

`-q` option invokes the quiet mode.

Result

By default, the `vlan delete` command prompts you to confirm the deletion.

Note: If you do not want to receive this prompt, use the `-q` option with the `vlan delete` command. This action invokes the quiet mode, which causes the operation to complete without prompting.

Enabling or disabling GVRP on your VLAN interface

GVRP dynamically registers the VLAN memberships of stations on your network. This reduces the overhead of maintaining static VLAN configuration on switch ports every time a change occurs in your network. To enable or disable GVRP on all interfaces of a network adapter, you should use the `vlan modify` command.

About this task

- When you enable GVRP on a network interface, it is enabled on all the associated VLANs.
  For example, you can enable GVRP only on the network interface e8 of a storage system. However, you cannot enable or disable GVRP for the VLAN e8-2.
- If you enable GVRP on an interface that is configured to the `down` status, the state of the interface and all associated VLAN interfaces is automatically configured to the `up` status.
  This state change occurs so that the interface can start sending VLAN registration frames to register its VLAN membership with the switch.
- VLANs modified using the `vlan modify` command are not persistent across reboots unless the `vlan` commands are added to the `/etc/rc` file.

Step

1. Enter the following command:

   `vlan modify -g {on|off}` ***`adap_name`***

   `-g on` enables GVRP.

   `-g off` disables GVRP.

   `adap_name` is the name of the network adapter.

Related concepts

GARP VLAN Registration Protocol on page 95
GVRP configuration for VLAN interfaces on page 95

Viewing VLAN statistics

You can use the `vlan stat` command to view the statistics of all VLANs configured on a network interface. You can view the frames received and transmitted on an interface and the number of frames that were rejected because the frames did not belong to any of the VLAN groups.

Step

1. Enter the following command:

   vlan stat *interface_name*

   interface_name is the name of the network interface.

   Example
   The following example displays the statistics of all VLANs on a storage system:

```
vlan stat e4
Vlan Physical Interface: e4 (5 hours, 50 minutes, 38 seconds) --
Vlan IDs: 3,5
GVRP: enabled

RECEIVE STATISTICS
Total frames: 0 | Total bytes: 0 |Multi/broadcast: 0

Untag drops:0 | Vlan tag drops: 0

TRANSMIT STATISTICS
Total frames: 8 | Total bytes: 368

Vlan Interface: e4-3 (0 hours, 20 minutes, 45 seconds) --

ID: 3 MAC Address: 00:90:27:5c:58:14
```

Viewing statistics for a specific VLAN

You can use the `vlan stat` command to view the statistics for a specific VLAN configured on a network interface. You can view the frames received and transmitted on an interface and the number of frames that were rejected because the frames did not belong to any of the VLAN groups.

Step

1. Enter the following command:

   vlan stat *interface_name vlanid*

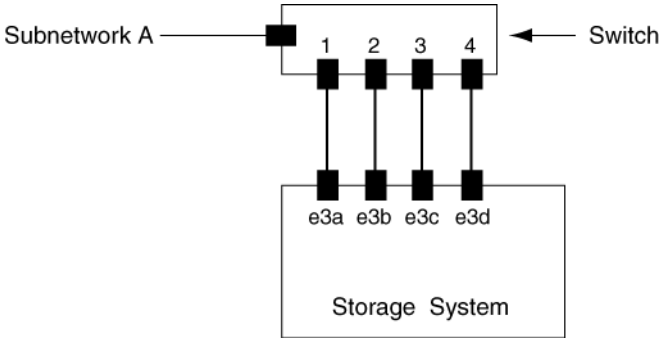
   interface_name is the name of the network interface.

`vlanid` is the VLAN identifier to which the *`interface_name`* interface belongs. You can include a list of VLAN identifiers.

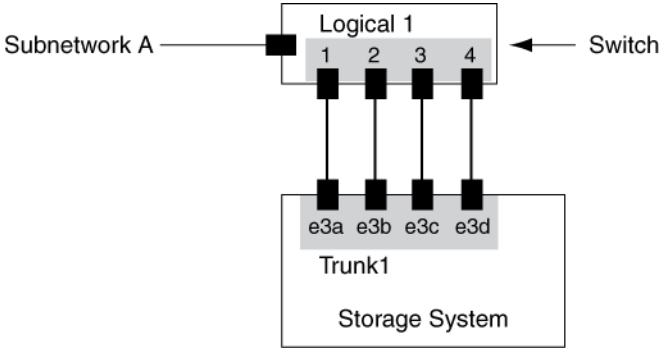
How vifs work in Data ONTAP

A virtual interface (vif) is a feature in Data ONTAP that implements link aggregation on your storage system. Vifs provide a mechanism to group together multiple network interfaces (links) into one logical interface (aggregate). After a vif is created, it is indistinguishable from a physical network interface.

The following figure shows four separate network interfaces, e3a, e3b, e3c, and e3d, before they are grouped into a vif.



The following figure shows the four network interfaces grouped into a single vif called Trunk1.



Different vendors refer to vifs by the following terms:

- Virtual aggregations
- Link aggregations
- Trunks
- EtherChannel

Vifs provide several advantages over individual network interfaces:

- Higher throughput
  Multiple interfaces work as one interface.
- Fault tolerance
  If one interface in a vif goes down, your storage system stays connected to the network by using the other interfaces.
- No single point of failure
  If the physical interfaces in a vif are connected to multiple switches and a switch goes down, your storage system stays connected to the network through the other switches.

Next topics

Types of vifs

You can create three different types of vifs on your storage system: single-mode vifs, static multimode vifs, and dynamic multimode vifs.

Each vif provides different levels of fault tolerance. Multimode vifs provide methods for load balancing network traffic.

Starting with Data ONTAP 7.3.1, IPv6 supports both single-mode and multimode vifs.

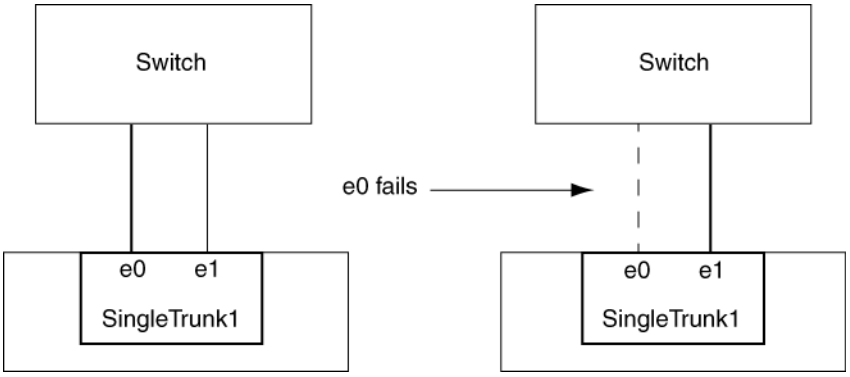
Next topics

Single-mode vif

In a single-mode vif, only one of the interfaces in the vif is active. The other interfaces are on standby, ready to take over if the active interface fails. All interfaces in a single-mode vif share a common MAC address.

There can be more than one interface on standby in a single-mode vif. If an active interface fails, your storage system randomly picks one of the standby interfaces to be the next active link. The active link is monitored and link failover is controlled by the storage system; therefore, single-mode vif does not require any switch configuration. Single-mode vifs also do not require a switch that supports link aggregation.

The following figure is an example of a single-mode vif. In the figure, e0 and e1 are part of the SingleTrunk1 single-mode vif. If the active interface, e0, fails, the standby e1 interface takes over and maintains the connection to the switch.



Static multimode vif

The static multimode vif implementation in Data ONTAP is in compliance with IEEE 802.3ad (static). Any switch that supports aggregates, but does not have control packet exchange for configuring an aggregate, can be used with static multimode vifs.

Static multimode vifs do not support IEEE 802.3ad (dynamic), also known as Link Aggregation Control Protocol (LACP). Port Aggregation Protocol (PAgP), the proprietary link aggregation protocol from Cisco, too is not supported.

In a static multimode vif, all interfaces in the vif are active and share a single MAC address. This logical aggregation of interfaces provides higher throughput than a single-mode vif. Static multimode vifs can recover from a failure of up to "n-1" interfaces, where n is the total number of interfaces that form the vif.

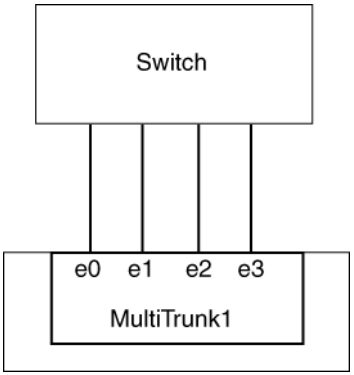
A static multimode vif requires a switch that supports link aggregation over multiple switch ports. The switch is configured so that all ports to which links of a vif are connected are part of a single

logical port. Some switches might not support link aggregation of ports configured for jumbo frames. For more information, see your switch vendor's documentation.

Several load-balancing options are available to distribute traffic among the interfaces of a static multimode vif.

The IEEE 802.3 standard states that the transmitting device in an aggregated link determines the physical interface for transmission. Therefore, Data ONTAP is only responsible for distributing outbound traffic and cannot control how inbound frames arrive. If an administrator wants to manage or control the transmission of inbound traffic on an aggregated link, it must be modified on the directly connected network device.

The following figure is an example of a static multimode vif. Interfaces e0, e1, e2, and e3 are part of the MultiTrunk1 multimode vif. All four interfaces in the MultiTrunk1 multimode vif are active.



Several technologies exist that enable traffic in a single aggregated link to be distributed across multiple physical switches. The technologies used to enable this capability vary among networking products. Static multimode vifs in Data ONTAP conform to the IEEE 802.3 standards. If a particular multiple switch link aggregation technology is stated to interoperate or conform to the IEEE 802.3 standards, it should operate with Data ONTAP.

Dynamic multimode vif

Dynamic multimode vifs can detect not only the loss of link status (as do static multimode vifs), but also a loss of data flow. This feature makes dynamic multimode vifs compatible with high-availability environments. The dynamic multimode vif implementation in Data ONTAP is in compliance with IEEE 802.3ad (dynamic), also known as Link Aggregation Control Protocol (LACP).

Dynamic multimode vifs have some special requirements. They include the following:

- Dynamic multimode vifs must be connected to a switch that supports LACP.
- Dynamic multimode vifs must be configured as first-level vifs.
- Dynamic multimode vifs should be configured to use the port-based and IP-based load-balancing methods.

In a dynamic multimode vif, all interfaces in the vif are active and share a single MAC address. This logical aggregation of interfaces provides higher throughput than a single-mode vif.

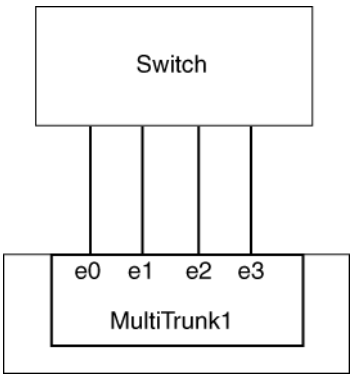
A dynamic multimode vif requires a switch that supports link aggregation over multiple switch ports. The switch is configured so that all ports to which links of a vif are connected are part of a single logical port. For information about configuring the switch, see your switch vendor's documentation. Some switches might not support link aggregation of ports configured for jumbo frames. For more information, see your switch vendor's documentation.

Attention: Data ONTAP supports only the active and passive modes of LACP.

Several load-balancing options are available to distribute traffic among the interfaces of a dynamic multimode vif.

The IEEE 802.3 standard states that the transmitting device in an aggregated link determines the physical interface for transmission. Therefore, Data ONTAP is only responsible for distributing outbound traffic and cannot control how inbound frames arrive. If an administrator wants to manage or control the transmission of inbound traffic on an aggregated link, it must be modified on the directly connected network device.

The following figure is an example of a dynamic multimode vif. Interfaces e0, e1, e2, and e3 are part of the MultiTrunk1 multimode vif. All four interfaces in the MultiTrunk1 dynamic multimode vif are active.



Several technologies exist that enable traffic in a single aggregated link to be distributed across multiple physical switches. The technologies used to enable this capability vary among networking products. Dynamic multimode vifs in Data ONTAP conform to the IEEE 802.3 standards. If a particular multiple switch link aggregation technology is stated to interoperate or conform to the IEEE 802.3 standards, it should operate with Data ONTAP.

Load balancing in multimode vifs

You can ensure that all interfaces of a multimode vif are equally utilized for outgoing traffic. You can use the IP address, MAC address, round-robin, or port based load-balancing methods to equalize traffic.

The load-balancing method for a multimode vif can be specified only when the vif is created. If no method is specified, the IP address based load-balancing method is used.

Next topics

IP address and MAC address load balancing on page 112
Round-robin load balancing on page 112
Port-based load balancing on page 112

IP address and MAC address load balancing

IP address and MAC address load balancing are the methods for equalizing traffic on multimode vifs.

These load-balancing methods use a fast hashing algorithm on the source and destination addresses (IP address and MAC address). If the result of the hashing algorithm maps to an interface that is not in the UP link-state, the next active interface is used.

Note: Do not select the MAC address load-balancing method when creating vifs on a storage system that connects directly to a router. In such a setup, for every outgoing IP frame, the destination MAC address is the MAC address of the router. As a result, only one interface of the vif is used.

IP address load balancing works in the same way for both IPv4 and IPv6 addresses.

Round-robin load balancing

You can use round-robin for load balancing multimode vifs. You should use the round-robin option for load balancing a single connection's traffic across multiple links to increase single connection throughput. However, this method might cause out-of-order packet delivery.

If the remote TCP endpoints do not handle TCP reassembly correctly or lack enough memory to store out-of-order packets, they might be forced to drop packets. Therefore, this can lead to unnecessary retransmissions from the storage controller.

Port-based load balancing

You can equalize traffic on a multimode vif based on the transport layer (TCP/UDP) ports by using the port-based load-balancing method.

The port-based load-balancing method uses a fast hashing algorithm on the source and destination IP addresses along with the transport layer port number.

Guidelines for configuring vifs

Before creating and configuring vifs, you must follow certain guidelines about the type, MTU size, speed, and media of the underlying interfaces.

The following guidelines apply when you create and configure vifs on your storage system:

- The network interfaces that are part of a vif do not have to be on the same network adapter, but it is best that all network interfaces be full-duplex.

  You can group up to 16 physical Ethernet interfaces on your storage system to obtain a vif.
- You cannot include a VLAN interface in a vif.
- The interfaces that form a vif must have the same Maximum Transmission Unit (MTU) size.

  If you attempt to create or add to a vif and the member interfaces have different MTU sizes, Data ONTAP automatically modifies the MTU size to be the same. To ensure that the desired MTU size is configured, you can use the `ifconfig` command to configure the MTU size of the vif after it is created. You need to configure the MTU size only if you are enabling jumbo frames on the interfaces.
- You can include any interface, except the e0M management interface that is present on some storage systems.
- Do not mix interfaces of different speeds or media in the same multimode vif.

Some switches might not support multimode link aggregation of ports configured for jumbo frames. For more information, see your switch vendor's documentation.

The vif command

You can manage vifs on your storage system by using the `vif` command. This command enables you to create vifs, add interfaces to vifs, delete interfaces from vifs, view status and statistics of vifs, and destroy vifs.

The following table gives the `vif` command syntax:

Command	Description
`vif create [single|multi|lacp] *vif_name* -b [rr|mac|ip|port] [*interface_list*]`	Create a single-mode or multimode vif
`vif {favor|nofavor} *interface_name*`	Designate a favored or nonfavored interface in a single-mode vif
`vif add *vif_name interface_list*`	Add network interfaces to a vif
`vif delete *vif_name interface_name*`	Delete a network interface from a vif

Command	Description
`vif destroy` *`vif_name`*	Destroy a vif
`vif status` [*`vif_name`*]	View the status of a vif
`vif stat` *`vif_name`* [*`interval`*]	View the statistics of data packets on the network interfaces of a vif

The following `vif` commands are not persistent if used from the command-line interface; however, you can put any of these commands in the `/etc/rc` file to make it persistent across reboots:

- `vif create`
- `vif add`
- `vif delete`
- `vif destroy`
- `vif favor`
- `vif nofavor`

For more information about the `vif` command and all the options available with this command, see the na_vif(1) man page.

Creating a single-mode vif

You can create a single-mode vif in which only one interface is active at a time and the others are ready to take over if the active interface fails. A single-mode vif increases the redundancy for providing more availability.

Before you begin

- Decide on a case-sensitive name for the vif that meets the following criteria:
  - It must begin with a letter.
  - It must not contain any spaces.
  - It must not contain more than 15 characters.
  - It must not already be in use for a vif.
- Decide on a list of the interfaces you want to combine into the vif.
- To make a specific interface active, you must specify that interface as preferred by using the `vif favor` command; otherwise, an interface is randomly selected to be the active interface.

Steps

1. Configure all interfaces that are to be included in the vif to the `down` status by entering the following command:

ifconfig *interface_list* down

interface_list is a list of the interfaces you want as part of the vif.

Example

ifconfig e0a e0b down

2. To create a vif, enter the following command:

   vif create single *vif_name* [*interface_list*]

   vif_name is the name of the vif.

   interface_list is a list of the interfaces you want as part of the vif.

   Note: The operation performed using the `vif create` command is not persistent across reboots unless you add the command to the `/etc/rc` file.

3. To configure the vif, enter the following command:

   ifconfig *vif_name IP_address*

   vif_name is the name of the vif.

   IP_address is the IP address for this interface.

   Note: If you have enabled IPv6 on your storage system, you can create a vif and then configure the vif to the up status. After this, the vif has two IPv6 addresses automatically configured on it. Therefore, you need not manually configure the IP address for a vif.

Example: Creating a single-mode vif with an IPv4 address

1. To create a single-mode vif, enter the following command:

   vif create single SingleTrunk1 e0 e1

2. To configure an IP address of 192.0.2.4 and a netmask of 255.255.255.0 on the single-mode vif SingleTrunk1, enter the following command:

   ifconfig SingleTrunk1 192.0.2.4 netmask 255.255.255.0

Example: Creating a single-mode vif when IPv6 is enabled

1. To create a single-mode vif, enter the following command:

   vif create single SingleTrunk1 e0 e1

2. Configure the vif by using one of the following methods:

   - To automatically configure the vif, configure the interface to the up status by entering the following command:

     ifconfig SingleTrunk1 up

     The vif now has two automatically configured addresses, as shown below:

     ```
     system1> ifconfig SingleTrunk1
     SingleTrunk1: flags=0x20608862<UP,BROADCAST,RUNNING,MULTICAST,TCPCKSUM> mtu 1500
     ```

```
inet6 2001:0db8:a0:98ff:fe08:618a prefixlen 64 scopeid 0x9 autoconf
inet6 2001:0db8:a0:98ff:fe08:618a prefixlen 64 autoconf
ether 02:a0:98:08:61:8a (Enabled virtual interface)
```

- To manually configure an IPv6 address of 2001:0db8:85a3:0:0:8a2e:0370:99 for the vif, enter the following command:

  `ifconfig SingleTrunk1 2001:0db8:85a3:0:0:8a2e:0370:99`

Next topics

Selecting an active interface in a single-mode vif on page 116
Designating a nonfavored interface in a single-mode vif on page 117
Failure scenarios for a single-mode vif on page 117

Related concepts

Single-mode vif on page 109

Related tasks

Changing the status of an interface on page 50

Selecting an active interface in a single-mode vif

When you create a single-mode vif, an interface is randomly selected to be the active interface (also known as the preferred or favored interface). You can specify another interface as active—for example, when you add a higher speed or higher bandwidth interface—by using the `vif favor` command to override the random selection.

Step

1. Enter the following command:

   `vif favor` ***`interface_name`***

   `interface_name` is the name of the interface that you want to specify as active.

   Example
   To specify the interface e1 as preferred, enter the following command:

   `vif favor e1`

   Note: The operation performed using the `vif favor` command is not persistent across reboots unless the command is added to the `/etc/rc` file.

Related concepts

Single-mode vif on page 109

Related tasks

Designating a nonfavored interface in a single-mode vif on page 117

Designating a nonfavored interface in a single-mode vif

When you create a single-mode vif, an interface is randomly selected to be the active interface. You can designate an interface as nonfavored so that it is not considered during the random selection of an active interface.

About this task

The interface marked as nonfavored can become the active interface when all other interfaces in a single-mode vif fail. Even after other interfaces come to the `up` state, a nonfavored interface continues to remain the active interface until it fails or until you, the system administrator, change the active interface by using the `vif favor` command.

Step

1. Enter the following command:

   `vif nofavor` ***`interface_name`***

   `interface_name` is the name of the interface you do not want to be considered during the random selection of an active interface.

   Note: The operation performed using the `vif nofavor` command is not persistent across reboots unless the command is added to the `/etc/rc` file.

Example

Specify the interface e2 to be nonfavored with the following command:

```
vif nofavor e2
```

Related concepts

Single-mode vif on page 109

Related tasks

Selecting an active interface in a single-mode vif on page 116

Failure scenarios for a single-mode vif

A single-mode vif fails when the link status of the vif is `down`. Failure can also occur if link-monitoring Address Resolution Protocol (ARP) packets do not reach any of the interfaces that form the vif.

When the link status of a single-mode vif is configured to the `down` status, it signals that the interfaces that are part of the vif have lost connection with the switch.

Link-monitoring ARP packets are sent over the ports of a single-mode vif to detect whether the ports are in the same broadcast domain. If these ARP packets do not reach any of the interfaces in the vif, the vif is configured to the `down` status. To avoid this problem, you must ensure that all the interfaces of a single-mode vif are in the same broadcast domain (for example, a LAN or a VLAN).

Related concepts

Single-mode vif on page 109

Related tasks

Viewing vif status on page 122

Creating a static multimode vif

You can use the `vif create` command to create a static multimode vif. If you do not specify the type of vif in the `vif create` command, a static multimode vif is created by default.

Before you begin

You must meet the following prerequisites to create a multimode vif:

- Identify or install a switch that supports link aggregation over multiple port connections in your network, configured according to your switch vendor's instructions.
- Decide on a case-sensitive name for the vif that meets the following criteria:
  - It must begin with a letter.
  - It must not contain a space.
  - It must not contain more than 15 characters.
  - It must not already be in use for a vif.
- Decide on the interfaces that you want to select as part of the vif.
- Configure all interfaces that are to be included in the vif to the `down` status, by using the `ifconfig` command.

About this task

You can improve throughput by creating a static multimode vif. With a multimode vif, all interfaces in the vif are active and share a single MAC address. This logical aggregation of interfaces provides higher throughput than a single-mode vif.

Steps

1. To create the vif, enter the following command:

   `vif create multi` *`vif_name`* `-b {rr|mac|ip|port} [`*`interface_list`*`]`

   `-b` describes the load-balancing method.

   `rr` specifies round-robin load balancing.

   `mac` specifies MAC address load balancing.

   Note: Do not select the MAC address load-balancing method when creating vifs on a storage system that connects directly to a router. In such a setup, for every outgoing IP frame, the

destination MAC address is the MAC address of the router. As a result, only one interface of the vif is used.

`ip` indicates IP address load balancing (default).

`port` indicates port-based load balancing.

`vif_name` is the name of a previously created vif.

`interface_list` is a list of the interfaces you want to add to the vif.

Example

To create a static multimode vif, comprising interfaces e0, e1, e2, and e3 and using MAC address load balancing, enter the following command:

```
vif create multi MultiTrunk1 -b mac e0 e1 e2 e3
```

2. To configure the vif, enter the following command:

```
ifconfig vif_name IP_address netmask mask
```

Related concepts

Static multimode vif on page 109
Load balancing in multimode vifs on page 112

Related tasks

Changing the status of an interface on page 50

Creating a dynamic multimode vif

With a dynamic multimode vif, all interfaces in the vif are active and share a single MAC address. This logical aggregation of interfaces provides higher throughput than a single-mode vif. Dynamic multimode vifs can detect both loss of link and loss of data flow.

Before you begin

You must meet the following prerequisites to create a multimode vif:

- Identify or install a switch that supports LACP over multiple port connections in your network, configured according to your switch vendor's instructions.
- Decide on a case-sensitive name for the vif that meets the following criteria:
  - It must begin with a letter.
  - It must not contain a space.
  - It must not contain more than 15 characters.
  - It must not already be in use for a vif.
- Decide on the interfaces you want to select as part of the vif.

- Configure all interfaces that are to be included in the vif to the `down` status, by using the `ifconfig` command.

About this task

Data ONTAP logs information about the LACP negotiation for dynamic multimode vifs in the `/vol0/etc/log/lacp_log` file.

Steps

1. To create a dynamic multimode vif, enter the following command:

   `vif create lacp *vif_name* -b {rr|mac|ip|port} [*interface_list*]`

   `-b` specifies the load-balancing method.

   `rr` specifies round-robin load balancing.

   `mac` specifies MAC address load balancing.

   Note: Do not select the MAC address load-balancing method when creating vifs on a storage system that connects directly to a router. In such a setup, for every outgoing IP frame, the destination MAC address is the MAC address of the router. As a result, only one interface of the vif is used.

   `ip` specifies IP address based load balancing (default).

   `port` indicates port-based load balancing.

   `vif_name` is the name of a previously created vif.

   `interface_list` is a list of the interfaces that form the vif.

   Example
   To create a dynamic multimode vif, comprising interfaces e0, e1, e2, and e3 and using IP address based load balancing, enter the following command:

   `vif create lacp MultiTrunk1 -b ip e0 e1 e2 e3`

2. To configure the dynamic multimode vif, enter the following command:

   `ifconfig *vif_name* *IP_address* netmask *mask*`

Related concepts

Dynamic multimode vif on page 110
Load balancing in multimode vifs on page 112

Related tasks

Changing the status of an interface on page 50

Adding interfaces to a vif

You can add one or more interfaces to a vif to expand your network. You can add physical interfaces to a vif any time after you create it by using the `vif add` command.

Before you begin

- You must configure additional ports on the switch where the new interfaces will be connected. For information about configuring the switch, see your switch vendor's documentation.
- The interface to be added to the vif must be configured to the `down` status by using the `ifconfig` command.

Step

1. Enter the following command:

   `vif add` ***`vif_name interface_list`***

   `vif_name` is the name of a previously configured vif.

   `interface_list` is a list of the interfaces you want to add to the vif.

   Note: The operation performed using the `vif add` command is not persistent across reboots unless the command is added to the `/etc/rc` file.

   Example
   To add the interface e4 to the multimode vif MultiTrunk1, enter with the following command:

   `vif add MultiTrunk1 e4`

Related tasks

Changing the status of an interface on page 50

Deleting interfaces from a vif

You might have to delete a physical interface from a vif—for example, when the interface needs maintenance or when you want to use the interface for a different purpose. You can use the `vif delete` command to delete one or more interfaces from a vif.

Before you begin

You must configure the vif to the `down` state before you can delete a network interface from the vif. You can configure the vif to the `down` status by using the following command:

`ifconfig` ***`vif_name`*** **`down`**

vif_name is the name of the vif that you want to configure to the down status.

About this task

The operation performed using the `vif delete` command is not persistent across reboots unless the command is added to the `/etc/rc` file.

Step

1. Enter the following command:

   vif delete *vif_name interface*

   vif_name is the name of the vif.

   interface is the interface of the vif you want to delete.

   Example
   To delete the interface e4 from a multimode vif MultiTrunk1, enter the following commands:

   ifconfig MultiTrunk1 down

   vif delete MultiTrunk1 e4

Related tasks

Changing the status of an interface on page 50

Viewing vif status

You can view the current status of a specified vif or all single-mode and multimode vifs on your storage system.

Step

1. Enter the following command:

   vif status [*vif_name*]

   vif_name is the name of the vif whose status you want to display.

   If you do not specify the vif name, the status of all vifs is displayed.

Example

The following example displays the status of the vif vif1:

```
vif status
default: transmit 'IP Load balancing', VIF Type 'multi_mode', fail 'log'
vif1: 2 links, transmit 'IP+port Load balancing', VIF Type 'multi_mode' fail
'default'
        VIF Status     Up      Addr_set
       up:
       e0b: state up, since 30Jan2009 14:23:24 (00:04:40)
```

```
                mediatype: auto-1000t-fd-up
                flags: enabled
                input packets 324193, input bytes 468036576
                output packets 161472, output bytes 13983580
                up indications 2, broken indications 0
                drops (if) 0, drops (link) 0
                strike count: 0 of 10
                indication: up at 30Jan2009 14:23:24
                        consecutive 604, transitions 5
        e0c: state up, since 30Jan2009 14:23:24 (00:04:40)
                mediatype: auto-1000t-fd-up
                flags: enabled
                input packets 526276, input bytes 762227558
                output packets 262355, output bytes 22321102
                up indications 2, broken indications 0
                drops (if) 0, drops (link) 0
                strike count: 0 of 10
                indication: up at 30Jan2009 14:23:24
                        consecutive 606, transitions 5
```

What the vif status information table contains

You can view the status information of a vif by using the `vif status` command.

The following table describes the information that is shown in each field and subfield of the `vif status` command output.

Field	Subfield	Description
`default`		Indicates the default values for fields such as transmit, VIF Type, and fail. These values apply if you do not specify any values for these fields when creating a vif.
	`transmit`	Indicates the default load-balancing method.
	`VIF Type`	Indicates the default vif type.
	`fail`	Indicates the default location where the errors are logged.
`vif_name`		Indicates that the data that follows this field pertains to the vif, *`vif_name`*.
	`transmit`	Indicates the load-balancing method used.
	`VIF Type`	Indicates the type of vif. Possible values are single-mode, multi_mode, or lacp.
	`fail`	Indicates the location where errors are logged for the vif.
	`VIF Status`	Indicates the current status of the vif, *`vif_name`*.
	`Addr_set`	Indicates that a MAC address has been configured for the vif, *`vif_name`*, and all its interfaces.

Field	Subfield	Description
	`state`	Indicates the current link-state of the interface. Possible values are up or down.
	`since`	Indicates the date, time, and number of hours since the interface has been up.
	`mediatype`	Indicates the media type that defines the speed and duplex for that interface.
	`flags`	Indicates whether the interface is enabled or disabled to send and receive data.
	`strike count`	Indicates the number of attempts for link-monitoring. When an underlying link of a vif does not receive any packets (including ARP packets that are used for link-monitoring), the strike count gets incremented once in 5 seconds. If this strike count reaches 10, the underlying link is brought "down."
	`consecutive`	Indicates the number of consecutively received "up" or "broken" indications from the switch and link interaction.
	`transitions`	Indicates the number of indications received that caused a state transition from "up" to "broken" or "down" to "up".

For more information about the `vif status` command, see the na_vif(1) man page.

Viewing vif statistics

You can view the statistics for a specific vif or for all vifs. The statistics include the number of packets received and sent by each vif.

Step

1. Enter the following command:

   `vif stat [`*`vif_name`*`] [`*`interval`*`]`

   `vif_name` is the name of the vif. If you do not specify a vif, the status of all vifs is displayed.

   `interval` is the interval, in seconds. The default is one second.

Example

The following example displays the output of the `vif stat` command for a multimode vif created with the round-robin load-balancing method:

```
vif stat vif0
vif (trunk) vif0
```

```
        e3a                    e3b
  Pkts In    Pkts Out   Pkts In    Pkts Out
  8637076    47801540   158        159
  1617       9588       0          0
  1009       5928       0          0
  1269       7506       0          0
  1293       7632       0          0
  920        5388       0          0
  1098       6462       0          0
  2212       13176      0          0
  1315       7776       0          0
```

The first row of the output shows the total number of packets received and sent until the time the `vif stat` command was run. The following rows show the total number of packets received and sent per second thereafter.

For vifs created with the round-robin load-balancing option, the outgoing packets are balanced among the network interfaces of the vif.

```
vif stat vif1
Virtual interface (trunk) vif1
        e0c                 e0b
  Pkts In   Pkts Out  Pkts In   Pkts Out
  82        208k      796k      208k
  1         27342     104774    27326
  2         26522     102088    26560
  8         20332     77275     20335
  5         27198     103529    27186
```

Destroying a vif

You destroy a vif when you no longer need it or when you want to use the interfaces that form the vif for other purposes. After you destroy the vif, the interfaces in the vif act individually rather than as an aggregate.

Steps

1. Configure the vif to the `down` status by entering the following command:

   `ifconfig` *`vif_name`* `down`

   `vif_name` is the name of the vif you want to configure to the `down` status.

2. Enter the following command:

   `vif destroy` *`vif_name`*

   `vif_name` is the name of the vif you want to destroy.

Second-level vifs

If you have more than one multimode vif, you can use the `vif create` command to group them by creating a second layer of vif called the *second-level vif*. Second-level vifs enable you to provide a standby multimode vif in case the primary multimode vif fails.

You can use second-level vifs on a single storage system or in an active/active configuration.

Note: You cannot use LACP vifs as second-level vifs.

Next topics

Guidelines for creating a second-level vif on page 126
Creating a second-level vif on page 126
Enabling failover in a second-level vif on page 127

Guidelines for creating a second-level vif

You can create a single-mode second-level vif over two multimode vifs. The ports of the underlying multimode vifs should be connected to the same switch. If you create a second-level vif over two multimode vifs that are connected to two different switches, you should connect the two switches with an inter-switch link (ISL).

For a single-mode vif, the switch ports must be in the same broadcast domain (for example, a LAN or a VLAN). Link-monitoring ARP packets are sent over the ports of a single-mode vif to detect whether the ports are in the same broadcast domain. If the ports are not in the same broadcast domain, the vif is configured to the `down` status.

When the ports of a single-mode vif are connected to different broadcast domains, it is called a *split-network condition*. Therefore, a second-level vif, created over two multimode vifs that are connected to two different switches without an ISL, is automatically configured to the `down` status.

Creating a second-level vif

You can create a second-level vif by using two multimode vifs. Second-level vifs enable you to provide a standby multimode vif in case the primary multimode vif fails.

Before you begin

You must meet the following prerequisites to create a second-level vif:

- Identify or install a switch that supports link aggregation over multiple port connections in your network, configured according to your switch vendor's instructions.
- Decide on a name for the second-level vif:
  - It must begin with a letter.
  - It must not contain a space.

  - It must not contain more than 15 characters.
  - It must not already be in use for a vif.
- Decide on a list of the interfaces you want to select as part of the vif.
- Configure all interfaces that are to be included in the vif to the `down` status, by using the `ifconfig` command.

Steps

1. Enter the following command to create the first of two multimode interfaces:

   `vif create multi -b {rr|mac|ip|port} vif_name1 if1 if2`

   The *`vif_name1`* vif is composed of two physical interfaces, *`if1`* and *`if2`*.

   `-b`—specifies the type of load-balancing method.

   `rr`—specifies the round-robin load-balancing option.

   `mac`—specifies the MAC address load-balancing option.

   `ip`—indicates the IP address load-balancing option (default option).

   `port`—indicates the port-based load-balancing option.

2. Enter the following command to create the second of two multimode interfaces:

   `vif create multi -b {rr|mac|ip|port} vif_name2 if3 if4`

   The *`vif_name2`* vif is composed of two physical interfaces, *`if3`* and *`if4`*.

3. Enter the following command to create a single-mode interface from the multimode interfaces:

   `vif create single vif_name vif_name1 vif_name2`

   `vif_name` is the second-level vif created with two multimode vifs, *`vif_name1`* and *`vif_name2`*.

Example

Use the following commands to create two vifs and a second-level vif. In this example, IP address load balancing is used for the multimode vifs.

```
vif create multi Firstlev1 e0 e1

vif create multi Firstlev2 e2 e3

vif create single Secondlev Firstlev1 Firstlev2
```

Related tasks

Changing the status of an interface on page 50

Enabling failover in a second-level vif

In a second-level single-mode vif over two or more multimode vifs, you can enable the `vif.failover.link_degraded` option for failing over to a multimode vif with higher aggregate

bandwidth. The failover happens regardless of whether the currently active vif is favored or not. By default, this option is `off`.

Step

1. To enable failover to a multimode vif with higher aggregate bandwidth when one or more of the links in the active multimode vif fail, enter the following command:

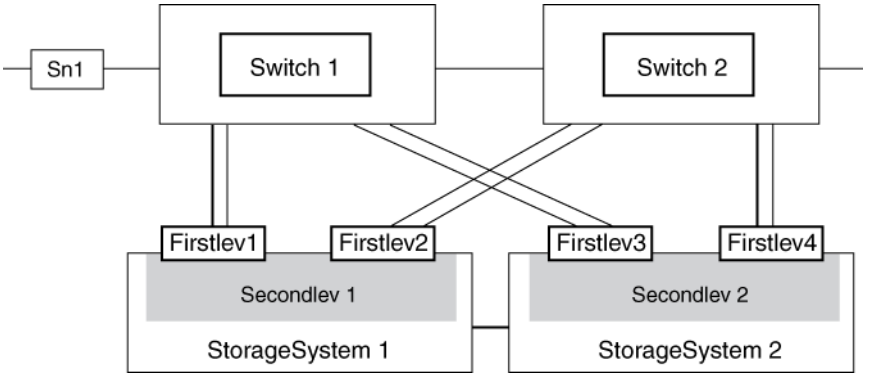
   `options vif.failover.link_degraded on`

Second-level vifs in an active/active configuration

In an active/active configuration, you can access data from both storage systems even if one of the storage system in the configuration fails.

With a second-level vif connected in a single-mode configuration, you can maintain connectivity to your storage system even if one of the switches fails. Therefore, by using the two configurations together, you can achieve a fully redundant storage system connectivity architecture.

The following figure shows second-level vifs in an active/active configuration.



When both storage systems are in operation, the following connections exist:

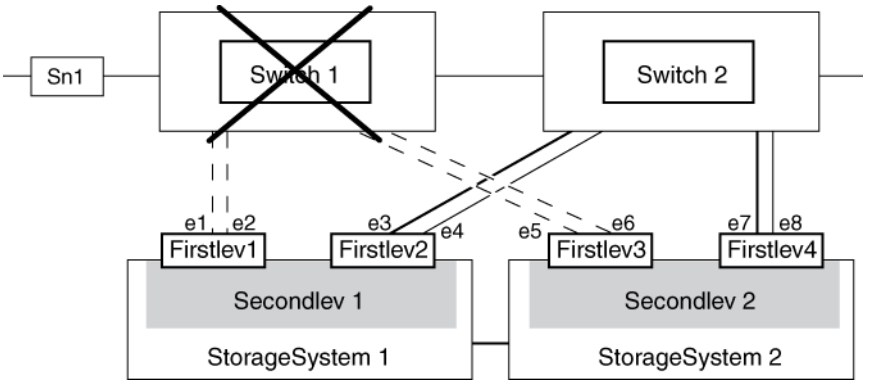
- Firstlev1 in Secondlev 1 connects StorageSystem 1 to the network through Switch 1.
- Firstlev2 in Secondlev 1 connects StorageSystem 1 to Switch 2.
- Firstlev4 in Secondlev 2 connects StorageSystem 2 to the network through Switch 2.
- Firstlev3 in Secondlev 2 connects StorageSystem 2 to Switch 1.

Firstlev2 and Firstlev3 are in standby mode.

If one of the switches fails, the following happens:

- If Switch 1 fails, Firstlev2 and Firstlev4 maintain the connection for their storage systems through Switch 2.
- If Switch 2 fails, Firstlev1 and Firstlev3 maintain the connection for their storage systems through Switch 1.

In the following figure, Switch 1 fails in an active/active configuration. Firstlev2 takes over the MAC address of Firstlev1 and maintains the connectivity through Switch 2.



Creating a second-level vif in an active/active configuration

You can create two second-level vifs in an active/active configuration so that you can access data from both storage systems even if one of the storage system in the configuration fails.

Before you begin

You must ensure that all interfaces to be included in the vif are configured to the `down` status. You can use the `ifconfig` command to configure an interface to the `down` status.

About this task

The operation performed using the `vif create` command is not persistent across reboots unless the command is added to the `/etc/rc` file.

Assume *`StorageSystem1`* and *`StorageSystem2`* are the storage systems that are configured in an active/active configuration.

Steps

1. Enter the following commands on *`StorageSystem1`* to create two multimode vifs:

   `vif create multi -b {rr|mac|ip|port}` ***`vif_name1 if1 if2`***

   `vif create multi -b {rr|mac|ip|port}` ***`vif_name2 if3 if4`***

`-b` specifies the type of load-balancing method.

`rr` specifies the round-robin load-balancing option.

`mac` specifies the MAC address load-balancing option.

`ip` specifies the IP address load-balancing option (default option).

`port` specifies the port-based load-balancing option.

`if1`, *`if2`*, *`if3`*, *`if4`* are the network interfaces.

`vif_name1` and *`vif_name2`* are the names of the multimode vifs.

2. Enter the following command on *`StorageSystem1`* to create a second-level interface from the multimode vifs:

   `vif create single` ***`secondlev1 vif_name1 vif_name2`***

   `secondlev1` is the name of the second-level vif.

3. Enter the following commands on *`StorageSystem2`* to create two multimode vifs:

   `vif create multi -b {rr|mac|ip|port)` ***`vif_name3 if5 if6`***

   `vif create multi -b {rr|mac|ip|port)` ***`vif_name4 if7 if8`***

4. Enter the following command on *`StorageSystem2`* to create a second-level interface from the multimode vifs:

   `vif create single` ***`secondlev2 vif_name3 vif_name4`***

5. Enter the following command on *`StorageSystem1`* to configure the second-level vifs for takeover:

   `ifconfig` ***`secondlev1`*** **`partner`** ***`secondlev2`***

6. Enter the following command on *`StorageSystem2`* to configure the second-level vifs for takeover:

   `ifconfig` ***`secondlev2`*** **`partner`** ***`secondlev1`***

   In steps 5 and 6, secondlev1 and secondlev2 (arguments to the partner option) must be interface names and not interface IP addresses. If secondlev1 is a vif, secondlev2 must also be a vif.

Example

Use the following commands to create a second-level vif in an active/active configuration. In this example, IP-based load balancing is used for the multimode vifs.

On *`StorageSystem1`*:

`vif create multi Firstlev1 e1 e2`

vif create multi Firstlev2 e3 e4

vif create single Secondlev1 Firstlev1 Firstlev2

On *StorageSystem2* :

vif create multi Firstlev3 e5 e6

vif create multi Firstlev4 e7 e8

vif create single Secondlev2 Firstlev3 Firstlev4

On *StorageSystem1*:

ifconfig Secondlev1 partner Secondlev2

On *StorageSystem2* :

ifconfig Secondlev2 partner Secondlev1

Related tasks

Changing the status of an interface on page 50

How CDP works with Data ONTAP

In a data center, you can use Cisco Discovery Protocol (CDP) to view network connectivity between a pair of physical or virtual systems and their network interfaces. CDP is also useful for verifying network connectivity before performing online migration of vFiler units.

CDP is a protocol that enables you to automatically discover and view information about directly connected CDP-enabled devices in a network. Each device advertises identification, capabilities, and connectivity information. This information is transmitted in Ethernet frames to a multicast MAC address and is received by all neighboring CDP-enabled devices.

Neighboring devices of the storage system that are discovered by using CDP are called *CDP neighbors*. For two devices to become CDP neighbors, each must have the CDP protocol enabled and correctly configured. The functionality of CDP is limited to directly connected networks. CDP neighbors include CDP-enabled devices such as switches, routers, bridges, and so on.

Next topics

Data ONTAP support for CDP

By default, Cisco devices or CDP-compliant devices send CDPv2 advertisements. CDP-compliant devices send CDPv1 advertisements only when they receive CDPv1 advertisements. Data ONTAP supports only CDPv1. Therefore, when the storage controller sends CDPv1 advertisements, the immediately connected CDP-compliant devices send back CDPv1 advertisements.

You should consider the following information before enabling CDP on your storage system:

- CDP advertisements are sent only by the ports that are in the up state and configured with IP addresses.
- CDP must be enabled on both the transmitting and receiving devices for sending and receiving CDP advertisements.
- CDP advertisements are sent at regular intervals. You can configure the time interval.
- When IP addresses are changed at the storage system side, the storage system sends the updated information in the next CDP advertisement.

  Note: Sometimes when IP addresses are changed at the storage system side, the CDP information is not updated at the receiving device side (for example, a switch). If you

encounter such problem, you should configure the network interface of the storage system to the `down` status and then to the `up` status.

- Only IPv4 addresses are advertised in CDP advertisements.
- For physical network ports with VLANs, all the IP addresses configured on the VLANs on that port are advertised.
- For physical ports that are part of a vif, all the IP addresses configured on that vif are advertised on each physical port.
- For a vif that hosts VLANs, all the IP addresses configured on the vif and the VLANs are advertised on each of the network ports.
- The number of IP addresses that can fit into a 1500 MTU sized packet is advertised for packets with MTU sizes equal and greater than 1500 bytes.

Enabling or disabling CDP on your storage system

To discover and send advertisements to CDP-compliant neighboring devices, CDP must be enabled on the storage system. You should use the `cdpd.enable` option to enable or disable CDP on your storage system.

About this task

When the `cdpd.enable` option is set to `on`, CDPv1 is enabled on all physical ports of the storage system.

Step

1. To enable or disable CDP, enter the following command:

   `options cdpd.enable {on|off}`

   `on`—Enables CDP

   `off`—Disables CDP

Configuring hold time for CDP messages

Hold time is the period of time for which all CDP advertisements are stored in a cache in the neighboring CDP-compliant devices. Hold time is advertised by the storage controller in each CDPv1 packet. You can use the `cdpd.holdtime` option to configure hold time.

About this task

The value of the `cdpd.holdtime` option applies to both members of an active/active configuration.

The default value of hold time is 180 seconds.

Step

1. To configure the hold time, enter the following command:

   options cdpd.holdtime *holdtime*

   holdtime is the time interval, in seconds, for which the CDP advertisements are cached in the neighboring CDP-compliant devices. You can enter values ranging from 10 seconds to 255 seconds.

Setting the intervals for sending CDP advertisements

CDP advertisements are sent at periodic intervals. You can increase or decrease the intervals between the sending of each CDP advertisement, depending on the network traffic and change in the network topology. You can use the `cdpd.interval` option to configure the time interval for sending CDP advertisements.

About this task

The value of the `cdpd.interval` option applies to both the members of an active/active configuration.

Step

1. To configure the interval for sending CDP advertisements, enter the following command:

   options cdpd.interval *interval*

   interval is the time interval after which CDP advertisements should be sent. The default interval is 60 seconds. The time interval can be set between the range of 5 seconds and 900 seconds.

Viewing or clearing CDP statistics

You can analyze the CDP statistics to detect any network connectivity issues. You can use the `cdpd show-stats` command to view the CDP send and receive statistics. CDP statistics are cumulative from the time they were cleared the last time. To reinitialize the CDP statistics, you can use the `cdpd zero-stats` command.

Step

1. Depending on whether you want to view or clear the CDP statistics, perform the following step:

If you want to...	Enter the following command:
View the CDP statistics	**cdpd show-stats**
Clear the CDP statistics	**cdpd zero-stats**

Example of showing the statistics before and after clearing them

The following example shows the CDP statistics before they were cleared:

```
system1> cdpd show-stats

RECEIVE
 Packets:          9116  | Csum Errors:         0  | Unsupported
Vers:    4561
 Invalid length:      0  | Malformed:           0  | Mem alloc
fails:        0
 Missing TLVs:        0  | Cache overflow:      0  | Other
errors:           0

TRANSMIT
 Packets:          4557  | Xmit fails:          0  | No
hostname:            0
 Packet truncated:    0  | Mem alloc fails:     0  | Other
errors:           0
```

This output displays the total packets that are received from the last time the statistics were cleared.

Enter the following command to clear the statistics:

cdpd zero-stats

The following output shows the statistics after they are cleared:

```
system1> cdpd show-stats

RECEIVE
 Packets:             0  | Csum Errors:         0  | Unsupported
Vers:    0
 Invalid length:      0  | Malformed:           0  | Mem alloc
fails:     0
 Missing TLVs:        0  | Cache overflow:      0  | Other
errors:        0


TRANSMIT
 Packets:             0  | Xmit fails:          0  | No
hostname:         0
 Packet truncated:    0  | Mem alloc fails:     0  | Other
errors:        0
```

```
OTHER
 Init failures:       0
```

After the statistics are cleared, the statistics get added from the time the next CDP advertisement is sent or received.

Viewing neighbor information by using CDP

You can view information about the neighboring devices connected to each port of your storage system, provided the port is connected to a CDP-compliant device. You can use the `cdpd show-neighbors` command to view neighbor information.

Before you begin

CDP must be enabled on your storage system.

Step

1. To view information about all CDP-compliant devices connected to your storage system, enter the following command:

   `cdpd show-neighbors`

Example

The following example shows the output of the `cdpd show-neighbors` command:

```
system1> cdpd show-neighbors
Local  Remote          Remote                 Remote           Hold
Remote
Port   Device          Interface              Platform         Time
Capability
------ --------------- ---------------------- ---------------- -----
----------
e0a    sw-215-cr(4C2)  GigabitEthernet1/17    cisco WS-C4948    125
RSI
e0b    sw-215-11(4C5)  GigabitEthernet1/15    cisco WS-C4948    145
SI
e0c    sw-215-11(4C5)  GigabitEthernet1/16    cisco WS-C4948    145
SI
```

The output lists the Cisco devices that are connected to each port of the storage system. The "Remote Capability" column specifies the capabilities of the remote device that are connected to the network interface. The following capabilities are available:

- R—Router
- T—Transparent bridge
- B—Source-route bridge
- S—Switch

- H—Host
- I—IGMP
- r—Repeater
- P—Phone

How to monitor your storage system with SNMP

If you enable SNMP in Data ONTAP, the SNMP managers can query your storage system's SNMP agent for information. The SNMP agent gathers information and forwards it to the managers by using SNMP. The SNMP agent also generates trap notifications whenever specific events occur.

For diagnostic and other network management services, Data ONTAP provides an SNMP agent compatible with SNMP versions 1 and 3. SNMPv3 offers advanced security by using pass phrases and encryption. SNMPv3 supports the MIB-II specification and the MIBs of your storage system. The following MIB-II groups are supported:

- System
- Interfaces
- Address translation
- IP
- ICMP
- TCP
- UDP
- SNMP

Note: Transmission and EGP MIB-II groups are not supported.

Starting with Data ONTAP 7.3.1, IPv6 (RFC 2465), TCP (RFC 4022), UDP (RFC 4113), and ICMP (RFC 2466) MIBs, which show both IPv4 and IPv6 data, are supported.

Next topics

Types of SNMP traps in Data ONTAP on page 139
What a MIB is on page 140
What the SNMP agent does on page 140
How to configure the SNMP agent on page 140
User-defined SNMP traps on page 148

Types of SNMP traps in Data ONTAP

SNMP traps capture system monitoring information in Data ONTAP. There are two types of traps in Data ONTAP: built-in and user-defined.

- Built-in traps are predefined in Data ONTAP and are automatically sent to the network management stations on the traphost list if an event occurs. These traps are based on one of the following:
  - RFC 1213, which defines traps such as coldStart, linkDown, linkUp, and authenticationFailure.

  - Specific traps defined in the custom MIB, such as diskFailedShutdown, cpuTooBusy, and volumeNearlyFull.
- User-defined traps are defined by `snmp traps` commands or the FilerView SNMP Traps windows. These traps are sent using proxy trap ID numbers 11 through 18, which correspond to a trap's MIB priority.

What a MIB is

A MIB file is a text file that describes SNMP objects and traps. MIBs are not configuration files. Data ONTAP does not read these files and their contents do not affect SNMP functionality.

Data ONTAP provides two MIB files:

- A custom MIB (`/etc/mib/netapp.mib`)
- An Internet SCSI (iSCSI) MIB (`/etc/mib/iscsi.mib`)

Data ONTAP also provides a short cross-reference between object identifiers (OIDs) and object short names in the `/etc/mib/traps.dat` file. This file is useful for creating user-defined traps.

Note: The latest versions of the Data ONTAP MIBs and `traps.dat` files are available online on the IBM NAS support site. However, the versions of these files on the Web site do not necessarily correspond to the SNMP capabilities of your Data ONTAP version. These files are provided to help you evaluate SNMP features in the latest Data ONTAP version.

What the SNMP agent does

The storage system includes an SNMP agent that responds to queries and sends traps to network management stations.

The SNMP agent on the storage system has only read privileges—that is, it cannot be used to take corrective action in response to a trap.

Note: Starting with Data ONTAP 7.3.1, the SNMP agent supports IPv6 transport.

How to configure the SNMP agent

You need to configure the SNMP agent on your storage system to set SNMP values and parameters. You can configure your SNMP agent through the command-line interface or with FilerView.

To configure the SNMP agent on your storage system, you need to perform the following tasks:

- Verify that SNMP is enabled.

  Note: SNMP is enabled by default in Data ONTAP.

- If you are running SNMPv3, configure SNMPv3 for read-only access.
- Enable traps.

  Although SNMP is enabled by default, traps are disabled by default.
- Specify host names of one or more network management stations.

  Traps can only be sent when at least one SNMP management station is specified as a traphost. Trap notifications can be sent to a maximum of eight network management stations.

  Note: The SNMP agent can send traps over IPv6 transport to the traphosts whose IPv6 address is configured on the storage system. You can specify traphosts by their IPv6 addresses, but not by their host names.

You can perform the following tasks after configuring SNMP:

- Provide courtesy information about storage system location and contact personnel.
- Set SNMP access privileges. You can restrict SNMP access on a host or interface basis.
- Specify SNMP communities.

  Community strings function as group names to establish trust between SNMP managers and clients. Data ONTAP imposes the following limitations on SNMP communities:

  - No more than eight communities are allowed.
  - Only read-only communities are supported.
- Enable query authentication.

  You can enable authentication failure traps, which are generated when the agent receives queries with the wrong community string, for the SNMP agent. The traps are sent to all hosts specified as traphosts.
- Create and load user-defined traps.

Note: Storage systems in an active/active configuration can have different SNMP configurations. For more information, see the na_snmp(1) man page.

Next topics

Enabling or disabling SNMP using the command-line interface on page 142
Configuring SNMPv3 users on page 142
Setting SNMP access privileges on page 143
Viewing or modifying your SNMP configuration from the command-line interface on page 143
Modifying your SNMP configuration from FilerView on page 144
SNMP command syntax on page 144
SNMP security parameters on page 145
Example: SNMP commands on page 146

Related concepts

User-defined SNMP traps on page 148

Enabling or disabling SNMP using the command-line interface

You can enable or disable SNMP from the command-line interface by entering the `options snmp.enable` command.

Step

1. Enter the following command:

   `options snmp.enable {on|off}`

   `on`—Enables SNMP

   `off`—Disables SNMP

Configuring SNMPv3 users

To access MIB objects by using SNMPv3, you should create users with `login-snmp` capability.

Steps

1. Enter the following command to create a role with `login-snmp` capability:

   `useradmin role add *role_name* -a login-snmp`

   `role_name` is the role name with `login-snmp` capability.

   Example

   `useradmin role add myrole1 -a login-snmp`

2. Enter the following command to create a group and add the created role to that group:

   `useradmin group add *group_name* -r *role_name*`

   `group_name` is the group name to which you want to add the created role, *`role_name`*.

   Example

   `useradmin group add mygroup1 -r myrole1`

3. Enter the following command to create a user and add the user to the created group:

   `useradmin user add *user_name* -g *group_name*`

   `user_name` is the user name belonging to the group, *`group_name`*.

   Example

   `useradmin user add myuser1 -g mygroup1`

4. Create a password for the new user.

   Ensure that the password has a minimum of eight characters.

5. Enter the `snmpwalk` command through the system MIB:

snmpwalk -v 3 -u *user_name* -l authNoPriv -A *password storage_system* system

password is the user's password that you entered in Step 3.

storage_system is the storage system that contains the MIBs.

Example

```
snmpwalk -v 3 -u myuser1 -l authNoPriv -A johndoe123 host1 system
```

Setting SNMP access privileges

You can set SNMP access privileges on a host or an interface by using the command-line interface. The `snmp.access` option defines a method to restrict access to the storage system on a protocol-by-protocol basis.

About this task

You cannot set access privileges from FilerView.

Step

1. Enter the following command:

   options snmp.access *access_spec*

   access_spec consists of keywords and their values. Access can be allowed or restricted by host name, IP address, and network interface name.

   Example
   To allow access to SNMP for network interfaces e0, e1, and e2, enter the following command:

   ```
   options snmp.access if=e0,e1,e2
   ```

Viewing or modifying your SNMP configuration from the command-line interface

You can use the `snmp` command to view or modify your SNMP configuration values.

Step

1. Enter the following command:

   snmp {*options values*}

   options are the available options for the `snmp` command, such as `authtrap`, `community`, `contact`, `init`, `location`, `traphost`, and `traps`.

   values are the values that you want to set for a particular option.

Related references

SNMP command syntax on page 144

Modifying your SNMP configuration from FilerView

You can use FilerView to modify your SNMP configuration.

Steps

1. From the list on the left pane, click **SNMP > Configure**.

   The current SNMP configuration is displayed.

2. To set or modify SNMP configuration values, enter configuration values in the drop-down lists or text fields.

3. Click **Apply**.

SNMP command syntax

If you specify one or more values for an option of the SNMP commands, the value of that option is set or changed. However, if no values are specified, the current value of that option is returned.

The following table describes the syntax and parameters of SNMP commands.

Command	Description
`snmp`	Displays the current values of all SNMP options, such as `init`, `community`, `contact`, and `traphost`.
`snmp authtrap [0|1]`	**With a value**: Enables (with value 1) or disables (with value 0) authentication failure traps on the SNMP agent. **Without a value**: Displays the current value of `authtrap` set in Data ONTAP.
`snmp community`	Displays the current list of communities.
`snmp community add` *rocommunity*	Adds a community. **Default value**: The default community for the SNMP agent in Data ONTAP is public. The only access mode available on storage systems is the default `ro` (read-only).
`snmp community delete {all |` *rocommunity* `}`	Deletes one or all communities.

Command	Description
`snmp contact [`*`contact`*`]`	**With a value**: Sets the contact name for your storage system. You must enclose the contact string in single quotes (' ') if the string contains spaces. You can enter a maximum of 255 characters for the contact information. **Without a value**: Displays the current contact name set in Data ONTAP.
`snmp init [0|1]`	**With a value**: Enables (with value 1) or disables (with value 0) built-in traps and the traps defined using the `snmp traps` command. **Without a value**: Displays the current value of `snmp init` in Data ONTAP. **Default value**: By default, SNMP traps are disabled in Data ONTAP; the system uses the equivalent of `snmp init 0`.
`snmp location [`*`location`*`]`	**With the option**: Sets the location of your storage system. You must enclose the *`location`* string in single quotes (' ') if the string contains spaces. **Without the option**: Displays the current location set in Data ONTAP.
`snmp traphost [{add|delete} {`*`hostname`*`|`*`ipaddress`*`}]`	**With the option**: Adds or deletes SNMP hosts that receive traps from Data ONTAP. When IPv6 is enabled on your storage system, IPv6 traphosts can be added and deleted. You can specify IPv6 addresses, and not host names, to identify IPv6 traphosts. **Without the option**: Displays the current traphosts set in Data ONTAP.
`snmp traps [options]`	Displays the list of user-defined traps set in Data ONTAP

SNMP security parameters

SNMPv3 includes an authentication feature that, when selected, requires users to enter their name, an authentication protocol, and an authentication key, in addition to their desired security level when invoking a command.

If the security level is set to authNoPriv, authentication is performed by using a user's authKey to sign the message being sent. The authProtocol parameter must be MD5. The authKey parameters are generated from a passphrase that must have a minimum of eight characters.

If the security level is set to authNoPriv, you must enter the following parameters:

Parameter	Command-line flag	Description
securityName	-u *`Name`*	User name must not exceed 31 characters.

Parameter	Command-line flag	Description
authProtocol	-a (MD5)	Authentication type must be *MD5*.
authKey	-A *PASSPHRASE*	Passphrase with a minimum of eight characters.
securityLevel	-l (authNoPriv)	Security level: must be Authentication, No Privacy. **Note:** Data ONTAP does not support retrieving MIB values using the noAuthNoPriv security level.
context	-n *CONTEXTNAME*	Sets the context name used for SNMPv3 messages.

Example: SNMP commands

You can use the `snmpget`, `snmpwalk`, `snmpbulkget`, and `snmpbulkwalk` commands to retrieve information from network elements with SNMP agents.

`snmpwalk`

The following command retrieves all the variables under the system sys1:

```
snmpwalk -Os -c public -v 1 sys1 system
sysDescr.0 = STRING: Data ONTAP Release 7.3.1
sysObjectID.0 = OID: enterprises.789.2.3
sysUpTimeInstance = Timeticks: (121596665) 14 days, 1:46:06.65
sysContact.0 = STRING:
sysName.0 = STRING: sys1.lab.example.com
sysLocation.0 = STRING:
sysServices.0 = INTEGER: 72
```

The following command is an example of an SNMP request from an IPv6 client:

```
snmpwalk -v2c -c public udp6:[2001:0db8:85a3:0:0:8a2e:0370:99]:161 system
SNMPv2-MIB::sysDescr.0 = STRING: Data ONTAP Release 7.3.1
SNMPv2-MIB::sysObjectID.0 = OID:
SNMPv2-SMI::enterprises.789.2.3
DISMAN-EVENT-MIB::sysUpTimeInstance = Timeticks: (11415057) 1 day,7:42:30.57
SNMPv2-MIB::sysContact.0 = STRING:
SNMPv2-MIB::sysName.0 = STRING:n3700-183-85.sys1.lab.example.com
SNMPv2-MIB::sysLocation.0 = STRING:
SNMPv2-MIB::sysServices.0 = INTEGER: 72
```

The following command is an example of an SNMPv3 request to retrieve all variables under the system sys1:

```
snmpwalk -v 3 -u joeblow -l authNoPriv -A joeblow12 sys1 system
SNMPv2-MIB::sysDescr.0 = STRING: Data ONTAP Release 7.3.1
SNMPv2-MIB::sysObjectID.0 = OID:
SNMPv2-SMI::enterprises.789.2.3
DISMAN-EVENT-MIB::sysUpTimeInstance = Timeticks: (121622059) 14
days, 1:50:20.59
SNMPv2-MIB::sysContact.0 = STRING:
```

```
SNMPv2-MIB::sysName.0 = STRING: sys1.lab.example.com
SNMPv2-MIB::sysLocation.0 = STRING:
SNMPv2-MIB::sysServices.0 = INTEGER: 72
```

Note: You need to enter authentication information for using SNMPv3.

snmpget

The following command retrieves the `system.sysDescr.0` object from the host sys1 by using the `public` community string:

```
snmpget -c public sys1 system.sysDescr.0
system.sysDescr.0 = Data ONTAP Release 7.3.1  Mon Mar 16 16:56:43 IST 2009
```

The following command retrieves the value of an ICMP object (OID=56.1.1.1.1) from the host sys1:

```
snmpget -c public -v 2c sys1 .1.3.6.1.2.1.56.1.1.1.1
    56.1.1.1.1 = Counter32: 0
```

snmpbulkget

The following command retrieves the system object `sysDescr.0` and the first three objects in the ifTable:

```
snmpbulkget -v2c -Cn1 -Cr3 -Os -c public sys1 system ifTable
sysDescr.0 = STRING: Data ONTAP Release 7.3.1
ifIndex.1 = INTEGER: 1
ifIndex.2 = INTEGER: 2
ifDescr.1 = STRING: "lo0"
```

The following example shows a part of the output from retrieving all variables under the IPv6 object (OID=55.1):

```
snmpbulkget -c public -v 2c 192.0.2.19 .1.3.6.1.2.1.55.1
    55.1.1.0 = 2
    55.1.2.0 = 64
    55.1.3.0 = Gauge32: 4
    55.1.4.0 = Counter32: 0
    55.1.5.1.1.1 = 1
    55.1.5.1.2.1 = "ns0"
    55.1.5.1.3.1 = OID: .ccitt.zeroDotZero
    55.1.5.1.4.1 = 1500
    55.1.5.1.5.1 = 65535
    55.1.5.1.6.1 = IpAddress: 00 00 00 00 00 00 00 00 02 05 00 FF FE 00 02 AB
    55.1.5.1.7.1 = 64
    55.1.5.1.8.1 =  Hex: 00 05 00 00 02 AB
    55.1.5.1.9.1 = 1
    55.1.5.1.10.1 = 1
```

snmpbulkwalk

The following command retrieves all the variables under the system sys1:

```
snmpbulkwalk -v2c -Os -c public sys1 system
sysDescr.0 = STRING: Data ONTAP Release 7.3.1
sysObjectID.0 = OID: enterprises.789.2.3
sysUpTimeInstance = Timeticks: (121603434) 14 days, 1:47:14.34
sysContact.0 = STRING:
```

```
sysName.0 = STRING: sys1.lab.example.com
sysLocation.0 = STRING:
sysServices.0 = INTEGER: 72
```

The following example shows a part of the output from retrieving all the variables for the UDP object:

```
snmpbulkwalk -c public -v 2c 192.0.2.19 udp
    udp.udpInDatagrams.0 = Counter32: 347
    udp.udpNoPorts.0 = Counter32: 4
    udp.udpInErrors.0 = Counter32: 0
    udp.udpOutDatagrams.0 = Counter32: 138
    udp.udpTable.udpEntry.udpLocalAddress.0.0.0.0.69 = IpAddress: 00 00 00 00
    udp.udpTable.udpEntry.udpLocalAddress.0.0.0.0.111 = IpAddress: 00 00 00 00
```

User-defined SNMP traps

If the predefined built-in traps are not sufficient to create alerts for conditions you want to monitor, you can create user-defined traps in Data ONTAP.

Before you define a new trap, you should consult the Data ONTAP MIBs to see if any existing traps serve your purpose.

Next topics

How SNMP traps work

You can set SNMP traps to inspect the value of MIB variables periodically. Whenever the value of a MIB variable meets the conditions you specify, a trap is sent to the network management stations on the traphost list. The traphost list specifies the network management stations that receive the trap information.

You can set traps on any numeric variable in the MIB. For example, you can set a trap to monitor the fans on your storage system and have the SNMP application on your network management station show a flashing message on your console when a fan has stopped working.

Traps are persistent. After you set a trap, it exists across reboots until you remove it or modify it.

Follow these guidelines when creating traps:

- Use the `/etc/mib/traps.dat` file to find Object Identifiers (OIDs) for objects in the MIB files of your storage system.
- Ensure that the trap can be generated in the storage system environment.
- Do not set traps on tabular data.

  It is possible to set traps on row entries in a sequence—for example, an entry in a table. However, if the order in the table is changed by adding or removing rows, you will no longer be trapping the same numeric variables.

How to define or modify a trap

You can define traps or modify traps you have already defined by entering values from the command-line interface, in FilerView, or in a configuration file.

You must supply the following elements when you create or modify traps:

- Trap name

  Trap name is the name of the user-defined trap you want to create or change. A trap name must not have any embedded periods.
- Trap parameters
- Parameter values

Note: When you create a user-defined trap, it is initially disabled by default. You must enable a trap before it can be triggered. You enable traps by using the `snmp traps` command or FilerView.

Viewing or modifying trap values from the command-line interface

You can view or modify your trap values by using the `snmp traps` command.

Step

1. Enter the following command:

   `snmp traps {`*`options variables`*`}`

   `options` are the options for SNMP traps such as `walk`, `load`, `trapname`, and so on.

   `variables` are values for the specified option.

Viewing or modifying trap values from FilerView

You can use FilerView to view or modify a trap value.

Steps

1. From the list on the left pane, click **SNMP > Traps**.
2. Depending on whether you want to create, modify, or view a trap, perform the following step:

If you want to...	Then...
Create a new trap	**a.** Click **Add**. **b.** In the **Add an SNMP Trap** window, enter the requested information. **c.** Click **Add** again.
View or modify an existing trap	**a.** Click **Manage** for the trap you want to view or modify. **b.** To modify the trap, click **Modify** in the **Manage SNMP Traps** window.

Defining traps in a configuration file

You can define SNMP traps in a configuration file and then load the file with the `snmp traps load` command. Data ONTAP automatically backs up your SNMP configuration as Snapshot copies, making it easy to transfer user-defined traps to other storage systems and to recover SNMP configurations in case of a disaster.

Steps

1. Create a traps configuration file on your storage system.

   You can choose the name and location of the file.

   Example
   `/etc/mib/mytraps`

2. Enter the traps in the configuration file in the following format:

   trapname.parmvalue

   The parameters are the same as those used with the `snmp traps` command.

3. Test each line of the file by entering the `snmp traps` command using the command-line interface or by specifying the trap using FilerView. Make corrections as needed.

4. Load the configuration file with the following command:

   `snmp traps load` ***`file_name`***

   `file_name` is the name of the configuration file.

   Example

   `snmp traps load /etc/mib/mytraps`

Related references

SNMP trap parameters on page 152

Example: Trap definitions

You can define a group of traps by using the command-line interface or FilerView.

The following example sets a group of traps. The trap descriptions are numbered in brackets.

snmp traps cifstotalops.var snmp.1.3.6.1.4.1.789.1.7.3.1.1.1.0
[1]

snmp traps cifstotalops.trigger level-trigger

snmp traps cifstotalops.edge-1 1000000
[4]

snmp traps cifstotalops.interval 10
[2]

snmp traps cifstotalops.backoff-calculator step-backoff
[5]

snmp traps cifstotalops.backoff-step 3590
[5]

snmp traps cifstotalops.rate-interval 3600
[3]

snmp traps cifstotalops.priority alert

snmp traps cifstotalops.message snmp.1.3.6.1.4.1.789.1.7.3.1.1.1.0

A cifstotalops trap [1] is evaluated every 10 seconds [2]. The value received from the previous evaluation and the current value are used to calculate the number of CIFS operations per hour [3]. If the number exceeds one million [4], the trap triggers and continues to be triggered every hour [5] until the total number of CIFS operations drops below one million.

Command syntax for SNMP trap parameters

If you specify one or more values for an option of the SNMP commands, the value of that option is set or changed. However, if no values are specified, the current value of that option is returned.

The following table describes the syntax and parameters for the `snmp traps` command.

Command	Description
`snmp traps`	Displays the list of user-defined traps set in Data ONTAP.
`snmp traps [enable| disable| reset| delete]` *`trapname`*	Enables, disables, resets, or deletes the trap *`trapname`*. If you do not specify a trap name, all traps defined so far are acted on.
`snmp traps walk` *`prefix`*	Walks (traverses in order) the trap list by prefix; that is, lists all traps that have names beginning with *`prefix`*.

Command	Description
`snmp traps load` *`trap_list_filename`*	Loads a set of traps from a configuration file. The file contains a list of traps and parameters without the `snmp traps` command preceding each trap. If the specified file name is defaults, traps are read from the `/etc/defaults/` traps file.
`snmp traps` *`trapname.parm value`*	Defines or changes a user-defined trap parameter.

SNMP trap parameters

You must specify certain parameters to create SNMP traps.

The following table lists SNMP trap parameters that you enter with the `snmp traps` command in the command-line interface and the equivalent parameters that you select in FilerView.

Parameter in command-line interface	Equivalent in FilerView
`var`	OID
`trigger`	Trigger
`edge-1` `edge-2`	Edge 1 Edge 2
`edge-1-direction` `edge-2-direction`	Edge 1 Direction Edge 2 Direction
`interval`	Interval
`interval-offset`	Interval Offset
`rate-interval`	Rate Interval
`backoff-calculator`	Backoff Style
`backoff-step`	Backoff Step
`backoff-multiplier`	Backoff Multiplier
`priority`	Priority
`message`	Not available

Next topics

The var parameter on page 153
The trigger parameter on page 153
The edge-1 and edge-2 parameters on page 154

The var parameter

The `var` parameter associates a user-defined trap name (specified by the *`trapname`* variable in the `snmp traps` command or Trap Name in FilerView) with a specific MIB object. The MIB object is specified in the value field of the `snmp traps` command. It must be in the format `snmp.`*`oid`*, where *`oid`* is an Object Identifier (OID).

The `traps.dat` file, which is located in the `/etc/mib` directory on your storage system, can help you determine OIDs. This file maps MIB objects' short names in the Data ONTAP MIB files to their numeric OIDs. For more information about a particular OID, see the MIB.

In FilerView, it is necessary to enter only the numerical OID, and not the "snmp" prefix.

The trigger parameter

The trigger parameter specifies the type of triggers that you can set for a trap. If a trap is triggered, data about the event that caused the trigger is sent to the network management stations.

You can specify the following values for the `trigger` parameter:

single-edge-trigger	Triggers a trap and sends data when the value of the trap's MIB variable crosses an edge (a value that you specify) for the first time.
double-edge-trigger	Triggers a trap and sends data when either of two edges is crossed. A double-edge-trigger enables you to set two edges, each with its own direction.
level-trigger	Triggers a trap and sends data whenever the trap's value crosses a specified edge value.
change-trigger	Keeps track of the last value received from the trap. If the current value differs from the previously received value, the trap is triggered.
always-trigger	Enables a trap to always trigger at the specified evaluation interval (specified by the `interval` parameter). For example, a trap can trigger every 24 hours for the agent to send the total number of CIFS operations to an SNMP manager.

The edge-1 and edge-2 parameters

The edge-1 and edge-2 parameters of a trap specify the threshold values that are compared during trap evaluation to determine whether to fire a trap and send data.

The edge-1 parameter specifies the value for the edge in a single-edge-triggered trap or the first edge in a double-edge-triggered trap. The default value for the edge-1 parameter is MAXINT.

The edge-2 parameter specifies the value for the second edge in a double-edge-triggered trap. The default value for the edge-2 parameter is 0.

Note: The edge-2 parameter is not displayed in FilerView during trap creation unless double-edge-trigger is selected in the trigger parameter.

The edge-1-direction and edge-2-direction parameters

The edge-1-direction and edge-2-direction parameters enable you to set or change the direction that is used to evaluate a trap. The edge-triggered traps only send data when the edge is crossed in either the up or down direction.

The default value for the edge-1-direction parameter is `up` and for the edge-2-direction parameter is `down`.

Note: You enter the direction values on the same line as the edge value when you run the `snmp traps` command. The edge-2-direction parameter is not displayed in FilerView during trap creation unless double-edge-trigger is selected in the trigger parameter.

The interval parameter

The `interval` parameter is the time, in seconds, between evaluations of a trap.

A trap can only send data as often as it is evaluated, even if the edge values are exceeded sooner. The default value for the `interval` parameter is 3600.

Note: The maximum value that can be specified for the `interval` parameter in Data ONTAP is 2147482.

The interval-offset parameter

The `interval-offset` parameter is the amount of time, in seconds, until the first trap evaluation.

The default value for the `interval-offset` parameter is 0. You can set it to a nonzero value to prevent too many traps from being evaluated at once (for example, at system startup).

The rate-interval parameter

The `rate-interval` parameter specifies the time, in seconds, in which the change in value of a trap's variable (rate of change) is expressed.

If the `rate-interval` value is set for a trap, the samples of data obtained at the interval points (set using the `interval` parameter) for a trap variable are used to calculate the rate of change. If the calculated value exceeds the value set for the `edge-1` or `edge-2` parameter, the trap is fired.

For example, to obtain the number of CIFS operations per hour, you specify a `rate-interval` of 3600. If `rate-interval` is set to 0, no sampling at interval points occurs and trap evaluation proceeds as with any other kind of trap. The default value for the `rate-interval` parameter is 0.

The backoff-calculator parameter

The `backoff-calculator` parameter enables you to change the trap evaluation interval for a trap after a trap fires.

After a trap fires and sends data, you might not want it to be evaluated so often. For instance, you might want to know within a minute of when a file system is full, but only want to be notified every hour thereafter that it is still full.

The `backoff-calculator` parameter can take the following values in the value variable field:

- `step-backoff`
- `exponential-backoff`
- `no-backoff`

The default value for the `backoff-calculator` parameter is `no-backoff`.

The backoff-step parameter

The `backoff-step` parameter specifies the number of seconds by which the trap evaluation interval is increased.

If a trap interval is 10 and its backoff-step is 3590, the trap is evaluated every 10 seconds until it fires the first time and sends data, and once an hour thereafter. The default value for the `backoff-step` parameter is 0.

Note: The `backoff step` parameter is not displayed in FilerView during trap creation unless "step" is selected in the Backoff Style field.

The backoff-multiplier parameter

The `backoff-multiplier` parameter specifies the value by which to multiply a trap's evaluation interval each time it fires.

If you set `backoff-calculator` to `exponential-backoff` and `backoff-multiplier` to `2`, the interval doubles each time the trap fires. The default value of the `backoff-multiplier` parameter is 1.

Note: The `backoff multiplier` parameter is not displayed in FilerView during trap creation unless "exponential" is selected in the Backoff Style field.

The priority parameter

The priority parameter sets the priority of a trap. If several traps are scheduled to be triggered at the same time, you can use the priority parameter to decide which trap is serviced first.

The possible values for the priority parameter, from highest to lowest, are as follows:

- `emergency`
- `alert`
- `critical`
- `error`
- `warning`
- `notification`
- `informational`
- `debug`

The default value for the priority parameter is `notification`.

The message parameter

The `message` parameter specifies a message that goes out with a trap.

The message can be a string of text or simply the SNMP OID, in the form `snmp.oid`. If you specify the OID as your message, Data ONTAP sends the information that was trapped concerning the OID. If you do not specify a message parameter for a trap, when the trap fires you see a string with the numerical OID value and its priority level.

For example, the following string is sent to the network management stations for the trap `cpuUpTime` if the message parameter is not set:

```
cpuUpTime == 10562288.priority == notification
```

Note: If the message is a string that includes spaces, you must enclose the string in quotation marks (" ").

You cannot set the `message` parameter in FilerView.

Internet Protocol Security

Internet Protocol Security (IPsec) is a security protocol suite that protects data from unauthorized disclosure. Using IPsec, you can add policies that configure encryption and authentication algorithms between the storage system and the client, and negotiate a security association (SA) between two end-stations that initiate and receive secure communications.

A security association is used for secure data exchanges between the storage system and the client systems.

Note: IPsec is not supported over IPv6.

Next topics

What security associations are

A security association (SA) is an authenticated simplex (uni-directional) data connection between two end-stations.

Security associations are typically configured in pairs. An SA has all of the following:

- A unique Security Parameter Index (SPI) number
- An IP destination address
- An IPsec security protocol

The IPsec security protocol must be one of the following:

- Authentication Header (AH)

- Encapsulating Security Payload (ESP)

The AH protocol inserts an authentication header into each packet before the data payload. The authentication header includes a checksum created with a cryptographic hash algorithm, either Message Digest function 95 (MD5 - 128 bit key) or Secure Hash Algorithm (SHA - 160 bit key). The AH protocol does not alter the packet's data payload.

The ESP protocol inserts a header before the data payload and a trailer after it. When you specify an encryption algorithm, either Data Encryption Standard (DES) or triple DES, ESP alters the data payload by encrypting it. Alternatively, you can specify packet authentication using the same MD5 or SHA-1 algorithms that are available with the AH protocol. If you use the ESP security protocol, you need to specify either authentication or encryption, or both.

Note: When you specify the AH protocol, only packet authentication (providing data integrity) is enabled. When you specify the ESP protocol, both packet authentication and packet encryption (providing data privacy) can be enabled.

At least two security associations, inbound and outbound, are required between end-stations. Security associations are stored in the Security Association Database (SAD) when IPsec is enabled on an end-station. Security associations are created from security policies.

What security policies include

IPSec security associations are created based on information collected in security policies, which determine how security is handled in a transfer of information. Security policies include specifications such as addresses of end-stations, authentication methods, and encryption mechanism.

Security policies can include any of the following types of specifications:

- The source and destination addresses (or ranges of addresses) of the end-stations (storage system and client)
- Packet authentication methods
- Packet encryption methods
- Restrictions on ports and services
- Whether inbound and outbound SAs are mirrored
- Strictness of policy application

Security policies are stored in the Security Policy Database (SPD) when IPsec is enabled on an end-station. Matching security policies must be configured on your storage system and clients.

Key exchanges

Key exchanges are a vital part of establishing security associations (SA). An IPsec SA is negotiated by means of the key management protocol, Internet Key Exchange (IKE). Phase 1 of an IKE key

exchange authenticates the identity of the end-stations, which allows the establishment of an IPsec SA in Phase 2.

Three key exchange mechanisms using IKE are supported between storage systems and clients: certificate authentication, Kerberos, and preshared keys.

- Certificate authentication lets an end-station prove its identity by providing a certificate that has been digitally signed by a third-party certificate authority (CA), such as Verisign or Entrust. With certificate authentication, administrators need not configure keys between all IPsec peers. Instead, administrators request and install a certificate on each peer, enabling it to dynamically authenticate all other participating peers.
- Kerberos is a network authentication system in which end-stations prove their identities by obtaining identical secret keys from a Key Distribution Center (KDC), the Kerberos security server. For Windows 2000 and later, the KDC is located on the Windows domain controller, which processes IKE authentication requests for storage systems and Windows clients in the domain. Kerberos authentication is enabled automatically when CIFS is licensed and configured on your storage system.
- Preshared keys are identical ASCII text strings entered manually on each end-station. Authentication is validated when IKE successfully compares the hash value of the two keys. Preshared key configuration is simple, but it requires manual management on each end-station. Also, preshared keys are static and persistent, therefore vulnerable unless changed frequently.

Note: The authentication of end-station identity provided by the key exchange protocol IKE is different from the packet integrity authentication provided by the IPsec protocols, AH and ESP.

IPsec implementation in Data ONTAP

The IPsec implementation in Data ONTAP conforms to the Internet Engineering Task Force (IETF) Security Architecture for the Internet Protocol (RFC 2401) and related protocols.

The IPsec implementation in Data ONTAP has some restrictions that might affect its implementation on your storage system and its clients.

The following restrictions apply to the IPsec implementation in Data ONTAP:

- By default, storage systems obey all IPsec parameters that are configured on clients. The only exception is Perfect Forward Secrecy (PFS), which is not supported on storage systems.
- Only transport mode is supported on storage systems; tunnel mode is not supported. Consequently, IPsec is supported for security associations between storage systems and clients, but it is not supported for security associations between storage systems and security gateways.
- Only clients running Solaris or Windows 2000 or later are supported for IPsec connections.
- IPsec is not supported over IPv6.

The following authentication methods are supported:

- For Solaris—preshared keys authentication and certificate authentication.

- For Windows—preshared keys authentication, certificate authentication, and Kerberos authentication; however, Kerberos authentication is available only for Windows Domains, not Windows Workgroups.
- Between storage systems—preshared keys authentication and certificate authentication.

The following restrictions apply to these authentication methods:

- Data ONTAP supports preshared keys and Kerberos key exchange mechanisms, but it cannot be configured to use a specific mechanism. Instead, Data ONTAP relies on the client to specify which key exchange mechanism to use.
- For certificate authentication, Data ONTAP supports v3 certificates in accordance with RFC 3280, but it does not support Certificate Revocation Lists (CRLs).
- You cannot configure parameters associated with SA, for example, how long the SA is valid, how many bytes of data can pass through the SA, in Data ONTAP. Instead, Data ONTAP uses the parameters that the client provides.

For more information about implementation and standards, see the na_ipsec(1) man page.

IPsec in an active/active configuration

If you are considering implementing IPsec in an active/active configuration, you need to optimize IPsec to function in this environment.

The IPsec protocol, by its nature, does not work well in a failover environment (an environment in which one storage system in an active/active configuration must take over the other storage system). This is because security policies, but not security associations, are taken over from the failed storage system. Clients continue to send packets to the failed client for the remainder of the client security association lifetime, after which a new security association must be renegotiated and dropped packets re-sent.

For this reason, you should reduce the security association lifetime to a minimum value to optimize IPsec operation in an active/active configuration. This minimizes the time clients use to destroy their security associations and negotiate new ones with the storage system that took over.

Note: You should set the value of the security association's lifetime on clients rather than on your storage system.

IPsec in a vFiler unit configuration

IPsec can be enabled on a per-vFiler-unit basis, with distinct security policies for each vFiler unit. IPsec configuration is preserved when vFiler units are moved from one hosting storage system to another, unless the vFiler unit's IP address is changed.

IPsec configuration can be set within the context of a vFiler unit or by using the `vfiler run` command.

Note: The IPsec policies and configurations must be set individually for each vFiler unit.

How to set up IPsec

You need to perform several steps to set up IPsec. These steps involve key exchanges, IPsec functionality, and security policies.

1. Select and configure one of the following key exchange mechanisms:
   - Certificate authentication
   - Kerberos
   - Preshared keys
2. Enable IPsec functionality on your storage system.
3. Create security policies.
4. View security associations.

Related concepts

Kerberos support on page 169
Security policies and IPsec on page 170

Related tasks

Configuring certificate authentication on page 161
Configuring preshared keys on page 169
Enabling or disabling IPsec on page 170

Configuring certificate authentication

To configure certificate authentication, you need to complete a number of steps on each storage system and Windows client that will be participating in IPsec communications.

Steps

1. Request a signed certificate from a certificate authority.

   You can request a signed certificate from a Windows 2000 Server certificate authority or from a non-Windows 2000 certificate authority.
2. Install the signed certificate.

   The proper installation method depends on whether the certificate was signed by a certificate authority and whether you are installing the certificate on a storage system or a Windows client.
3. Download and install one or more root certificates.

The storage system or Windows client can establish an IPsec connection with any other storage system or Windows client that uses a certificate signed by a certificate authority that you trust. To specify that you trust a specific certificate authority, you should install that certificate authority's root certificate. Then, you can optionally specify a subset of 1 to 15 certificates that Data ONTAP should use for certificate authentication.

4. Enable the IPsec certificate authentication mechanism.

Next topics

Requesting a signed certificate from a Windows 2000 certificate authority on page 162
Installing a certificate signed by a Windows 2000 certificate authority on a Windows client on page 163
Requesting a signed certificate from a non-Windows 2000 certificate authority on page 164
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Installing root certificates on a Windows client on page 167
Enabling the IPsec certificate authentication mechanism on a storage system on page 168
Enabling the IPsec certificate authentication mechanism on a Windows client on page 168

Requesting a signed certificate from a Windows 2000 certificate authority

You can request a signed certificate from a Windows 2000 certificate authority.

Steps

1. Navigate to the Windows 2000 certificate authority in your Web browser.

   The URL is: http://`host`/certsrv

   `host` is the IP address or fully-qualified host name of the Windows 2000 Server hosting the certification authority.

2. Select **Advanced request** and click **Next**.
3. Select **Submit a certificate request to this CA using a form** and click **Next**.
4. Under identifying information, type your name, e-mail address, company name, department name, state (as a two-letter abbreviation), and country (as a two-letter code).

   Note: All symbols, such as ampersand (&) or at (@) symbols, should be spelled out in or omitted from the company and department names.

5. Under Intended Purpose, select **Server Authentication Certificate**.
6. In the Key size box, type **1024**.
7. Select **Mark keys as exportable**.

   Note: If you do not complete this step, you will not be able to export the certificate and private key into separate files, a step that is required during installation.

8. Click **Submit**.

   After the certificate authority notifies you that your certificate has been issued, you can install the certificate.

Installing a certificate signed by a Windows 2000 certificate authority on a Windows client

If you have requested a certificate signed by a Windows 2000 certificate authority, you must then install it on your Windows client.

Before you begin

You must request for a signed certificate and receive a notification from the Windows 2000 certificate authority that your certificate has been issued.

Steps

1. Navigate to the Windows 2000 certificate authority in your Web browser.

   The URL is: http://*host*/certsrv

   host is the IP address or fully-qualified host name of the Windows 2000 Server hosting the certification authority.

2. Select **Check on a pending certificate** and click **Next**.
3. Select your certificate and click **Next**.
4. Click the link to install the certificate automatically.
5. Start the Microsoft Management Console (MMC). To do this, from the Start menu, select **Run**. Then enter `mmc`.
6. If you have not done so already, add the Certificates - Current User snap-in to the MMC by performing the following steps:
   a. From the File menu, select **Add/Remove Snap-in**.
   b. Click **Add**, select **Certificates**, and click **Add**.
   c. Select **My User Account**.
   d. Click **Finish**.

7. Export the certificate from the Certificates - Current User store by performing the following steps:
   a. In the MMC, right-click the certificate, which is in the Personal or Certificates folder of the Certificates - Current User store, and then select **Export** from the All Tasks menu.
   b. Use the **Certificate Export** wizard to export the certificate, including its private key, to a file.
8. Import the certificate into the Certificates (Local Computer) store by performing the following steps:
   a. In the MMC, right-click the Certificates folder in the Certificates (Local Computer) store, and then select **Import** from the All Tasks menu.
   b. Use the **Certificate Export** wizard to import the certificate.

   Note: Although the MMC allows you to copy a certificate from one store to another, the installation will not succeed unless you export the certificate from the first store and import the certificate into the second store.

Requesting a signed certificate from a non-Windows 2000 certificate authority

You can request a signed certificate from a non-Windows 2000 certificate authority.

Before you begin

To request a signed certificate from a non-Windows 2000 certificate authority, you should follow the instructions on the certificate authority's Web site. Non-Windows 2000 certificate authorities typically require you to generate and submit a certificate signing request.

To generate a certificate signing request for a certificate that you install on a Windows client, you can use the openssl utility. For more information, search the Internet for "openssl."

Step

1. From the command-line interface, enter the following command:

   keymgr generate cert *cert_file_name* KeyLen = *key_length* KeyFile = *key_file_name* Common = *storage_system_common_name* Country = *two_character_country_code* State = *full_state_name* Local = *organization_locality* Organ = *organization_name* Unit = *unit_name*

   cert_file_name is the name of the file into which to store the unsigned certificate. Data ONTAP stores this file in the `/etc/keymgr/cert` directory.

   key_length is the length of the private key in bits. For example, 1024.

   key_file_name is the name of the file in which to store the private key. Data ONTAP stores this file in the `/etc/keymgr/key` directory.

two_character_country_code is the two-character abbreviation (without punctuation) for the country where the storage system is located. For example, US or CA.

full_state_name is the full name of the state where the storage system is located. For example, California or Washington.

organization_name is the name of the organization or company running the storage system.

organization_locality is the city where the storage system is located. For example, Sunnyvale or Berkeley.

unit_name is name of the department or organization unit running the storage system.

Note: All symbols, such as ampersand (&) or at (@) symbols, must be spelled out in or omitted from the organization and unit names.

Installing a certificate signed by a non-Windows 2000 certificate authority on a Windows client

If you have requested a certificate signed by a non-Windows 2000 certificate authority, you must then install it on your Windows client.

Steps

1. Convert the signed certificate to the Windows PKCS12 (*.pfx) format.

   For example, copy the certificate into a file and then use the openssl utility to convert it to the Windows PKCS12 (*.pfx) format. For more information, search the Internet for "openssl."

2. Start the Microsoft Management Console (MMC). To do this, from the Start menu, select **Run**. Then enter `mmc`.
3. If you have not done so already, add the Certificates (Local Computer) snap-in to the MMC by performing the following steps:
   a. From the File menu, select **Add/Remove Snap-in**.
   b. Click **Add**, select **Certificates**, and click **Add**.
   c. Select **Computer Account** and click **Next**.
   d. Select **Local Computer** and click **Finish**.
4. Import the certificate into the Certificates (Local Computer) store by performing the following steps:
   a. In the MMC, right-click the Certificates folder in the Certificates (Local Computer) store, and then select **Import** from the All Tasks menu.
   b. Use the **Certificate Import** wizard to import the certificate.

Installing a signed certificate on a storage system

You need to install a signed certificate on a storage system if you are going to use the certificate authentication method for the IPsec protocol.

Before you begin

If the certificate was signed by a Windows 2000 certificate authority, you should install the certificate on a Windows client and export the certificate, including its private key, to a file.

Steps

1. Copy the signed certificate onto the root volume of the storage system.

   Example
   Mount the storage system's root volume on an NFS client, such as your administration console, and then copy the file containing the signed certificate onto the storage system's root volume.

2. If the signed certificate is in the Windows PKCS12 (*.pfx) format, convert it to the X.509 (*.pem) format.

   You can use the openssl utility to convert the certificate to the X.509 (*.pem) format. For more information, search the Internet for "openssl."

3. Install the signed certificate by entering the following command:

   `keymgr install cert` ***`signed_certificate_file_name`***

   `signed_certificate_file_name` is the full path to the file containing the signed certificate.

Installing root certificates on a storage system

You must install one or more root certificates in each of the storage systems that will be part of a security association among clients and storage systems.

Steps

1. Download the root certificate (in PEM format, if possible) from the certificate authority's Web site.

2. Copy the root certificate onto the root volume of the storage system.

   Example
   Mount the storage system's root volume on an NFS client, such as your administration console, and then copy the file containing the root certificate onto the storage system's root volume.

3. If the root certificate is not in PEM format, convert it to PEM format.

   You can convert the certificate using the openssl utility. For more information, search the Internet for "openssl."

4. Install the root certificate. From the storage system command line, enter the following command:

   keymgr install root *path*

   path is the full path and file name of the root certificate.

Specifying the subset of root certificates that Data ONTAP uses for certificate authentication

By default, Data ONTAP uses all of your storage system's root certificates for certificate authentication. You can specify that Data ONTAP should use only a subset of these root certificates for certificate authentication.

Step

1. From the storage system command line, enter the following command:

   ipsec cert set -r *file_names*

   file_names is a space-delimited list of 1 to 15 names of files containing root certificates that you downloaded and installed previously. Data ONTAP uses this subset of root certificates for certificate authentication, ignoring all other root certificates.

   Note: To remove root certificates from this subset, repeat this step, specifying a new subset.

Viewing the subset of root certificates that Data ONTAP uses for certificate authentication

You can use the `ipsec cert show` command to view the subset of root certificates that Data ONTAP is currently using for certificate authentication.

Step

1. From the command-line interface, enter the following command:

   ipsec cert show

Installing root certificates on a Windows client

After you have installed root certificates on your storage system, you must also install them on your Windows clients.

Steps

1. Download the root certificate (in CER format, if possible) from the certificate authority's Web site.
2. If the root certificate is not in CER format it, convert it to CER format.

You can convert the certificate using the openssl utility. For more information, search the Internet for "openssl."

3. Start the Microsoft Management Console (MMC).

   From the Start menu, select **Run**. Then enter `mmc`.

4. Import the root certificate by performing the following steps:

   a. Right-click the Trusted Root Certification Authorities folder in the Certificates (Local Computer) store, and then select **Import** from the All Tasks menu.

   b. Use the **Certificate Import** wizard to import the root certificate.

Enabling the IPsec certificate authentication mechanism on a storage system

After your certificates are installed on a storage system, you must enable the IPsec security authentication mechanism.

Step

1. From the command line, enter the following command:

   ipsec cert set -c *signed_certificate_file* -k *private_key_file*

   signed_certificate_file is the full path to the file containing the signed certificate. *private_key_file* is the full path to the file containing the private key for the signed certificate.

Enabling the IPsec certificate authentication mechanism on a Windows client

You must enable the IPsec certificate authentication mechanism on a Windows client before you can use IPsec.

Steps

1. Start the Microsoft Management Console (MMC). From the Start menu, select **Run**. Then enter `mmc`.

2. If you have not done so already, add the IP Security Policies on Local Computer snap-in to the MMC by performing the following steps:

   a. From the File menu, select **Add/Remove Snap-in**.

   b. Click **Add**, then select **IP Security Policy Management**, and click **Add**.

   c. Select **Local computer** and click **Finish**.

3. Right-click **IP Security Policies on Local Computer**, and then select **Create IP Security Policy**.
4. Use the **IP Security Policy** wizard to create an IPsec policy.
5. In the MMC console, right-click your new IPsec policy, which is in the IP Security Policies on Local Computer store, and then select **Properties**.
6. Select **Add**.
7. Use the **Security Rule** wizard to create a security rule.
8. For the authentication method, select **Use a certificate from this certificate authority (CA)**, click **Browse**, and then select the certificate that you installed previously.

Kerberos support

Kerberos support is enabled by default on storage systems when CIFS is licensed and configured for Windows domain authentication.

Kerberos support for Windows clients requires all of the following:

- A Windows 2000 or later client that is a member of a domain
- Kerberos selected in the client's Authentication Methods list
- A functioning Key Distribution Center (KDC) on an accessible domain controller

Note: To authenticate a client by using the Kerberos key-exchange mechanism, the storage system should have enough space in its root volume to store the security credentials of the client. If Kerberos support is enabled, the system administrator must ensure that the storage system has at least four kilobytes of free space in its root volume at all times.

Configuring preshared keys

You can configure preshared keys if you want to use a simple encryption system on a pair of end-stations. Preshared key configuration requires manual management on each end-station. To configure preshared keys, you must create an ASCII text string and store it on your storage system and the client that will be sharing the secure connection.

Steps

1. Create a file named `psk.txt` in the `/etc` directory.
2. Decide an ASCII text key that you use for authenticating the client and storage system.
3. In the `psk.txt` file, enter a line using the following format:

   `ip_address key`

ip_address is the IP address of the client.

key is the preshared key you decided upon.

Example

```
192.0.2.1 ag8key
```

4. Copy this file to both the storage system and the client.

Enabling or disabling IPsec

You can use the `options ip.ipsec.enable` command to enable or disable IPsec on your storage system.

Step

1. From the command line, enter the following command:

   ```
   options ip.ipsec.enable {on|off}
   ```

   `on`—Enables IPsec.

   `off`—Disables IPsec.

Security policies and IPsec

You can use the `ipsec` command to add, modify, display, delete, and monitor security policies in your Security Policy Database (SPD) and on your storage system.

Next topics

Creating a security policy

You need to create a security policy for your storage system and its clients to implement IPsec.

Step

1. Enter the following command:

ipsec policy add [-s *src_ip/prefixlen*[*port*]] [-t *dst_ip/prefixlen*[*port*]] -p {esp|ah|none} [-e {des|3des|null} | -a {sha1|md5|null}] -d {in|out} [-m] [-f *ip_protocol*] [-l {restrict|permit}]

Example

ipsec policy add -s 192.0.2.5 -t 192.0.1.12/24[139] -p esp -e des -a ah -d in -l restrict

Security policy options

You must select a number of security policy options when you create a security policy on your storage system and its Windows clients.

When you create security policies, you must select from the following required and optional parameters on your storage system. You must also select corresponding values on any Windows clients served by the storage system.

Parameter	Options	Description
source and destination address	**-s** and **-t**	Required. Addresses can have any of the following forms: • A single IP address • A range of addresses • An IP address at a specific port • A range of addresses at a specific port
security protocol	**-p**	Required. Must be either Authentication Header (AH) or Encapsulated Security Payload (ESP)
encryption	**-e**	Optional. If the ESP protocol is selected, DES, triple DES, or no encryption can be specified. If this option is not specified, the best algorithm is selected based on the peer capabilities.
authentication	**-a**	Required for AH protocol, optional for ESP protocol. SHA-1, MD5, or no authentication can be specified.
direction	**-d**	Required. Specifies an inbound or outbound connection relative to your storage system. By default, a mirrored policy (with the same parameters, except direction) is created unless mirroring is turned off.
protocol	**-f**	Optional. Specifies an upper-layer protocol by number.
permission level	**-l**	Optional. Traffic can be restricted or permitted if a valid SA is not available.
index	**-i**	Specifies an index in the Security Policy Database. The index is obtained by the `ipsec policy show` command.

Displaying existing security policies

You can use the `ipsec policy show` command to display the contents of the Security Policies Database (SPD), either in its entirety or by combinations of parameters.

About this task

You can display the contents of the Security Policies Database (SPD) by a combination of these parameters:

- Source and destination addresses
- Security protocol (AH or ESP)
- Direction (relative to your storage system)
- Specifications of upper-layer protocols

Step

1. From the command line, enter the following command:

   ipsec policy show [-s *src_ip*] [-t *dst_ip*] [-f *ip_protocol*] [-d {in|out}] [-p {esp|ah}]

   src_ip is the source IP address.

   dst_ip is the destination IP address.

   ip_protocol is an upper-layer protocol expressed as a numeric protocol number. For example, the protocol number is 6 for TCP and 17 for UDP.

Example

The following example displays security policy information for the device that has a source IP address (`-s`) of 192.0.2.17:

```
ipsec policy show -s 192.0.2.17

Index IPAddress /prefix/port/protocol Dir/Policy Alg/SecLevel
----------------------------------- ------
1 192.0.2.17 / 0/ [any ]/any in /IPSEC esp/Default
```

Deleting a security policy

You can delete an obsolete security policy and replace it with an up-to-date one.

About this task

You can remove entries from the security policy database by deleting any of the following:

- All entries

- Individual entries identified by SPD index number (displayed by the `ipsec policy show` command)
- Groups of entries identified by any of the following:
  - Source and destination addresses
  - Direction (relative to your storage system)
  - Mirror policy

Step

1. From the command line, enter the following command:

   `ipsec policy delete {all|-i index} [[-s src_ip|-t dst_ip] -d {in|out} [-m]]`

   `index` is the SPD index number of the policy that you want to delete.

   `src_ip` is the source IP address.

   `dst_ip` is the destination IP address.

   Note: You must delete the same policies from corresponding clients.

Viewing IPsec statistics

You can use the `ipsec stats` command to view the cumulative IPsec statistics. You can use these statistics to verify IPsec configuration and monitor protocol processing, and to view IPsec violations.

About this task

The `ipsec stats` command displays the following statistics:

- Total number of IPsec packets processed inbound and outbound
- Total number of AH and ESP packets processed
- Total number of AH and ESP processing failures
- Total number of failures and successes of AH and ESP replay windows

The anti-replay service window protects against replay attacks. It keeps track of the transmit and receive violations, which might be any of the following:

- Improper or missing policies
- Improper or missing security associations
- Successful and failed IKE exchanges

Step

1. Enter the following command, depending on whether you want to view or clear the IPsec statistics:

If you want to...	Enter the following command...
View IPsec statistics	`ipsec stats`
Reset the IPsec statistics counter	`ipsec stats -z`

Example

The following output shows the statistics provided by the `ipsec stats` command.

```
system1> ipsec stats
ipsec:
148460138 inbound packets processed successfully
0 inbound packets violated process security policy
983 inbound packets with no SA available
0 invalid inbound packets
0 inbound packets failed due to insufficient memory
0 inbound packets failed getting SPI
0 inbound packets failed on AH replay check
0 inbound packets failed on ESP replay check
143929988 inbound packets considered authentic
0 inbound packets failed on authentication ESP input packets
des : 3886739
3des : 140043249
AH input packets
md5 : 4530150
134002232 outbound packets processed successfully
0 outbound packets violated process security policy
0 outbound packets with no SP available
11 outbound packets with no SA available
0 invalid outbound packets
0 outbound packets failed due to insufficient memory
0 outbound packets with no route
ESP output packets
des : 4571170
3des : 124667606
AH output packets
md5 : 4763456
ike:
IKE input packets
Identity Protection : 107
Informational :3682
Quick : 7310
IKE output packets
Identity Protection : 108
Informational : 10
Quick : 3663
```

Viewing security associations

You can view the currently active security associations on your storage system.

About this task

You can view any of the following security associations:

- The entire contents of the Security Associations Database (SAD)
- An individual entry in the SAD identified by the Security Parameter Index (SPI)
- A group of entries that include all of the following:
  - Source and destination addresses
  - Security protocol (AH or ESP)
  - Direction (relative to your storage system)
  - Upper-level protocols specified

Note: To learn the SPI for a database entry, you must first display the entire contents of the SAD.

Step

1. From the command line, enter the following command:

   `ipsec sa show [`*`spi`*`|`*`options`*`]`

   `spi` is the Security Parameter Index number that identifies an individual entry in the Security Associations Database.

   `options` include the source and destination IP addresses, and the encryption protocol, either `esp` (ESP based on RFC 2405) or `ah` (AH based on RFC 2402).

Example

The following example displays security association information for the device that has a source IP address of 192.0.2.17:

```
ipsec sa show 1 -s 192.0.2.17 -p esp
Alg/State/Spi Current Bytes/CreatedTime SrcIPAddr->DstIPAddr
------------- ------------------------ --------------------
esp/M/0001388 0/20 Aug 2002 17:28:19 192.0.2.17->192.0.2.20
```

The possible values for state are:

- M—Mature and active
- D—Dead
- d—Dying

- L—Larval (uninitiated)

How to diagnose network problems

You can diagnose problems on your network by using commands such as `netdiag`, `ping`, and `pktt`. You can also use commands such as `ping6`, `ndp`, and `traceroute6` to diagnose IPv6 problems.

`cdpd`

The `cdpd` command displays information of the devices that advertise themselves by using the CDPv1 protocol. You can use this command to view information about the CDP neighbors of the storage system and therefore, detect network connectivity.

`netdiag`

The `netdiag` command continuously gathers and analyzes statistics, and performs diagnostic tests. These diagnostic tests identify and report problems with your physical network or transport layers and suggest remedial action.

For a full description of the `netdiag` command along with all available options, see the na_netdiag(1) man page.

`ping`

You can use the `ping` command to test whether your storage system can reach other hosts on your network.

For a full description of the `ping` command, see the na_ping(1) man page.

`pktt`

You can use the `pktt` command to trace the packets sent and received in the storage system's network.

For a full description of the `pktt` command, see the na_pktt(1) man page.

`ping6`

To reach IPv6 hosts, you can use the `ping6` command. Starting with Data ONTAP 7.3.3, you can use the `ping` command for reaching IPv6 hosts. You can use the `ping6` and `ping` commands with all types of IPv6 addresses.

The `-d` option in the `ping6` command specifies the number of data bytes to be sent. In addition, you might need to specify the `-b` option to extend the socket buffer size.

You must use the `-b` option with the `ping6` command when pinging hosts with jumbo frames. For the pinging to succeed with jumbo frames, the buffer must be large enough to reassemble IP fragments.

For example, when pinging an IPv6 address with an 8900 byte payload and specifying a 9000 byte buffer, you should use the following command:

```
ping6 -d 8900 -b 9000 2001:0db8::99
```

In the previous example, setting the buffer size to 8901 or 8902 bytes might not be adequate and might cause the `ping6` command to fail. Increasing the buffer size to 10000 allows the ping to succeed in both directions.

ndp You can use the `ndp` command to control the address mapping table used by Neighbor Discovery Protocol (NDP).

For a full description of the `ndp` command, see the na_ndp(1) man page.

traceroute6 You can use the `traceroute6` command to trace the route that the IPv6 packets take to a network node.

For a full description of the `traceroute6` command, see the na_traceroute6(1) man page.

Next topics

Diagnosing transport layer problems on page 178
Viewing diagnostic results on page 179
How to diagnose ping problems on page 180
Protecting your storage system from forged ICMP redirect attacks on page 181

Related references

Error codes for the netdiag command on page 213

Diagnosing transport layer problems

You can use the `netdiag -t` command to diagnose problems with the transport layer in your storage system.

Step

1. Enter the following command:

   `netdiag -t`

Example

A storage system whose TCP window size is smaller than the recommended value displays the following output:

```
Performing transport layer diagnostics.....
The TCP receive window advertised by CIFS client
192.0.2.13 is 8760. This is less than the recommended
value of 32768 bytes. You should increase the TCP receive
buffer size for CIFS on the client. Press enter to continue.
```

Viewing diagnostic results

You can use the `netdiag -s` command to view a summary of the various diagnostic checks and tests performed on your storage system.

About this task

If you enable the IPv6 option, you can view the IPv4 and IPv6 statistics in the network layer diagnostic summary.

Step

1. Enter the following command:

   `netdiag -s`

Example

The following output shows some issues in IPv6 configuration of the network layer.

```
netdiag -s

Physical Layer Diagnostics Summary:

Interface  H/W   Link  Configured   Speed     Duplex     AutoNeg
          Status           UP      Mismatch  Mismatch   Mismatch
e0a          OK   -         N          -         -          -
e0b          OK   -         N          -         -          -
e0c          OK   Y         Y          N         -          -
e0d          OK   -         N          -         -          -


Network Layer Diagnostics Summary:

Protocol         Status
IP                 OK
IPv6              Prob


Transport Layer Diagnostics Summary:

Protocol         Status
TCP                OK
UDP                OK

Use netdiag without the -s option for details
```

How to diagnose ping problems

You can use the Data ONTAP ping throttling mechanism and its `ip.ping_throttle.drop_level` option to help avoid denial-of-service attacks that can occur when using ICMP.

The ping throttling mechanism is active in intervals of 1 second. If the number of ICMP echo and reply packets that the storage system receives in a one-second interval exceeds the ping throttling threshold, the storage system drops all subsequent packets that are received within that one-second interval.

Note: Regardless of whether the ping throttling threshold has been reached, clients that send more than 16 packets per second to a storage system might experience packet loss. To allow clients to send more than 16 packets per second, you must disable ping throttling.

If your storage system supports a very large number of CIFS clients that use ICMP pings to determine CIFS shares accessibility, you can increase the ping throttling threshold value in the `ip.ping_throttle.drop_level` option.

If a large number of CIFS clients are experiencing temporary or persistent unavailability of the storage system, you should check to see if the ping throttling threshold has been exceeded for the storage system. If so, you can increase the ping throttling threshold value.

Next topics

Increasing the ping throttling threshold value on page 180
Checking the ping throttling threshold status on page 181
Disabling ping throttling on page 181

Increasing the ping throttling threshold value

If your storage system supports a very large number of CIFS clients that use ICMP pings to determine CIFS shares accessibility, you might need to increase the ping throttling threshold value.

Step

1. Enter the following command:

   `options ip.ping_throttle.drop_level` ***`packets_per_second`***

   `packets_per_second` specifies the maximum number of ICMP echo or echo reply packets (ping packets) that the storage system accepts per second. Any further packets within 1 second are dropped. The default value is 150.

Checking the ping throttling threshold status

If a large number of CIFS clients are experiencing temporary or persistent unavailability of the storage system, you should check if the ping throttling threshold has been exceeded for the storage system.

Step

1. Enter the following command:

   ```
   netstat -p icmp
   ```

Result

The resulting report lists the number of pings and ping replies that have been dropped, if any.

If the number of pings dropped, the number of ping replies dropped, or the number of both pings and ping replies dropped is greater than zero, you should increase the `ip.ping_throttle.drop_value` option to a number that is higher than the current value.

Disabling ping throttling

To allow clients to send more than 16 packets per second, you need to disable ping throttling.

Step

1. Enter the following command:

   ```
   options ip.ping_throttle.drop_level 0
   ```

Protecting your storage system from forged ICMP redirect attacks

You can disable ICMP redirect messages to protect your storage system against forged ICMP redirect attacks.

About this task

To efficiently route a series of datagrams to the same destination, your storage system maintains a route cache of mappings to next-hop gateways. If a gateway is not the best next-hop for a datagram with a specific destination, the gateway forwards the datagram to the best next-hop gateway and sends an ICMP redirect message to the storage system. By forging ICMP redirect messages, an attacker can modify the route cache on your storage system, causing it to send all of its communications through the attacker. The attacker can then hijack a session at the network level, easily monitoring, modifying, and injecting data into the session.

Step

1. Enter the following command:

   `options ip.icmp_ignore_redirect.enable on`

   Your storage system now ignores ICMP redirect messages.

   For more information about the `ip.icmp_ignore_redirect.enable` option, see the na_options(1) man page.

   Note: By default, the `ip.icmp_ignore_redirect.enable` option is `off`.

Network interface statistics

You can use the `ifstat` command to view statistics for the network interfaces supported by Data ONTAP. To determine the Ethernet controllers in your system, you can use the `sysconfig` command.

Next topics

Statistics for Gigabit Ethernet controller IV - VI and G20 interfaces

The `ifstat` command output displays several statistics when you use the command for the Gigabit Ethernet controllers and G20 interfaces.

The statistics in this section are for the following controllers:

- 10/100 Ethernet controller IV
- 10/100/1000 Ethernet controller IV through VII
- Gigabit Ethernet controller IV through VI
- 10/100/1000 Ethernet controller G20
- Gigabit Ethernet controller G20

RECEIVE section statistics

The following table describes the statistics in the RECEIVE section of the `ifstat` command output.

Statistic	Definition
`Frames/second`	Rate of received frames per second.
`Bytes/second`	Rate of received bytes per second.
`Errors/minute`	Rate of errors (which led to frames being lost) per minute.
`Discards/minute`	Rate per minute of packets discarded due to unavailable resources.
`Total frames`	Total frames that are received on the interface.
`Total bytes`	Total bytes that are received on the interface.

Statistic	Definition
`Total errors`	Total errors that occur on the interface.
`Total discards`	Total number of packets that were discarded even though no errors were detected. This number is a sum of the "No buffers", "Bus overruns", and "Queue overflows" statistics.
`Multi/broadcast`	Total number of multicast or broadcast packets received.
`Alignment errors`	Number of frames that are both misaligned and contain CRC errors.
`Non-primary u/c`	Number of Ethernet frames received for the partner's MAC address after a failover in an active/active configuration.
`Tag drop`	Number of tagged frames dropped on an interface that is not configured to support VLAN tagging.
`Vlan tag drop`	Number of tagged frames dropped that do not match the VLAN tags configured on the interface.
`Vlan untag drop`	Number of untagged frames dropped on an interface that is configured to be part of a VLAN.
`CRC errors`	Number of packets received with bad CRC.
`Bad length`	Total number of received packets with a bad length. These are frames counted as undersize, fragment, oversize, or jabber.
`Runt frames`	Number of received frames that were less than the minimum size (64 bytes) and had a valid CRC.
`Fragment`	Number of received frames that were less than the minimum size and had a bad CRC.
`Long frames`	Number of received frames that were greater than the maximum size and had a valid CRC.
`Jabber`	Number of received frames that were greater than the maximum size and had a bad CRC.
`Bus overruns`	Number of times the adapter's receive FIFO overflowed and a packet was dropped. This occurs when the bus is very busy and the adapter cannot transfer data into host memory. This might also occur when your storage system CPU is very busy and cannot process the received packets fast enough.
`Queue overflows`	Number of frames dropped on receive due to the driver receive queue overflowing.

Statistic	Definition
`No buffer`	Number of times the driver could not allocate a buffer and a packet was dropped. This might happen when your storage system is very busy. If the count increases continually, it might indicate that a software component is not returning buffers.
`Xon`	Number of XON frames received when receive or full flow control is enabled.
`Xoff`	Number of XOFF frames received when receive or full flow control is enabled.
`Jumbo`	Number of good packets received that were larger than the standard Ethernet packet size when jumbo frames are enabled.
`Reset`	Number of times the driver reset the NIC because the NIC was in a bad state.
`Reset1`	Number of times the driver reset the NIC because the NIC was in a bad state.
`Reset2`	Number of times the driver reset the NIC because the NIC was in a bad state.

TRANSMIT section statistics

The following table describes the statistics in the TRANSMIT section of the `ifstat` command output.

Statistic	Meaning
`Frames/second`	Rate of transmitted frames per second.
`Bytes/second`	Rate of transmitted bytes per second.
`Errors/minute`	Rate of errors (which led to frames being lost) per minute.
`Discards/minute`	Rate per minute of packets discarded due to unavailable resources.
`Total frames`	Total frames that are transmitted on the interface.
`Total bytes`	Total bytes that are transmitted on the interface.
`Total errors`	Total errors that occur on the interface.
`Total discards`	Total number of packets that were discarded even though no errors were detected. This number is a sum of the "No buffers" and "Queue overflows" statistics.
`Multi/broadcast`	Total number of multicast or broadcast packets transmitted.

Statistic	Meaning
`No buffers`	Number of times the driver failed to allocate a buffer for the transmit packet.
`Queue overflow`	Number of outgoing packets dropped because the driver's queue was full. It might indicate a system problem.
`Max collisions`	Number of frames that were not transmitted because they encountered the maximum number of allowed collisions. Only valid in half-duplex mode.
`Single collision`	Number of frames that encountered exactly one collision. Only valid in half-duplex mode.
`Multi collisions`	Number of frames that encountered more than one collision, but less than the maximum allowed. Only valid in half-duplex mode.
`Late collisions`	Number of collisions that occurred outside the collision window. Only valid in half-duplex mode.
`Xon`	Number of XON frames transmitted when send or full flow control is enabled.
`Xoff`	Number of XOFF frames transmitted when send or full flow control is enabled.
`Timeout`	Number of times the adapter's transmitter hung and the adapter had to be reset. This can happen when the cable is pulled and the transmitter cannot transmit a packet. The adapter is reset to reclaim packet buffers.
`Jumbo`	Number of packets transmitted that were larger than the standard Ethernet frame size (1,518 bytes).

LINK INFO section statistics

The following table describes the statistics in the LINK INFO section of the `ifstat` command output.

Statistic	Meaning
`Current state`	Current state of the interface: • `up` or `down`—The state of the link. • `cfg_down`—The interface is configured to the `down` status. • `enabling`—The interface is moving to the `up` status.
`Up to downs`	Number of times the link switched between the `up` status and the `down` status.

Statistic	Meaning
`Auto`	Operational state of autonegotiation: • `on`—Autonegotiation is enabled and succeeded. • `off`—Autonegotiation failed. This happens when the device to which the interface is connected has disabled autonegotiation or is incompatible with the interface. This might also indicate that the interface is in the `down` status.
`Speed`	Speed of link negotiated or set.
`Duplex`	Duplex of the link negotiated or set.
`Flow control`	The operational flow control setting.

Related tasks

Viewing or clearing network interface statistics on page 54

Statistics for Gigabit and 10 Gigabit Ethernet controllers T204, T210, and T320 interfaces

The `ifstat` command output displays several statistics when you use the command for the 10/100/1000 Ethernet controllers T204V and T204E, and the 10 Gigabit Ethernet controllers T210 and T320.

RECEIVE section statistics

The following table describes the statistics in the RECEIVE section of the `ifstat` command output when you use the command on the 10/100/1000 Ethernet controllers T204V and T204E, and the 10 Gigabit Ethernet controllers T210 and T320.

Statistic	Meaning
`Frames/second`	Rate of received frames per second.
`Bytes/second`	Rate of received bytes per second.
`Errors/minute`	Rate of errors (which led to frames being lost) per minute.
`Discards/minute`	Rate per minute of packets discarded due to unavailable resources.
`Total frames`	Total frames that are received on the interface.
`Total bytes`	Total bytes that are received on the interface.
`Total errors`	Total errors that occur on the interface.

Statistic	Meaning
`Total discards`	Total number of packets that were discarded even though no errors were detected. This number is a sum of the "No buffers", "Bus overruns", and "Queue overflows" statistics.
`Multi/broadcast`	Total number of multicast or broadcast packets received.
`Alignment errors`	Number of frames that are both misaligned and contain CRC errors.
`Non-primary u/c`	Number of Ethernet frames received for the partner's MAC address after a failover in an active/active configuration.
`Tag drop`	Number of tagged frames dropped on an interface that is not configured to support VLAN tagging.
`Vlan tag drop`	Number of tagged frames dropped that do not match the VLAN tags configured on the interface.
`Vlan untag drop`	Number of untagged frames dropped on an interface that is configured to be part of a VLAN.
`CRC errors`	Number of packets received with bad CRC.
`Runt frames`	Number of received frames that were less than the minimum size (64 bytes) and had a valid CRC.
`Long frames`	Number of received frames that were greater than the maximum size and had a valid CRC.
`Jabber`	Number of received frames that were greater than the maximum size and had a bad CRC.
`No buffer`	Number of times the driver could not allocate a buffer and a packet was dropped. This might happen when your storage system is very busy. If the count increases continually, it might indicate that a software component is not returning buffers.
`Jumbo`	Number of good packets received that were larger than the standard Ethernet packet size when jumbo frames are enabled.
`Pause Frames`	Number of MAC Control PAUSE frames sent to the link partner to inhibit transmission of data frames for a specified period of time. This can help the partner from overrunning the controller's receive buffers.

TRANSMIT section statistics

The following table describes the statistics in the TRANSMIT section of the `ifstat` command output when you use the command on the 10/100/1000 Ethernet controllers T204V and T204E, and the 10 Gigabit Ethernet controllers T210 and T320.

Statistic	Meaning
`Frames/second`	Rate of transmitted frames per second.
`Bytes/second`	Rate of transmitted bytes per second.
`Errors/minute`	Rate of errors (which led to frames being lost) per minute.
`Discards/minute`	Rate per minute of packets discarded due to unavailable resources.
`Total frames`	Total frames that are transmitted on the interface.
`Total bytes`	Total bytes that are transmitted on the interface.
`Total errors`	Total errors that occur on the interface.
`Total discards`	Total number of packets that were discarded even though no errors were detected. This number is a sum of the "No buffers" and "Queue overflows" statistics.
`Multi/broadcast`	Total number of multicast or broadcast packets transmitted.
`No buffers`	Number of times the driver failed to allocate a buffer for the transmit packet.
`Queue overflow`	Number of outgoing packets dropped because the driver's queue was full. It might indicate a system problem.
`Bus Underruns`	FIFO goes empty before an internal End-Of-Packet indicator is read.
`Pause Frames`	Number of MAC Control PAUSE frames sent to the link partner to inhibit transmission of data frames for a specified period of time. This can help the partner from overrunning the controller's receive buffers.

LINK INFO section statistics

The following table describes the statistics in the LINK INFO section of the `ifstat` command output when you use the command on the 10/100/1000 Ethernet controllers T204V and T204E, and the 10 Gigabit Ethernet controllers T210 and T320.

Statistic	Meaning
`Current state`	Current state of the interface: • `up` or `down`—The state of the link. • `cfg_down`—The interface is configured to the `down` status. • `enabling`—The interface is coming to the `up` status.
`Up to downs`	Number of times the link switched between the `up` status and the `down` status.

Statistic	Meaning
`Speed`	Speed of link negotiated or set.
`Duplex`	Duplex of the link negotiated or set.
`Flow control`	The operational flow control setting.

Statistics for the N3700 network interfaces

The `ifstat` command output displays several statistics when you use the command on the N3700 network interfaces of the storage system.

RECEIVE section statistics

The following table describes the statistics in the RECEIVE section of the `ifstat` command output when you use the command on the N3700 network interfaces.

Statistic	Meaning
`Frames/second`	Rate of received frames per second.
`Bytes/second`	Rate of received bytes per second.
`Errors/minute`	Rate of errors (which led to frames being lost) per minute.
`Discards/minute`	Rate per minute of packets discarded due to unavailable resources.
`Total frames`	Total frames that are received on the interface.
`Total bytes`	Total bytes that are received on the interface.
`Multi/broadcast`	Total number of multicast or broadcast packets received.
`Total discards`	Total number of "No buffers" packets that were discarded even though no errors were detected.
`No buffers`	Number of times the driver could not allocate a buffer and a packet was dropped. This might happen when your storage system is very busy. If the count increases continually, it might indicate that a software component is not returning buffers.
`Non-primary u/c`	Number of Ethernet frames received for the partner's MAC address after a failover in an active/active configuration.
`Tag drop`	Number of tagged frames dropped on an interface that is not configured to support VLAN tagging.
`Vlan tag drop`	Number of tagged frames dropped that do not match the VLAN tags configured on the interface.

Statistic	Meaning
`Vlan untag drop`	Number of untagged frames dropped on an interface that is configured to be part of a VLAN.
`Runt frames`	Number of received frames that were less than the minimum size (64 bytes) and had a valid CRC.
`Long frames`	Number of received frames that were greater than the maximum size and had a valid CRC.
`CRC errors`	Number of packets received with bad CRC.
`Length errors`	Number of frames received by the MAC address where the actual number of bytes received did not match the length given in the Ethernet header.
`Code errors`	The number of frames received by the MAC address that had a code error signaled by the Physical (PHY) layer.
`Dribble errors`	The number of frames received by the MAC address with an alignment error. This is not used for 1000 Mb/s operation.

TRANSMIT section statistics

The following table describes the statistics in the TRANSMIT section of the `ifstat` command output when you use the command on the N3700 network interfaces.

Statistic	Meaning
`Frames/second`	Rate of transmitted frames per second.
`Bytes/second`	Rate of transmitted bytes per second.
`Errors/minute`	Rate of errors (which led to frames being lost) per minute.
`Discards/minute`	Rate per minute of packets discarded due to unavailable resources.
`Total frames`	Total frames that are transmitted on the interface.
`Total bytes`	Total bytes that are transmitted on the interface.
`Multi/broadcast`	Total number of multicast or broadcast packets transmitted.
`Total discards`	Total number of packets that were discarded even though no errors were detected. This number is a sum of the "No buffers" and "Queue overflow" statistics.
`Queue overflow`	Number of outgoing packets dropped because the driver's queue was full. It might indicate a system problem.
`No buffers`	Number of times the driver failed to allocate a buffer for the transmit packet.

Statistic	Meaning
`CRC errors`	Number of packets transmitted by the MAC address with CRC errors. This can happen only when the MAC address is not appending the CRC to the transmitted packets.
`Abort errors`	Number of packets aborted during transmission. This could be because of a FIFO underrun.
`Runt frames`	Number of packets smaller than the minimum frame size (64 bytes) transmitted by the MAC address.
`Long frames`	Number of packets larger than the maximum frame size transmitted by the MAC address.
`Single collision`	Number of frames that encountered exactly one collision. Only valid in half-duplex mode.
`Late collisions`	Number of collisions that occurred outside the collision window. Only valid in half-duplex mode.
`Deferred`	Number of times a packet was aborted by the MAC address due to excessive collisions during transmission. If 16 consecutive collisions occur during the transmission of a packet, the transmission is deferred and the MAC address aborts the packet.

LINK INFO section statistics

The following table describes the statistics in the LINK INFO section of the `ifstat` command output when you use the command on the N3700 network interfaces.

Statistic	Meaning
`Current state`	Current state of the interface: • `up` or `down`—The state of the link. • `cfg_down`—The interface is configured to the `down` status. • `enabling`—The interface is coming to the `up` status.
`Up to downs`	Number of times the link switched between the `up` status and the `down` status.
`Speed`	Speed of the link negotiated or set.
`Duplex`	Duplex of the link negotiated or set.
`Flow Control`	The operational flow control setting.

Statistics for the BGE 10/100/1000 Ethernet interface

The `ifstat` command output displays several statistics when you use the command on the BGE 10/100/1000 Ethernet interface.

RECEIVE section statistics

The following table describes the statistics in the RECEIVE section of the `ifstat` command output when you use the command on the BGE 10/100/1000 Ethernet interface.

Statistic	Meaning
`Frames/second`	Rate of received frames per second.
`Bytes/second`	Rate of received bytes per second.
`Errors/minute`	Rate of errors (which led to frames being lost) per minute.
`Discards/minute`	Rate per minute of packets discarded due to unavailable resources.
`Total frames`	Total frames that are received on the interface.
`Total bytes`	Total bytes that are received on the interface.
`Total errors`	Total errors that occur on the interface.
`Total discards`	Total number of packets that were discarded even though no errors were detected. This number is a sum of the "No buffers", "Bus overruns", and "Queue overflows" statistics.
`Multi/broadcast`	Total number of multicast or broadcast packets received.
`Alignment errors`	Number of frames that are both misaligned and contain CRC errors.
`Non-primary u/c`	Number of Ethernet frames received for the partner's MAC address after a failover in an active/active configuration.
`Tag drop`	Number of tagged frames dropped on an interface that is not configured to support VLAN tagging.
`Vlan tag drop`	Number of tagged frames dropped that do not match the VLAN tags configured on the interface.
`Vlan untag drop`	Number of untagged frames dropped on an interface that is configured to be part of a VLAN.
`CRC errors`	Number of packets received with bad CRC.
`Runt frames`	Number of received frames that were less than the minimum size (64 bytes) and had a valid CRC.

Statistic	Meaning
`Fragment`	Number of received frames that were less than the minimum size and had a bad CRC.
`Long frames`	Number of received frames that were greater than the maximum size and had a valid CRC.
`Jabber`	Number of received frames that were greater than the maximum size and had a bad CRC.
`No buffer`	Number of times the driver could not allocate a buffer and a packet was dropped. This might happen when your storage system is very busy. If the count increases continually, it might indicate that a software component is not returning buffers.
`Xon`	Number of XON frames received when receive or full flow control is enabled.
`Xoff`	Number of XOFF frames received when receive or full flow control is enabled.
`Jumbo`	Number of good packets received that were larger than the standard Ethernet packet size when jumbo frames are enabled.
`Ring full`	Not used. Ignore.
`Jumbo error`	Error detected while processing a jumbo packet. Packet is discarded.

TRANSMIT section statistics

The following table describes the statistics in the TRANSMIT section of the `ifstat` command output when you use the command on the BGE 10/100/1000 Ethernet interface.

Statistic	Meaning
`Frames/second`	Rate of transmitted frames per second.
`Bytes/second`	Rate of transmitted bytes per second.
`Errors/minute`	Rate of errors (which led to frames being lost) per minute.
`Discards/minute`	Rate per minute of packets discarded due to unavailable resources.
`Total frames`	Total frames that are transmitted on the interface.
`Total bytes`	Total bytes that are transmitted on the interface.
`Total errors`	Total errors that occur on the interface.

Statistic	Meaning
`Total discards`	Total number of packets that were discarded even though no errors were detected. This number is a sum of the "No buffers" and "Queue overflows" statistics.
`Multi/broadcast`	Total number of multicast or broadcast packets transmitted.
`No buffers`	Number of times the driver failed to allocate a buffer for the transmit packet.
`Queue overflow`	Number of outgoing packets dropped because the driver's queue was full. It might indicate a system problem.
`Max collisions`	Number of frames that were not transmitted because they encountered the maximum number of allowed collisions. Only valid in half-duplex mode.
`Single collision`	Number of frames that encountered exactly one collision. Only valid in half-duplex mode.
`Multi collisions`	Number of frames that encountered more than one collision, but less than the maximum allowed. Only valid in half-duplex mode.
`Late collisions`	Number of collisions that occurred outside the collision window. Only valid in half-duplex mode.
`Xon`	Number of XON frames transmitted when send or full flow control is enabled.
`Xoff`	Number of XOFF frames transmitted when send or full flow control is enabled.
`Jumbo`	Number of packets transmitted that were larger than the standard Ethernet packet size when jumbo frames are enabled.
`Deferred`	Number of frames for which the first transmission was delayed because the medium was busy.
`MAC Internal`	Number of frames not transmitted due to an internal MAC sublayer error.

LINK INFO section statistics

The following table describes the statistics in the LINK INFO section of the `ifstat` command output when you use the command on the BGE 10/100/1000 Ethernet interface.

Statistic	Meaning
`Current state`	Current state of the interface: • `up` or `down`—The state of the link. • `cfg_down`—The interface is configured to the `down` status. • `enabling`—The interface is coming to the `up` status.
`Up to downs`	Number of times the link switched between the `up` status and the `down` status.
`Speed`	Speed of link negotiated or set.
`Duplex`	Duplex of the link negotiated or set.
`Flow control`	The operational flow control setting.

Related tasks

Viewing or clearing network interface statistics on page 54

Ways to improve your storage system's performance

You can improve your storage system's performance by performing certain configuration procedures, such as using vifs, correcting duplex mismatches, and upgrading to Ethernet interfaces.

The following configuration procedures might improve the performance of your storage system:

- Using static or dynamic multimode vifs to aggregate the bandwidth of multiple interfaces
- Using jumbo frames with your network interfaces to reduce CPU processing overhead
- Upgrading to a faster network interface

  You can increase the storage system's performance by upgrading to a faster network interface (10 Gigabit Ethernet interfaces).
- Correcting duplex mismatches on 10Base-T or 100Base-T Ethernet networks

  On 10Base-T or 100Base-T Ethernet networks, the speed and duplex settings for the interfaces at both ends of a link must match exactly. You can use the `ifconfig` *`interface`* command to check the duplex setting of your storage system's interface.

  If the setting is to autonegotiate, the `ifconfig` command displays a setting that begins with `auto` (for example, `auto-100tx-fd-up`). Otherwise, the `ifconfig` command displays the configured media type setting (for example, `100tx-fd-up`).

  Note: If one end of the link is set to autonegotiate, the other end must also be set to autonegotiate; otherwise, a mismatch might occur. You can determine the negotiated setting with the `ifstat` command.
- Using iSCSI multiconnection sessions to balance the load across interfaces

  For each iSCSI session, multiple connections are created. The number of allowed connections is negotiated during login and session creation. While it is possible to create multiple connections over a single physical interface, it is best to use multiple physical interfaces for bandwidth enhancement.
- Enabling fast path on your storage system

  Fast path provides load balancing by sending responses on the same network interface that receives the incoming requests and improved performance by skipping routing table lookups.

Related concepts

Static multimode vif on page 109
Dynamic multimode vif on page 110
What jumbo frames are on page 29

Related tasks

Specifying a media type for a network interface on page 43
Enabling or disabling fast path on page 64

IP port usage on a storage system

The Data ONTAP services file is available in the `/etc` directory. The `/etc/services` file is in the same format as its corresponding UNIX system's `/etc/services` file.

Next topics

Host identification

Although some port scanners are able to identify storage systems as storage systems, others port scanners report storage systems as unknown types—UNIX systems because of their NFS support, or Windows systems because of their CIFS support. There are several services that are not currently listed in the `/etc/services` file.

The following table gives a sample content of the `/etc/services` file.

Service	Port/ Protocol	Description
ftp-data	20/tcp	# File transfer protocol
ftp	21/tcp	# File transfer protocol
ssh	22/tcp	# SecureAdmin rsh replacement
telnet	23/tcp	# Remote login (insecure)
smtp	25/tcp	# outbound connections for autosupport
time	37/tcp	# Time Service
time	37/udp	# Time Service
domain	53/udp	# DNS - outbound only
domain	53/tcp	# DNS zone transfers - unused
dhcps	67/udp	# DHCP server - outbound only
dhcp	68/udp	# DHCP client - only first-time setup
tftp	69/udp	# Trivial FTP - for netboot support
http	80/tcp	# HTTP license, FilerView, SecureAdmin
kerberos	88/udp	# Kerberos 5 - outbound only
kerberos	88/tcp	# Kerberos 5 - outbound only
portmap	111/udp	# aka rpcbind, used for NFS
portmap	111/tcp	# aka rpcbind, used for NFS
nntp	119/tcp	# unused, shouldn't be listed here.

Service	Port/ Protocol	Description
ntp	123/tcp	# Network Time Protocol
ntp	123/udp	# Network Time Protocol
netbios-name	137/udp	# NetBIOS nameserver - for CIFS
netbios-dg	138/udp	# NetBIOS datagram service - for CIFS
ftp-data	139/tcp	# NetBIOS service session - for CIFS
ssl	443/tcp	# Secure FilerView (SecureAdmin)
cifs-tcp	445/tcp	# CIFS over TCP with NetBIOS framing
snmp	161/udp	# For Data Fabric Manager or other such tools
shell	514/tcp	# rsh, insecure remote command execution.
syslog	514/udp	# outbound only
route	520/udp	# for RIP routing protocol
kerberos-sec	750/udp	# outbound only, if at all
kerberos-sec	750/tcp	# outbound only, if at all
nfsd	2049/udp	# primary NFS service
nfsd	2049/tcp	# primary NFS service
ttcp	5001/udp	# unused, shouldn't be listed here.
ttcp	5001/tcp	# unused, shouldn't be listed here.
ndmp	10000/tcp	# for network backups
snapmirror	10566/tcp	# also SnapVault

Service	Port/ Protocol	Description
`ndmp-local`	`32243/tcp`	`# Internal connection inside your storage system`

/etc/services NNTP and TTCP ports

The NNTP and TTCP ports are not used by your storage system and should never be detected by a port scanner.

NFS-enabled ports

Some ports (port numbers in the 600 range) on the storage system are NFS-enabled.

The following ports are found on the storage system with NFS-enabled:

UDP	602	NFS mount daemon (`mountd`)
TCP	603	NFS mount daemon (`mountd`)
UDP	604	NFS status daemon (`statd`, `statmon`)
TCP	605	NFS status daemon (`statd`, `statmon`)
UDP	606	NFS lock manager (`lockd`, `nlockmgr`)
TCP	607	NFS lock manager (`lockd`, `nlockmgr`)
UDP	608	NFS quota daemon (`quotad`, `rquotad`)

On other systems, the ports appear as follows:

UDP	611	NFS mount daemon (`mountd`)
TCP	612	NFS mount daemon (`mountd`)
UDP	613	NFS status daemon (`statd`, `statmon`)
TCP	614	NFS status daemon (`statd`, `statmon`)
UDP	615	NFS lock manager (`lockd`, `nlockmgr`)
TCP	616	NFS lock manager (`lockd`, `nlockmgr`)
UDP	617	NFS quota daemon (`quotad`, `rquotad`)

The following command on UNIX systems obtains the correct information by querying the port mapper on port 111:

```
toaster# rpcinfo -p sys1

   program vers proto   port  service
    100011    1   udp    608  rquotad
    100021    4   tcp    607  nlockmgr
    100021    3   tcp    607  nlockmgr
    100021    1   tcp    607  nlockmgr
    100021    4   udp    606  nlockmgr
    100021    3   udp    606  nlockmgr
    100021    1   udp    606  nlockmgr
    100024    1   tcp    605  status
    100024    1   udp    604  status
    100005    3   tcp    603  mountd
    100005    2   tcp    603  mountd
    100005    1   tcp    603  mountd
    100005    3   udp    602  mountd
    100005    2   udp    602  mountd
    100005    1   udp    602  mountd
    100003    3   udp   2049  nfs
    100003    2   udp   2049  nfs
    100000    2   tcp    111  rpcbind
    100000    2   udp    111  rpcbind
```

Note: The port numbers listed for `mountd`, `statd`, `lockd`, and `quotad` are not committed port numbers. These services can be running on other ports of the storage systems. Because the system selects these port numbers at random when it boots, they are not listed in the `/etc/services` file.

Ports not listed in /etc/services

Some ports appear in a port scan but are not listed in the `/etc/services` file, for example, TCP ports 22 and 443.

The following ports appear in a port scan but are not listed in the `/etc/services` file.

Protocol	Port	Service
TCP	22	SSH (SecureAdmin)
TCP	443	SSL (SecureAdmin)
TCP	3260	iSCSI-Target
UDP	*xxxx*	Legato ClientPack for your storage system runs on random UDP ports and is now deprecated. It is best to use NDMP to back up your storage system using Legato Networker.

Note: Disable open ports that you do not need.

FTP

File Transfer Protocol (FTP) uses TCP ports 20 and 21.

If you use FTP to transfer files to and from your storage system, the FTP port is required; otherwise, use FilerView or the following CLI command to disable the FTP port:

```
options ftpd.enable off
```

FTP is not a secure protocol for two reasons:

- When users log in to the system, user names and passwords are transmitted over the network in clear text format that can easily be read by a packet sniffer program.
  These user names and passwords can then be used to access data and other network resources. You should establish and enforce policies that prevent the use of the same passwords to access storage systems and other network resources.
- FTP server software used on platforms other than storage systems contains serious security-related flaws that allow unauthorized users to gain administrative (root) access and control over the host.

Starting with Data ONTAP 7.3.1, FTP over IPv6 is supported.

For a detailed description of the FTP support for your storage system, see the *Data ONTAP File Access and Protocols Management Guide*.

SSH

Secure Shell (SSH) protocol is a secure replacement for RSH and runs on TCP port 22. This port appears in a port scan only if the SecureAdmin software is installed on your storage system.

There are three commonly deployed versions of the SSH protocol:

- SSH version 1—is secure than RSH or Telnet, but is vulnerable to TCP session attacks.
  This vulnerability to attack lies in the SSH protocol version 1 itself and not in the associated storage system products.
- SSH version 2—has a number of feature improvements over SSH version 1 and is less vulnerable to attacks.
- SSH version 1.5—is used to identify clients or servers that support both SSH versions 1 and 2.

To disable SSH support or to close TCP port 22, you must use the following CLI command:

```
secureadmin disable ssh
```

Telnet

Telnet is used for administrative control of your storage system and uses TCP connections on port 23. Telnet is more secure than RSH, as secure as FTP, and less secure than SSH or Secure Socket Layer (SSL).

Telnet is less secure than SSH and SSL because:

- When users log in to a system, such as your storage system, user names and passwords are transmitted over the network in clear text format.

  Clear text format can be read by an attacker by using a packet sniffer program. The attacker can use these user names and passwords to log in to your storage system and execute unauthorized administrative functions, including destruction of data on the system. If administrators use the same passwords on your storage system as they do on other network devices, the attacker can use these passwords to access the resources of the storage system as well.

  Note: To reduce the potential for attack, you must establish and enforce policies preventing administrators from using the same passwords on your storage system that they use to access other network resources.
- Telnet server software used on other platforms (typically in UNIX environments) have serious security-related flaws that allow unauthorized users to gain administrative (root) control over the host.

Telnet is also vulnerable to the same type of TCP session attacks as SSH protocol version 1. However, TCP session attacks are less common because a packet sniffing attack is easier.

To disable Telnet, you must set `options telnet.enable` to `off`.

Starting with Data ONTAP 7.3.1, Telnet supports IPv6. However, if you have enabled the IPv6 option when the storage system is in operation (not during setup), you must restart the Telnet service. That is, you need to turn off and then turn on the Telnet service for connecting over IPv6.

SMTP

Simple Mail Transport Protocol (SMTP) uses TCP port 25. Your storage system does not listen on this port but makes outgoing connections to mail servers using this protocol when sending AutoSupport e-mail.

Time service

Your storage system supports two different time service protocols, TIME protocol and Simple Network Time Protocol (SNTP).

The following are the two different time service protocols:

- TIME protocol (also known as rdate)—specified in the RFC 868 standard. This standard allows for time services to be provided on TCP or UDP port 37. Your storage system uses only UDP port 37.
- SNTP—specified in the RFC 2030 standard and is provided only on UDP port 123.

When your storage system has the `timed.enable` option set to `on` and a remote protocol (rdate or SNTP) is specified, the storage system synchronizes to a network time server.

If the `timed.enable` option is set to `off` , your storage system is unable to synchronize with the network time server using SNTP. You can use the `rdate` command to use the rdate TIME protocol.

You should set the `timed.enable` option to `on` in an active/active configuration.

DNS

The Domain Name System (DNS) uses UDP port 53 and TCP port 53. Your storage system does not typically listen on these ports because it does not run a domain name server. However, if DNS is enabled on your storage system, it makes outgoing connections using UDP port 53 for host name and IP address lookups.

The storage system never uses TCP port 53 because this port is used explicitly for communication between DNS servers. Outgoing DNS queries by your storage system are disabled by turning off DNS support. Turning off DNS support protects against receiving bad information from another DNS server.

Because your storage system does not run a domain name server, the name service must be provided by one of the following:

- Network information service (NIS)
- An `/etc/hosts` file
- Replacement of host names in the configuration files (such as `/etc/exports`, `/etc/usermap.cfg`, and so on) with IP addresses

DNS must be enabled for participation in an Active Directory domain.

DHCP

Clients broadcast messages to the entire network on UDP port 67 and receive responses from the Dynamic Host Configuration Protocol (DHCP) server on UDP port 68. The same ports are used for the BOOTP protocol.

DHCP is used only for the first-time setup of your storage system. Detection of DHCP activity on your storage system by a port scan other than the activity during the first-time setup indicates a serious configuration or software error.

TFTP

Trivial File Transfer Protocol (TFTP) uses TCP port 69. It is used mostly for booting UNIX or UNIX-like systems that do not have a local disk (this process is also known as netbooting) and for storing and retrieving configuration files for devices such as Cisco routers and switches.

Transfers are not secure on TFTP because it does not require authentication for clients to connect and transfer files.

Your storage system's TFTP server is not enabled by default. When TFTP is enabled, the administrator must specify a directory to be used by TFTP clients, and these clients cannot access other directories. Even within the TFTP directory, access is read-only. TFTP should be enabled only if necessary. You can disable TFTP using the following option:

```
options tftpd.enable off
```

You can configure the maximum number of simultaneous connections handled by the TFTP server by using the `tftpd.max_connections` option. The default number of TFTP connections is 8. The maximum number of connections supported is 32.

HTTP

Hypertext Transport Protocol (HTTP) runs on TCP port 80 and is the protocol used by Web browsers to access Web pages.

Your storage system uses HTTP to access the following:

- Files when HTTP is enabled
- FilerView for graphical user interface (GUI) administration
- Secure FilerView when SecureAdmin is installed

Starting with Data ONTAP 7.3.1, HTTP over IPv6 is supported and can be used for file access. Starting with Data ONTAP 7.3.3, HTTP and HTTPS over IPv6 can also be used to access FilerView.

The SecureAdmin SSL interface accepts connections on TCP port 443. SecureAdmin manages the details of the SSL network protocol, encrypts the connection, and then passes this traffic through to

the normal HTTP FilerView interface through a loopback connection. This loopback connection does not use a physical network interface. HTTP communication takes place inside your storage system, and no clear text packets are transmitted.

HTTP is not vulnerable to security attacks because it provides read-only access to documents by unauthenticated clients. Although authentication is not typically used for file access, it is frequently used for access to restricted documents or for administration purposes, such as FilerView administration. The authentication methods defined by HTTP send credentials, such as user names and passwords, over the network without encryption. The SecureAdmin product is provided with SSL support to overcome this shortcoming.

Note: You can stop your storage system from listening for new connections by setting the options `httpd.enable` and `httpd.admin.enable` to `off`. If either of the options is set to `on`, your storage system will listen for new connections.

Kerberos

There are four Kerberos ports in the `/etc/services` file: TCP port 88, UDP port 88, TCP port 750, and UDP port 750. These ports are used only for outbound connections from your storage system. Your storage system does not run Kerberos servers or services and does not listen on these ports.

Kerberos is used by your storage system to communicate with the Microsoft Active Directory servers for both CIFS authentication and, if configured, NFS authentication.

NFS

Network File System (NFS) is used by UNIX clients for file access. NFS uses port 2049.

NFSv3 and NFSv2 use the portmapper service on TCP or UDP port 111. The portmapper service is consulted to get the port numbers for services used with NFSv3 or NFSv2 protocols such as mountd, statd, and nlm. NFSv4 does not require the portmapper service.

NFSv4 provides the delegation feature that enables your storage system to grant local file access to clients. To delegate, your storage system sets up a separate connection to the client and sends callbacks on it. To communicate with the client, your storage system uses one of the reserved ports (port numbers less than 1024). To initiate the connection, the client registers the callback program on a random port and informs the server about it.

With delegations enabled, NFSv4 is not firewall-friendly because several other ports need to be opened up as well.

Starting with Data ONTAP 7.3.1, IPv6 over NFS is supported.

You can disable the TCP and UDP ports by setting the `nfs.tcp.enable` and `nfs.udp.enable` options to `off`.

To disable NFS, you should use the `nfs off` command.

CIFS

Common Internet File Service (CIFS) is the successor to the server message block (SMB) protocol. CIFS is the primary protocol used by Windows systems for file sharing.

CIFS uses UDP ports 137 and 138, and TCP ports 139 and 445. Your storage system sends and receives data on these ports while providing CIFS service. If it is a member of an Active Directory domain, your storage system must also make outbound connections destined for DNS and Kerberos.

Starting with Data ONTAP 7.3.1, CIFS over IPv6 is supported. CIFS over IPv6 uses only port 445. Ports 137, 138, and 139 are used by NetBIOS, which does not support IPv6.

CIFS is required for Windows file service. You can disable CIFS using FilerView or by issuing the `cifs terminate` command on your storage system console.

Note: If you disable CIFS, be aware that your storage system's `/etc/rc` file can be set up to automatically enable CIFS again after a reboot.

SSL

The Secure Sockets Layer (SSL) protocol provides encryption and authentication of TCP connections. Data ONTAP supports SSLv2, SSLv3, and Transport Layer Security (TLS) version 1.0. You should use TLSv1.0 or SSLv3 because it offers better security than previous SSL versions.

When SecureAdmin is installed and configured on your storage system, it listens for SSL connections on TCP port 443. It receives secure Web browser connections on this port and uses unencrypted HTTP, running on TCP port 80, through a loopback connection to pass the traffic to FilerView. This loopback connection is contained within your storage system and no unencrypted data is transmitted over the network.

You can enable or disable SSL by using FilerView or with the following command:

```
secureadmin {enable|disable} ssl
```

For TLS to be used for communication, both the client requesting the connection and the storage system must support TLS.

TLS is disabled by default, and setting up SSL does not automatically enable TLS. Before enabling TLS, ensure that SSL has been set up and enabled. To enable or disable TLS, enter the following command:

```
options tls.enable {on|off}
```

SNMP

Simple Network Management Protocol (SNMP) is an industry-standard protocol used for remote monitoring and management of network devices over UDP port 161.

SNMP is not secure because of the following reasons:

- Instead of using encryption keys or a user name and password pair, SNMP uses a community string for authentication. The community string is transmitted in clear text format over the network, making it easy to capture with a packet sniffer.

  Within the industry, devices are typically configured at the factory to use `public` as the default community string. The public password allows users to make queries and read values but does not allow users to invoke commands or change values. Some devices are configured at the factory to use `private` as the default community string, allowing users full read-write access.
- Even if you change the read and write community string on a device to something other than `private`, an attacker can easily learn the new string by using the read-only `public` community string and asking the router for the read-write string.

There are three versions of SNMP:

- SNMPv1 is the original protocol and is not commonly used.
- SNMPv2 is identical to SNMPv1 from a network protocol standpoint and is vulnerable to the same security problems. The only differences between the two versions are in the messages sent, messages received, and types of information. These differences are not important from a security perspective.
- SNMPv3 is the latest protocol version and includes security improvements but is difficult to implement and many vendors do not yet support it. SNMPv3 supports several different types of network encryption and authentication schemes. It allows for multiple users, each with different permissions, and solves SNMPv1 security problems while maintaining an important level of compatibility with SNMPv2.

SNMP is required if you want to monitor a storage system through an SNMP monitoring tool, such as DataFabric Manager. The SNMP implementation in the storage system allows read-only access. Regardless of the community string used, the user cannot issue commands or change variables using SNMP on your storage system.

You should use the `snmp.access` option to restrict SNMP access to a named set of trusted hosts.

You can disable SNMP entirely by setting the `snmp.enable` option to `off` to disable SNMP entirely.

The `snmp community delete` and `snmp community add` commands are used to change the community string to something other than the default value.

RSH

Remote Shell (RSH) protocol is used for remote command execution. It is less secure than TFTP and uses TCP port 514.

RSH is not secure because passwords are not required for login and commands are easy to misconfigure. Therefore, you should disable RSH by setting the `rsh.enable` option to `off`.

You should use the SSH supplied with SecureAdmin for remote command execution and login. If this is not possible, Telnet is preferred to RSH.

If RSH is the only alternative, follow these guidelines when using RSH:

- Specify only secure, trusted hosts in the `/etc/hosts.equiv` file.
- Always use IP addresses rather than host names in the `/etc/hosts.equiv` file.
- Always specify a single IP address with a single user name on each line in `/etc/hosts.equiv` file.
- Use the `rsh.access` option instead of the `trusted.hosts` option for access control.
- Make sure the `ip.match_any_ifaddr` option is set to `off`.

Syslog

Your storage system sends messages to hosts specified by the user in the `/etc/syslog.conf` file by using the syslog protocol on UDP port 514. It does not listen on this port, nor does it act as a syslog server.

The routed daemon

The routed daemon, routed, listens on UDP port 520. It receives broadcast messages from routers or other hosts using Routing Information Protocol (RIP). These messages are used by your storage system to update its internal routing tables to determine which network interfaces are optimal for each destination.

Your storage system never broadcasts RIP messages containing routes because Data ONTAP is not capable of acting as a router.

RIP is not secure because an attacker can easily send artificial RIP messages and cause hosts running the routed daemon (such as your storage system) to redirect network traffic to the attacker. The attacker can then receive and shift this traffic for passwords and other information and send it on to the actual destination, where the intrusion is undetected. This method can also be used as a starting point for TCP session attacks.

Because of these security issues, use static routes (those set up using the `route` command on your storage system) instead of using the routed daemon.

NDMP

Network Data Management Protocol (NDMP) runs on TCP port 10000 and is used primarily for backup of network-attached storage (NAS) devices, such as storage systems.

The protocol defines three authentication methods:

- NONE—allows authentication without restriction
- TEXT—sends a clear text password over the network, similar to Telnet or FTP
- MD5—uses the MD5 message digest algorithm along with a challenge-response message exchange to implement a secure login mechanism

Your storage system supports both the TEXT and MD5 authentication methods. Most NDMP-enabled backup software uses MD5 by default.

To entirely disable the TEXT authentication method, you should set the `ndmpd.authtype` option to `challenge`.

To restrict NDMP commands to certain authorized backup hosts, you should use the `ndmp.access` option.

Regardless of the authentication method used, NDMP sends backup data in decrypted format over the network, as does most other backup software. A separate network optimized for backup is a common means to increase performance while retaining data security.

To disable NDMP, you should set the `ndmp.enable` option to `off`.

SnapMirror and SnapVault

SnapMirror and SnapVault use TCP port 10566 for data transfer. Network connections are always initiated by the destination system; that is, SnapMirror and SnapVault *pull* data rather than *push* data.

Authentication is minimal with both SnapMirror and SnapVault. To restrict inbound TCP connections on port 10566 to a list of authorized hosts or IP addresses, you should configure the `snapmirror.access` or `snapvault.access` option. When a connection is established, the destination storage system communicates its host name to the source storage system, which then uses this host name to determine if a transfer is allowed. You should confirm a match between the host name and its IP address. To confirm that the host name and the IP address match, you should set the `snapmirror.checkip.enable` option to `on`.

To disable SnapMirror, you should set the `snapmirror.enable` option to `off`. To disable SnapVault, you should set the `snapvault.enable` option to `off`.

Error codes for the netdiag command

Network error codes are generated by the `netdiag` command. They describe the network problems and suggest the actions that you can take.

The following table lists some network error codes, describes the problems that the error codes point to, and suggests actions that you can take to fix the problems.

Note: Only a small fraction of the possible network error messages are presented in the following table. If you receive any problem code not listed in this table, contact your technical support.

Error code	Description	Recommended actions
201	Link not detected.	Complete the following steps until you detect a link: **1.** Ensure that the cable is connected between the switch port and your storage system interface, and that both ends are securely attached. **2.** Ensure that the switch port and interface are both configured to the `up` status, and one of the following is true: • Autonegotiation is enabled on both sides • Autonegotiation is disabled on both sides, and the duplex and speed settings match **3.** Because the switch port, cable, or NIC might be faulty, replace them, one by one, to locate the fault. **4.** If the problem persists, contact your technical support.
203	No link is detected because of a speed mismatch.	Change the interface configuration or peer switch port configuration to match the speed.
204	The interface is not configured to the `up` status.	Configure the interface state to the `up` status.
205	Duplex mismatch.	Change the interface or peer switch port duplex setting so that they match.
206	Link capacity problem.	Upgrade to a faster interface.

Error code	Description	Recommended actions
207	The interface is not transmitting or receiving.	Complete the following steps: **1.** Pull the network cable out from the network interface card. **2.** Reinsert the cable. **3.** Use `ifstat` to display statistics. • Link errors, such as CRC, are caused by a faulty switch port, cable, or NIC; replace them one by one to locate the fault. • Out-of-resource errors are caused by heavy loads. **4.** If the problem persists, contact your technical support.
208	Excessive I/O errors.	Complete the following steps: **1.** Reset the interface card. **2.** Check the cables. **3.** If the problem persists, contact your technical support.
209	Excessive unsupported protocol packets are being sent to your storage system.	The problem is not with your storage system. Contact your network administrator to resolve the problem.
301	The IP address and the netmask are inconsistent with the assigned broadcast address.	Change the configuration by using the `ifconfig` command.
302	The broadcast address reaches a larger set of hosts than the standard broadcast computed from the IP address and netmask.	If this behavior is erroneous, change the configuration.
303	There are excessive IP reassembly errors.	Switch from NFS over UDP to NFS over TCP.
401	The TCP window advertised by the client is too small.	The problem is not with your storage system. Reconfigure the client.

Error code	Description	Recommended actions
402	There is excessive packet loss on the sending side.	The problem is not with your storage system. Examine the network and the client for congestion.
403	There is excessive packet loss on the receiving side.	The problem is not with your storage system. Examine the network and the client for congestion.
404	The average TCP packet size is poor on the receiving side because the network, client, or both are not enabled to support jumbo frames.	The problem is not with your storage system. Enable support for jumbo frames in network devices and the client.
405	The average TCP packet size is poor on the receiving side because of a problem with the network, client, or both.	The problem is not with your storage system. Examine the network and client for configured MTUs.
406	The average TCP packet size is poor on the receiving side because of a client application problem.	The problem is not with your storage system. Examine the client application data transmission strategy.
407	Excessive TCP listen socket drops because the system is overloaded or under security attack.	Contact your network administrator to resolve the problem.
408	There are excessive filtered TCP port drops because the system is under security attack.	Check your network. Contact your network administrator to resolve the problem.

Error code	Description	Recommended actions
409	There are excessive embryonic TCP connection drops because the system is under security attack or because a client has a bug.	A packet trace might assist in locating the problem. Contact your network administrator to resolve the problem.
410	Excessive TCP checksum errors. These errors can be caused by bad hardware on the client, in the network infrastructure (for example, blade in switch or router), or on the NIC. These errors can also be caused by a bug in the client.	• Check your client system for bugs. • Replace hardware components until the problem is resolved. • Contact your network administrator to resolve the problem.
411	There are packets because of a client. Your system might be under a security attack.	The problem is not with your storage system. • Check your client system for bugs. • Check for a security attack.
451	There are excessive UDP checksum errors.	Switch from NFS over UDP to NFS over TCP.
601	The DNS server is not reachable.	Examine the DNS server and the path to the DNS server.
602	The NIS server is not reachable.	Examine the NIS server and the path to the NIS server.

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