Manage your network with the CLI

ONTAP 9

NetApp
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Network management overview

You can use the following information to perform basic storage network administration. You can configure physical and virtual network ports (VLANs and interface groups), create LIFs using IPv4 and IPv6, manage routing and host-resolution services in clusters, use load balancing to optimize network traffic, and monitor a cluster using SNMP.

Unless otherwise stated, these procedures apply to all versions of ONTAP 9.

You should use these procedures under the following circumstances:

- You want to understand the range of ONTAP network management capabilities.
- You want to use the CLI, not System Manager.

Upgrade considerations

Network features by release

Analyze the impact of network features available with each ONTAP 9 release.

Available beginning	Feature	Description
ONTAP 9.11.1	iSCSI LIF Failover	The new iSCSI LIF failover feature supports automatic and manual migration of iSCSI LIFs in an SFO partner failover and in a local failover. It is available for All SAN Array (ASA) platforms. iSCSI LIF failover for ASA platforms
ONTAP 9.11.1	LIF Services	New client-side LIF services provide more control over which LIFs are used for outbound AD, DNS, LDAP, and NIS requests. LIFs and service policies in ONTAP 9.6 and later
ONTAP 9.11.1	Link Layer Discovery Protocol (LLDP)	The cluster network supports LLDP to allow ONTAP to work with cluster switches that do not support Cisco Discovery Protocol (CDP). Display network connectivity with neighbor discovery protocols

ONTAP 9.10.1	Automatic detection and repair recommendations for network wiring issues	ONTAP can automatically detect and recommend corrections for network wiring issues based on a broadcast domain constituent's (ethernet ports) layer-2 reachability. When a port reachability issue is detected, System Manager recommends a repair operation to resolve the issue. Automatic detection and repair recommendations for network wiring issues
ONTAP 9.10.1	Internet Protocol security (IPsec) certificate authentication	IPsec policies now support pre-shared keys (PSKs) and certificates for authentication. • Policies configured with PSKs require sharing of the key among all clients in the policy. • Policies configured with certificates do not require sharing of the key among clients because each client can have its own unique certificate for authentication. Configure IP security (IPsec) over wire encryption
ONTAP 9.10.1	LIF services	Firewall policies are deprecated and wholly replaced with LIF service policies. A new NTP LIF service provides more control over which LIFs are used for outbound NTP requests. LIFs and service policies in ONTAP 9.6 and later
ONTAP 9.10.1	NFS over RDMA	ONTAP offers support for NFS over RDMA, a higher performance realization of NFSv4.0 for customers with the NVIDIA GDX ecosystem. Utilizing RDMA adapters allows memory to be copied directly from storage to the GPU, circumventing the CPU overhead. NFS over RDMA

ONTAP 9.9.1	Cluster resiliency	The following cluster resiliency and diagnostic improvements improve the customer experience:
		
		• Port monitoring and avoidance:
		  ◦ In two-node switchless cluster configurations, the system avoids ports that experience total packet loss (connectivity loss). Previously this functionality was only available in switched configurations.
		• Automatic node failover:
		  ◦ If a node cannot serve data across its cluster network, that node should not own any disks. Instead its HA partner should take over, if the partner is healthy.
		• Commands to analyze connectivity issues:
		  ◦ Use the following command to display which cluster paths are experiencing packet loss: `network interface check cluster-connectivity show`

<table>
<tr>
<td>ONTAP 9.9.1</td>
<td>VIP LIF enhancements</td>
<td>The following fields have been added to extend virtual IP (VIP) border gateway protocol (BGP) functionality:

• -asn or -peer-asn (4-byte value)
The attribute itself is not new, but it now uses a 4-byte integer.
• -med
• -use-peer-as-next-hop

The <code>asn_integer</code> parameter specifies the autonomous system number (ASN) or peer ASN.

• Beginning with ONTAP 9.8, ASN for BGP supports a 2-byte non-negative integer. This is a 16-bit number (0 - 64511 available values).
• Beginning with ONTAP 9.9.1, ASN for BGP supports a 4-byte non-negative integer (65536 - 4294967295). The default ASN is 65501. ASN 23456 is reserved for ONTAP session establishment with peers that do not announce 4-byte ASN capability.

You can make advanced route selections with Multi-Exit Discriminator (MED) support for path prioritization. MED is an optional attribute in the BGP update message that tells routers to select the best route for the traffic. The MED is an unsigned 32-bit integer (0 - 4294967295); lower values are preferred.

VIP BGP provides default route automation using BGP peer grouping to simplify configuration. ONTAP has a simple way to learn default routes using the BGP peers as next-hop routers when the BGP peer is on the same subnet. To use the feature, set the <code>-use-peer-as-next-hop</code> attribute to <code>true</code>. By default, this attribute is <code>false</code>.

Configure virtual IP (VIP) LIFs</td>
</tr>
</table>

ONTAP 9.8	Auto port placement	ONTAP can automatically configure broadcast domains, select ports, and help configure network interfaces (LIFs), virtual LANs (VLANs), and link aggregation groups (LAGs) based on reachability and network topology detection. When you first create a cluster, ONTAP automatically discovers the networks connected to ports and configures the needed broadcast domains based on layer 2 reachability. You no longer have to configure broadcast domains manually. A new cluster will continue to be created with two IPspaces: **Cluster IPspace**: Containing one broadcast domain for the cluster interconnect. You should never touch this configuration. **Default IPspace**: Containing one or more broadcast domains for the remaining ports. Depending on your network topology, ONTAP configures additional broadcast domains as needed: Default-1, Default-2, and so on. You can rename these broadcast domains if desired, but do not modify which ports are configured in these broadcast domains. When you configure network interfaces, the home port selection is optional. If you do not manually select a home port, ONTAP will attempt to assign an appropriate home port in the same broadcast domain as other network interfaces in the same subnet. When creating a VLAN or adding the first port to a newly created LAG, ONTAP will attempt to automatically assign the VLAN or LAG to the appropriate broadcast domain based on its layer 2 reachability. By automatically configuring broadcast domains and ports, ONTAP helps to ensure that clients maintain access to their data during failover to another port or node in the cluster. Finally, ONTAP sends EMS messages when it detects that the port reachability is incorrect and provides the "network port reachability repair" command to automatically repair common misconfigurations.
ONTAP 9.8	Internet Protocol security (IPsec) over wire encryption	To ensure data is continuously secure and encrypted, even while in transit, ONTAP uses the IPsec protocol in transport mode. IPsec offers data encryption for all IP traffic including the NFS, iSCSI, and SMB protocols. IPsec provides the only encryption in flight option for iSCSI traffic. Once IPsec is configured, network traffic between the client and ONTAP is protected with preventive measures to combat replay and man-in-the-middle (MITM) attacks. Configure IP security (IPsec) over wire encryption

ONTAP 9.8	Virtual IP (VIP) expansion	New fields have been added to the `network bgp peer-group` command. This expansion allows you to configure two additional Border Gateway Protocol (BGP) attributes for Virtual IP (VIP). **AS path prepend**: Other factors being equal, BGP prefers to select the route with shortest AS (autonomous system) Path. You can use the optional AS path prepend attribute to repeat an autonomous system number (ASN), which increases the length of the AS path attribute. The route update with the shortest AS path will be selected by the receiver. **BGP community**: The BGP community attribute is a 32-bit tag that can be assigned to the route updates. Each route update can have one or more BGP community tags. The neighbors receiving the prefix can examine the community value and take actions like filtering or applying specific routing policies for redistribution.
ONTAP 9.8	Switch CLI simplification	To simplify switch commands, the cluster and storage switch CLIs are consolidated. The consolidated switch CLIs include Ethernet switches, FC switches, and ATTO protocol bridges. Instead of using separate "system cluster-switch" and "system storage-switch" commands, you now use "system switch". For the ATTO protocol bridge, instead of using "storage bridge", use "system bridge". Switch health monitoring has similarly expanded to monitor the storage switches as well as the cluster interconnect switch. You can view health information for the cluster interconnect under "cluster_network" in the "client_device" table. You can view health information for a storage switch under "storage_network" in the "client_device" table.
ONTAP 9.8	IPv6 variable length	The supported IPv6 variable prefix length range has increased from 64 to 1 through 127 bits. A value of bit 128 remains reserved for virtual IP (VIP). When upgrading, non-VIP LIF lengths other than 64 bits are blocked until the last node is updated. When reverting an upgrade, the revert checks any non-VIP LIFs for any prefix other than 64 bits. If found, the check blocks the revert until you delete or modify the offending LIF. VIP LIFs are not checked.

ONTAP 9.7	Automatic portmap service	The portmap service maps RPC services to the ports on which they listen. The portmap service is always accessible in ONTAP 9.3 and earlier, is configurable in ONTAP 9.4 through ONTAP 9.6, and is managed automatically beginning with ONTAP 9.7. **In ONTAP 9.3 and earlier**: The portmap service (rpcbind) is always accessible on port 111 in network configurations that rely on the built-in ONTAP firewall rather than a third-party firewall. **From ONTAP 9.4 through ONTAP 9.6**: You can modify firewall policies to control whether the portmap service is accessible on particular LIFs. **Beginning with ONTAP 9.7**: The portmap firewall service is eliminated. Instead, the portmap port is opened automatically for all LIFs that support the NFS service. Portmap service configuration
ONTAP 9.7	Cache search	You can cache NIS `netgroup.byhost` entries using the `vserver services name-service nis-domain netgroup-database` commands.
ONTAP 9.6	CUBIC	CUBIC is the default TCP congestion control algorithm for ONTAP hardware. CUBIC replaced the ONTAP 9.5 and earlier default TCP congestion control algorithm, NewReno. CUBIC addresses the problems of long, fat networks (LFNs), including high round trip times (RTTs). CUBIC detects and avoids congestion. CUBIC improves performance for most environments.
ONTAP 9.6	LIF service policies replace LIF roles	You can assign service policies (instead of LIF roles) to LIFs that determine the kind of traffic that is supported for the LIFs. Service policies define a collection of network services supported by a LIF. ONTAP provides a set of built-in service policies that can be associated with a LIF. ONTAP supports service policies beginning with ONTAP 9.5; however, service policies can only be used to configure a limited number of services. Beginning with with ONTAP 9.6, LIF roles are deprecated and service policies are supported for all types of services. LIFs and service policies
ONTAP 9.5	NTPv3 support	Network Time Protocol (NTP) version 3 includes symmetric authentication using SHA-1 keys, which increases network security.

ONTAP 9.5	SSH login security alerts	When you log in as a Secure Shell (SSH) admin user, you can view information about previous logins, unsuccessful attempts to log in, and changes to your role and privileges since your last successful login.
ONTAP 9.5	LIF service policies	You can create new service policies or use a built-in policy. You can assign a service policy to one or more LIFs; thereby allowing the LIF to carry traffic for a single service or a list of services. LIFs and service policies
ONTAP 9.5	VIP LIFs and BGP support	A VIP data LIF is a LIF that is not part of any subnet and is reachable from all ports that host a border gateway protocol (BGP) LIF in the same IPspace. A VIP data LIF eliminates the dependency of a host on individual network interfaces. Create a virtual IP (VIP) data LIF
ONTAP 9.5	Multipath routing	Multipath routing provides load balancing by utilizing all the available routes to a destination. Enable multipath routing
ONTAP 9.4	Portmap service	The portmap service maps remote procedure call (RPC) services to the ports on which they listen. The portmap service is always accessible in ONTAP 9.3 and earlier. Beginning with ONTAP 9.4, the portmap service is configurable. You can modify firewall policies to control whether the portmap service is accessible on particular LIFs. Portmap service configuration
ONTAP 9.4	SSH MFA for LDAP or NIS	SSH multi-factor authentication (MFA) for LDAP or NIS uses a public key and nsswitch to authenticate remote users.
ONTAP 9.3	SSH MFA	SSH MFA for local administrator accounts use a public key and a password to authenticate local users.
ONTAP 9.3	SAML authentication	You can use Security Assertion Markup Language (SAML) authentication to configure MFA for web services such as Service Processor Infrastructure (spi), ONTAP APIs, and OnCommand System Manager.
ONTAP 9.2	SSH login attempts	You can configure the maximum number of unsuccessful SSH login attempts to protect against brute force attacks.

ONTAP 9.2	Digital security certificates	ONTAP provides enhanced support for digital certificate security with Online Certificate Status Protocol (OCSP) and pre-installed default security certificates.
ONTAP 9.2	Fastpath	As part of a networking stack update for improved performance and resiliency, fast path routing support was removed in ONTAP 9.2 and later releases because it made it difficult to identify problems with improper routing tables. Therefore, it is no longer possible to set the following option in the nodeshell, and existing fast path configurations are disabled when upgrading to ONTAP 9.2 and later: `ip.fastpath.enable` Network traffic not sent or sent out of an unexpected interface after upgrade to 9.2 due to elimination of IP Fastpath
ONTAP 9.1	Security with SNMPv3 traphosts	You can configure SNMPv3 traphosts with the User-based Security Model (USM) security. With this enhancement, SNMPv3 traps can be generated by using a predefined USM user's authentication and privacy credentials. Configure traphosts to receive SNMP notifications
ONTAP 9.0	IPv6	Dynamic DNS (DDNS) name service is available on IPv6 LIFs. Create a LIF
ONTAP 9.0	LIFs per node	The supported number of LIFs per node has increased for some systems. See the Hardware Universe for the number of LIFs supported on each platform for a specified ONTAP release. Create a LIF NetApp hardware universe
ONTAP 9.0	LIF management	ONTAP and System Manager automatically detect and isolate network port failures. LIFs are automatically migrated from degraded ports to healthy ports. Monitor the health of network ports
ONTAP 9.0	LLDP	Link Layer Discovery Protocol (LLDP) provides a vendor-neutral interface for verifying and troubleshooting cabling between an ONTAP system and a switch or router. It is an alternative to Cisco Discovery Protocol (CDP), a proprietary link layer protocol developed by Cisco Systems. Enable or Disable LLDP

ONTAP 9.0	UC compliance with DSCP marking	Unified Capability (UC) compliance with Differentiated Services Code Point (DSCP) marking. Differentiated Services Code Point (DSCP) marking is a mechanism for classifying and managing network traffic and is a component of Unified Capability (UC) compliance. You can enable DSCP marking on outgoing (egress) IP packet traffic for a given protocol with a default or user-provided DSCP code. If you do not provide a DSCP value when enabling DSCP marking for a given protocol, a default is used: **0x0A (10)**: The default value for data protocols/traffic. **0x30 (48)**: The default value for control protocols/traffic. DSCP marking for US compliance
ONTAP 9.0	SHA-2 password hash function	To enhance password security, ONTAP 9 supports the SHA-2 password hash function and uses SHA-512 by default for hashing newly created or changed passwords. Existing user accounts with unchanged passwords continue to use the MD5 hash function after the upgrade to ONTAP 9 or later, and users can continue to access their accounts. However, it is strongly recommended that you migrate MD5 accounts to SHA-512 by having users change their passwords.
ONTAP 9.0	FIPS 140-2 support	You can enable the Federal Information Processing Standard (FIPS) 140-2 compliance mode for cluster-wide control plane web service interfaces. By default, the FIPS 140-2 only mode is disabled. Configure network security using Federal Information Processing Standards (FIPS)

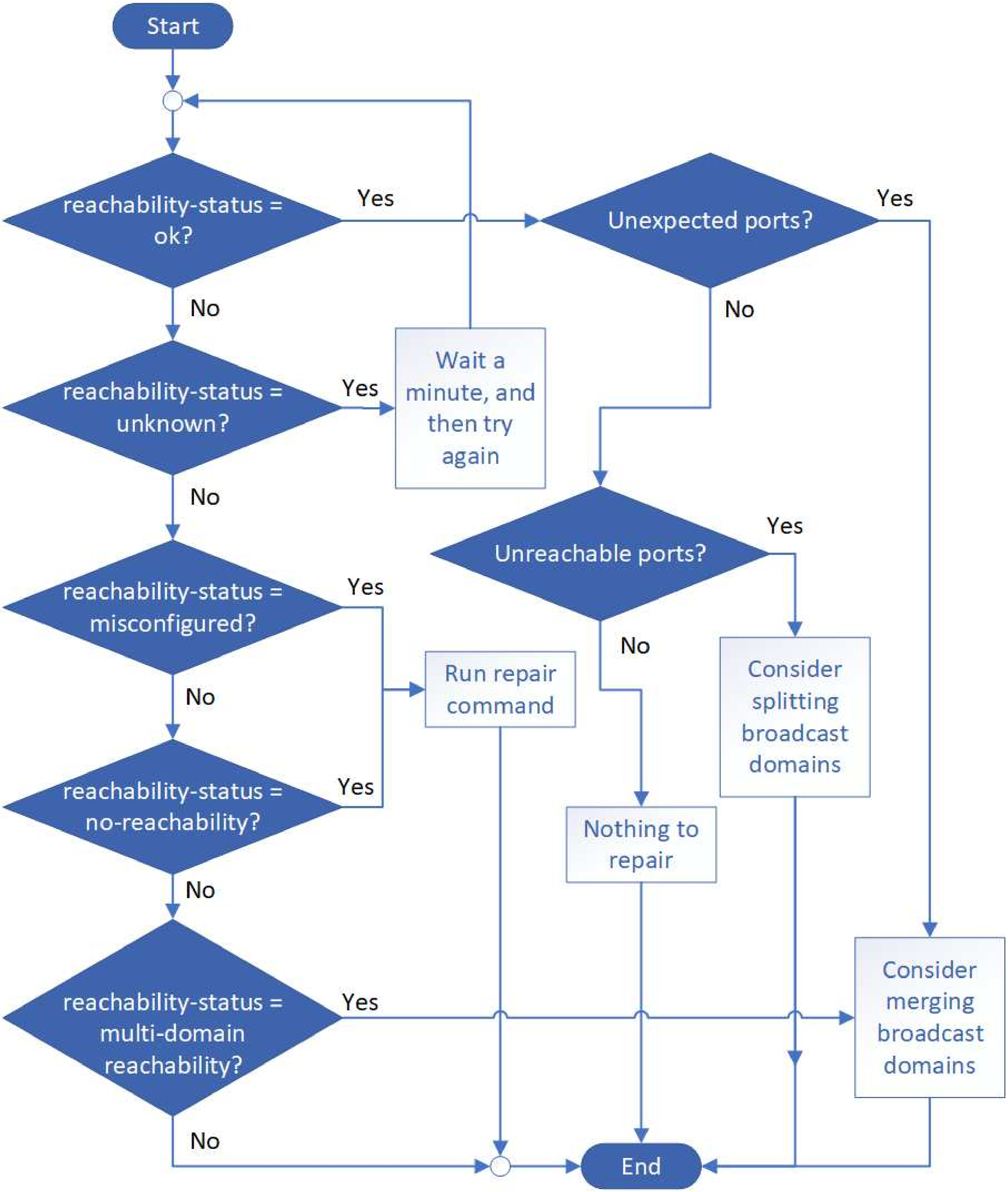
Verify your networking configuration after upgrading to ONTAP 9.8 or later

After an upgrade to ONTAP 9.8, you should verify your network configuration. After the upgrade, ONTAP automatically monitors layer 2 reachability.

Use the following command to verify each port has reachability to its expected broadcast domain:

```
network port reachability show -detail
```

The command output contains reachability results. Use the following decision tree and table to understand the reachability results (reachability-status) and determine what, if anything, to do next.



reachability-status	Description

ok	The port has layer 2 reachability to its assigned broadcast domain. If the reachability-status is "ok", but there are "unexpected ports", consider merging one or more broadcast domains. For more information, see Merge broadcast domains. If the reachability-status is "ok", but there are "unreachable ports", consider splitting one or more broadcast domains. For more information, see Split broadcast domains. If the reachability-status is "ok", and there are no unexpected or unreachable ports, your configuration is correct.
misconfigured-reachability	The port does not have layer 2 reachability to its assigned broadcast domain; however, the port does have layer 2 reachability to a different broadcast domain. You can repair the port reachability. When you run the following command, the system will assign the port to the broadcast domain to which it has reachability: `network port reachability repair -node -port` For more information, see Repair port reachability.
no-reachability	The port does not have layer 2 reachability to any existing broadcast domain. You can repair the port reachability. When you run the following command, the system will assign the port to a new automatically created broadcast domain in the Default IPspace: `network port reachability repair -node -port` For more information, see Repair port reachability.
multi-domain-reachability	The port has layer 2 reachability to its assigned broadcast domain; however, it also has layer 2 reachability to at least one other broadcast domain. Examine the physical connectivity and switch configuration to determine if it is incorrect or if the port's assigned broadcast domain needs to be merged with one or more broadcast domains. For more information, see Merge broadcast domains or Repair port reachability.
unknown	If the reachability-status is "unknown", then wait a few minutes and try the command again.

After you repair a port, you need to check for and resolve displaced LIFs and VLANs. If the port was part of an interface group, you also need to understand what happened to that interface group. For more information, see Repair port reachability.

Networking components of a cluster

Overview

You should familiarize yourself with the networking components of a cluster before setting up the cluster. Configuring the physical networking components of a cluster into logical components provides the flexibility and multi-tenancy functionality in ONTAP.

The various networking components in a cluster are as follows:

- Physical ports

  Network interface cards (NICs) and host bus adapters (HBAs) provide physical (Ethernet and Fibre Channel) connections from each node to the physical networks (management and data networks).

  For site requirements, switch information, port cabling information, and controller onboard port cabling, see the Hardware Universe at hwu.netapp.com.

- Logical ports

  Virtual local area networks (VLANs) and interface groups constitute the logical ports. Interface groups treat several physical ports as a single port, while VLANs subdivide a physical port into multiple separate ports.

- IPspaces

  You can use an IPspace to create a distinct IP address space for each SVM in a cluster. Doing so enables clients in administratively separate network domains to access cluster data while using overlapping IP addresses from the same IP address subnet range.

- Broadcast domains

  A broadcast domain resides in an IPspace and contains a group of network ports, potentially from many nodes in the cluster, that belong to the same layer 2 network. The ports in the group are used in an SVM for data traffic.

- Subnets

  A subnet is created within a broadcast domain and contains a pool of IP addresses that belong to the same layer 3 subnet. This pool of IP addresses simplifies IP address allocation during LIF creation.

- Logical interfaces

  A logical interface (LIF) is an IP address or a worldwide port name (WWPN) that is associated with a port. It is associated with attributes such as failover groups, failover rules, and firewall rules. A LIF communicates over the network through the port (physical or logical) to which it is currently bound.

  The different types of LIFs in a cluster are data LIFs, cluster-scoped management LIFs, node-scoped management LIFs, intercluster LIFs, and cluster LIFs. The ownership of the LIFs depends on the SVM where the LIF resides. Data LIFs are owned by data SVMs, node-scoped management LIFs, cluster-scoped management, and intercluster LIFs are owned by the admin SVMs, and cluster LIFs are owned by the cluster SVM.

- DNS zones

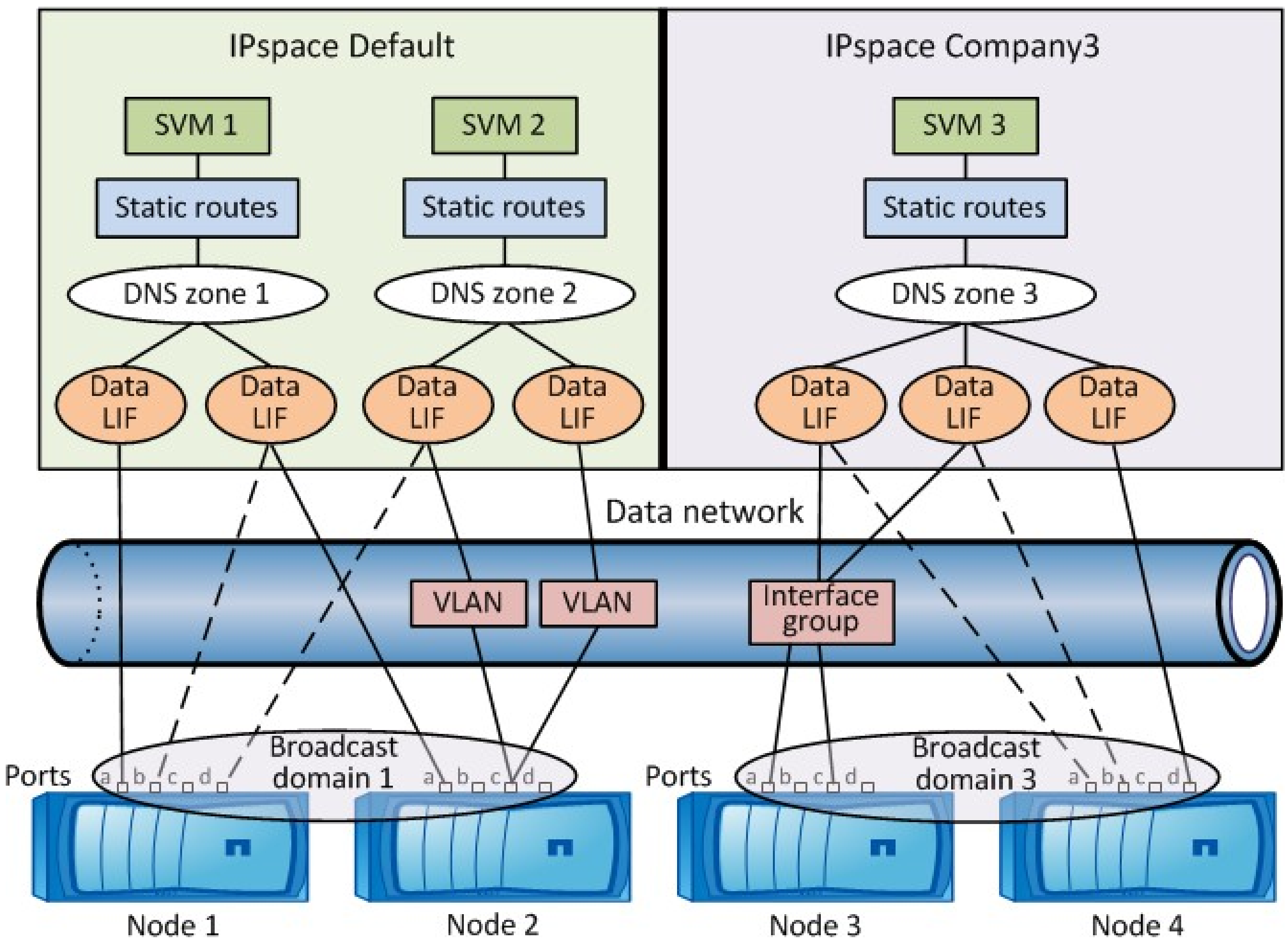
  DNS zone can be specified during the LIF creation, providing a name for the LIF to be exported through the cluster’s DNS server. Multiple LIFs can share the same name, allowing the DNS load balancing feature to distribute IP addresses for the name according to load.

SVMs can have multiple DNS zones.

- Routing

  Each SVM is self-sufficient with respect to networking. An SVM owns LIFs and routes that can reach each of the configured external servers.

  The following figure illustrates how the different networking components are associated in a four-node cluster:

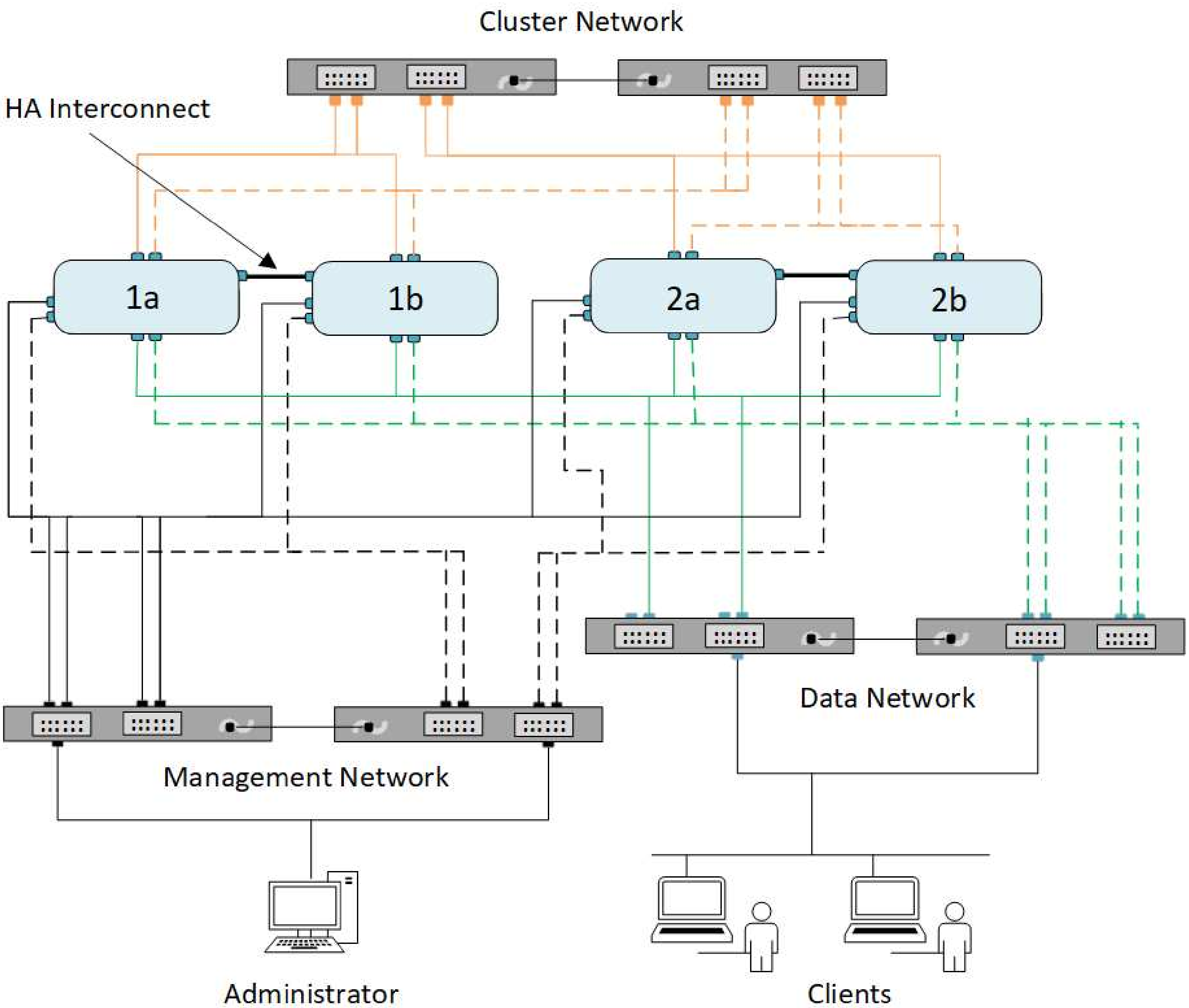


Network cabling guidelines

Network cabling best practices separate traffic into the following networks: cluster, management, and data.

You should cable a cluster so that the cluster traffic is on a separate network from all other traffic. It is an optional, but recommended practice to have network management traffic separated from data and intracluster traffic. By maintaining separate networks, you can achieve better performance, ease of administration, and improved security and management access to the nodes.

The following diagram illustrates the network cabling of a four-node HA cluster that includes three separate networks:



You should follow certain guidelines when cabling network connections:

- Each node should be connected to three distinct networks.

  One network is for management, one is for data access, and one is for intracluster communication. The management and data networks can be logically separated.

- You can have more than one data network connection to each node for improving the client (data) traffic flow.
- A cluster can be created without data network connections, but it must include a cluster interconnect connection.
- There should always be two or more cluster connections to each node, but nodes on FAS22xx systems can be configured with a single 10-GbE cluster port.

For more information on network cabling, see the AFF and FAS System Documentation Center and the Hardware Universe.

Relationship between broadcast domains, failover groups, and failover policies

Broadcast domains, failover groups, and failover policies work together to determine which port will take over when the node or port on which a LIF is configured fails.

A broadcast domain lists all the ports reachable in the same layer 2 Ethernet network. An Ethernet broadcast packet sent from one of the ports is seen by all other ports in the broadcast domain. This common-reachability characteristic of a broadcast domain is important to LIFs because if a LIF were to fail over to any other port in the broadcast domain, it could still reach every local and remote host that was reachable from the original port.

Failover groups define the ports within a broadcast domain that provide LIF failover coverage for each other. Each broadcast domain has one failover group that includes all its ports. This failover group containing all ports in the broadcast domain is the default and recommended failover group for the LIF. You can create failover groups with smaller subsets that you define, such as a failover group of ports that have the same link speed within a broadcast domain.

A failover policy dictates how a LIF uses the ports of a failover group when a node or port goes down. Consider the failover policy as a type of filter that is applied to a failover group. The failover targets for a LIF (the set of ports to which a LIF can failover) is determined by applying the LIF's failover policy to the LIF's failover group in the broadcast domain.

You can view the failover targets for a LIF using the following CLI command:

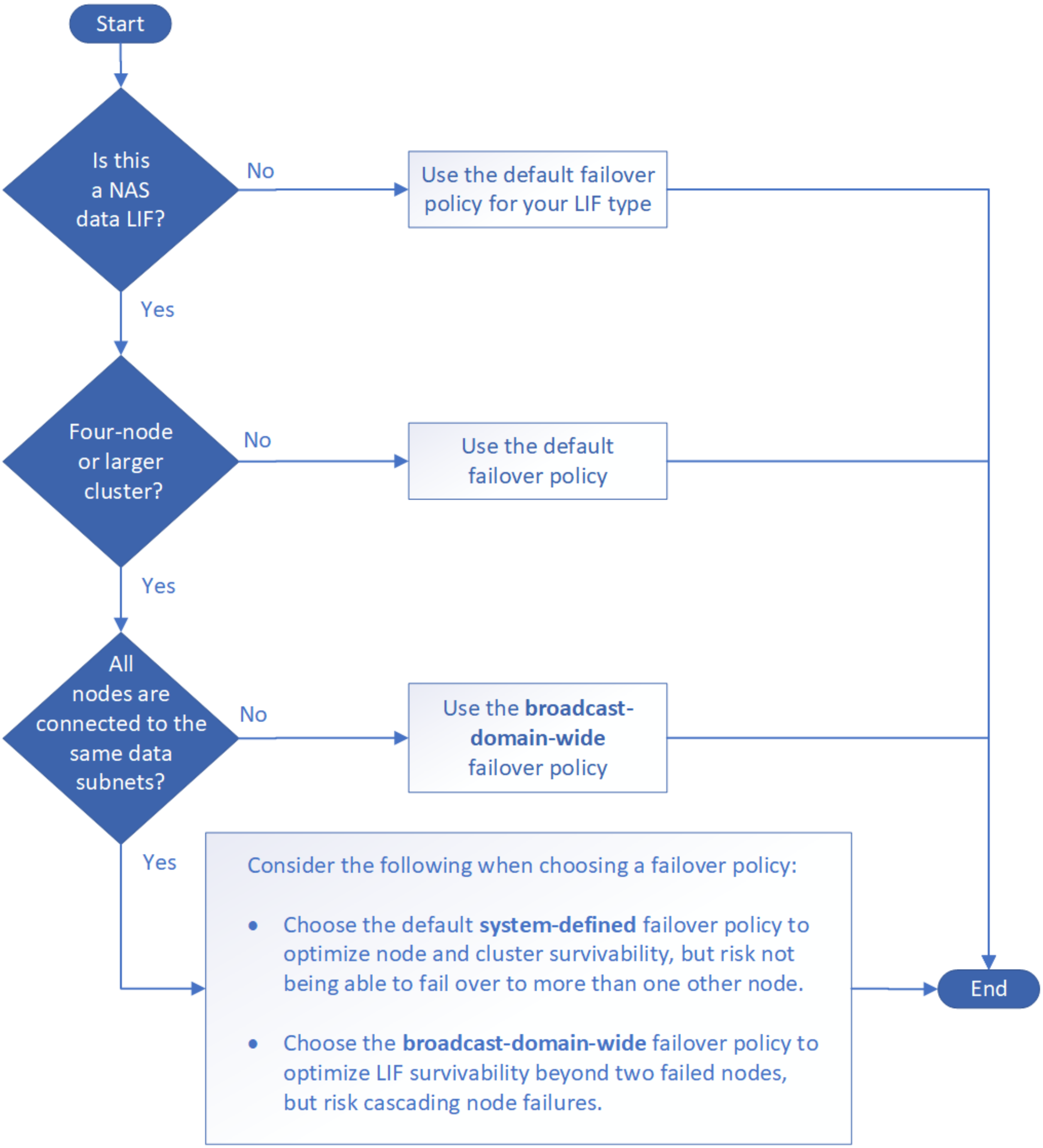
```
network interface show -failover
```

NetApp strongly recommends using the default failover policy for your LIF type.

Decide which LIF failover policy to use

Decide whether to use the recommended, default failover policy or whether to change it based on your LIF type and environment.

Failover policy decision tree



Default failover policies by LIF type

LIF type	Default failover policy	Description
BGP LIFs	disabled	LIF does not fail over to another port.
Cluster LIFs	local-only	LIF fails over to ports on the same node only.
Cluster-mgmt LIF	broadcast-domain-wide	LIF fails over to ports in the same broadcast domain, on any and every node in the cluster.

Intercluster LIFs	local-only	LIF fails over to ports on the same node only.
NAS data LIFs	system-defined	LIF fails over to one other node that is not the HA partner.
Node management LIFs	local-only	LIF fails over to ports on the same node only.
SAN data LIFs	disabled	LIF does not fail over to another port.

The `sfo-partner-only` failover policy is not a default, but can be used when you want the LIF to fail over to a port on the home node or SFO partner only.

Configure network ports (cluster administrators only)

Overview

Ports are either physical ports (NICs) or virtualized ports, such as interface groups or VLANs.

Virtual local area networks (VLANs) and interface groups constitute the virtual ports. Interface groups treat several physical ports as a single port, while VLANs subdivide a physical port into multiple separate logical ports.

- Physical ports: LIFs can be configured directly on physical ports.
- Interface group: A port aggregate containing two or more physical ports that act as a single trunk port. An interface group can be single-mode, multimode, or dynamic multimode.
- VLAN: A logical port that receives and sends VLAN-tagged (IEEE 802.1Q standard) traffic. VLAN port characteristics include the VLAN ID for the port. The underlying physical port or interface group ports are considered VLAN trunk ports, and the connected switch ports must be configured to trunk the VLAN IDs.

  The underlying physical port or interface group ports for a VLAN port can continue to host LIFs, which transmit and receive untagged traffic.
- Virtual IP (VIP) port: A logical port that is used as the home port for a VIP LIF. VIP ports are created automatically by the system and support only a limited number of operations. VIP ports are supported beginning with ONTAP 9.5.

The port naming convention is *enumberletter*:

- The first character describes the port type.
  "e" represents Ethernet.
- The second character indicates the numbered slot in which the port adapter is located.
- The third character indicates the port's position on a multiport adapter.
  "a" indicates the first port, "b" indicates the second port, and so on.

For example, `e0b` indicates that an Ethernet port is the second port on the node's motherboard.

VLANs must be named by using the syntax `port_name-vlan-id`.

`port_name` specifies the physical port or interface group.

`vlan-id` specifies the VLAN identification on the network. For example, `e1c-80` is a valid VLAN name.

Combine physical ports to create interface groups

An interface group is created by combining two or more physical ports into a single logical port. The logical port provides increased resiliency, increased availability, and load sharing.

Interface group types

Three types of interface groups are supported on the storage system: single-mode, static multimode, and dynamic multimode. Each interface group provides different levels of fault tolerance. Multimode interface groups provide methods for load balancing network traffic.

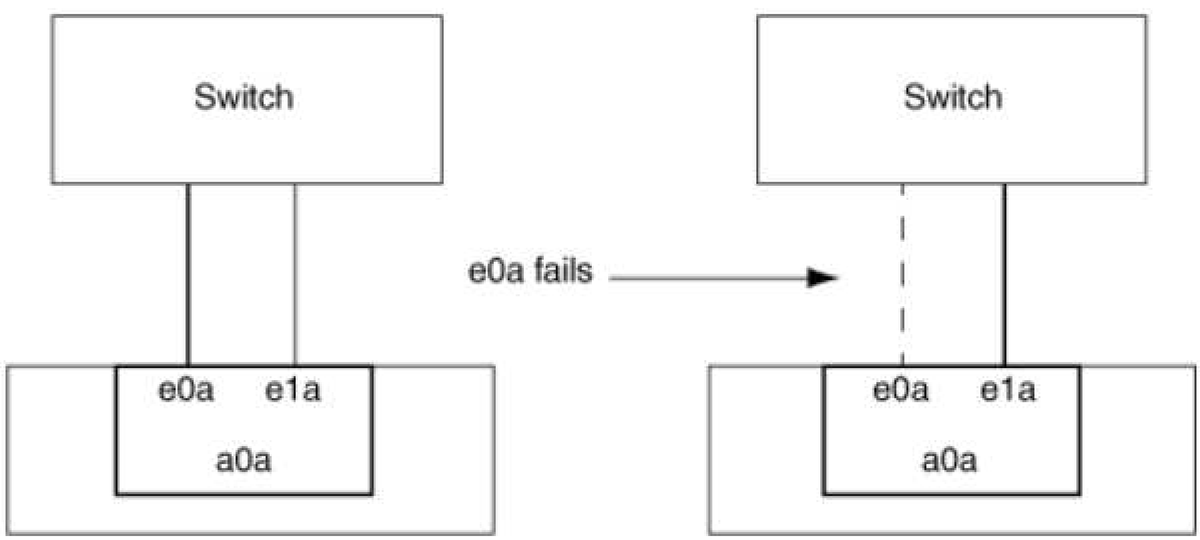
Characteristics of single-mode interface groups

In a single-mode interface group, only one of the interfaces in the interface group is active. The other interfaces are on standby, ready to take over if the active interface fails.

Characteristics of a single-mode interface groups:

- For failover, the cluster monitors the active link and controls failover.
  Because the cluster monitors the active link, there is no switch configuration required.
- There can be more than one interface on standby in a single-mode interface group.
- If a single-mode interface group spans multiple switches, you must connect the switches with an Inter-Switch link (ISL).
- For a single-mode interface group, the switch ports must be in the same broadcast domain.
- Link-monitoring ARP packets, which have a source address of 0.0.0.0, are sent over the ports to verify that the ports are in the same broadcast domain.

The following figure is an example of a single-mode interface group. In the figure, e0a and e1a are part of the a0a single-mode interface group. If the active interface, e0a, fails, the standby e1a interface takes over and maintains the connection to the switch.



> To accomplish single-mode functionality, the recommended approach is to instead use failover groups. By using a failover group, the second port can still be used for other LIFs and need not remain unused. Additionally, failover groups can span more than two ports and can span ports on multiple nodes.

Characteristics of static multimode interface groups

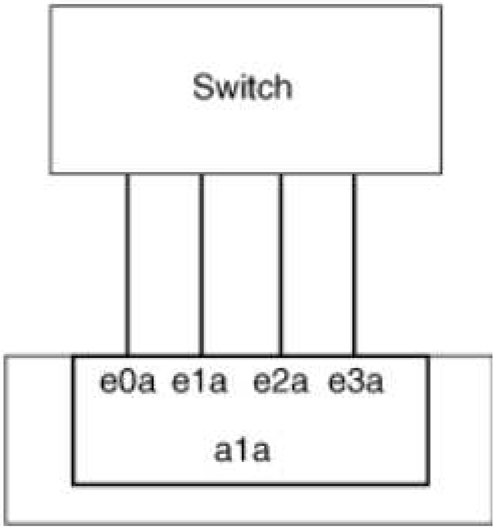
The static multimode interface group implementation in ONTAP complies with IEEE 802.3ad (static). Any switch that supports aggregates, but does not have control packet exchange for configuring an aggregate, can be used with static multimode interface groups.

Static multimode interface groups do not comply with IEEE 802.3ad (dynamic), also known as Link Aggregation Control Protocol (LACP). LACP is equivalent to Port Aggregation Protocol (PAgP), the proprietary link aggregation protocol from Cisco.

The following are characteristics of a static multimode interface group:

- All interfaces in the interface group are active and share a single MAC address.
  - Multiple individual connections are distributed among the interfaces in the interface group.
  - Each connection or session uses one interface within the interface group.
    When you use the sequential load balancing scheme, all sessions are distributed across available links on a packet-by-packet basis, and are not bound to a particular interface from the interface group.
- Static multimode interface groups can recover from a failure of up to "n-1" interfaces, where n is the total number of interfaces that form the interface group.
- If a port fails or is unplugged, the traffic that was traversing the failed link is automatically redistributed to one of the remaining interfaces.
- Static multimode interface groups can detect a loss of link, but they cannot detect a loss of connectivity to the client or switch misconfigurations that might impact connectivity and performance.
- A static multimode interface group requires a switch that supports link aggregation over multiple switch ports.
  The switch is configured so that all ports to which links of an interface group 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 interface group.

The following figure is an example of a static multimode interface group. Interfaces e0a, e1a, e2a, and e3a are part of the a1a multimode interface group. All four interfaces in the a1a multimode interface group 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 interface groups in ONTAP conform to the IEEE 802.3 standards. If a particular multiple switch link aggregation technology is said to interoperate with or conform to the IEEE 802.3 standards, it should operate with ONTAP.

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

Dynamic multimode interface group

Dynamic multimode interface groups implement Link Aggregation Control Protocol (LACP) to communicate group membership to the directly attached switch. LACP enables you to detect the loss of link status and the inability of the node to communicate with the direct-attached switch port.

Dynamic multimode interface group implementation in ONTAP complies with IEEE 802.3 AD (802.1 AX). ONTAP does not support Port Aggregation Protocol (PAgP), which is a proprietary link aggregation protocol from Cisco.

A dynamic multimode interface group requires a switch that supports LACP.

ONTAP implements LACP in nonconfigurable active mode that works well with switches that are configured in either active or passive mode. ONTAP implements the long and short LACP timers (for use with nonconfigurable values 3 seconds and 90 seconds), as specified in IEEE 802.3 AD (802.1AX).

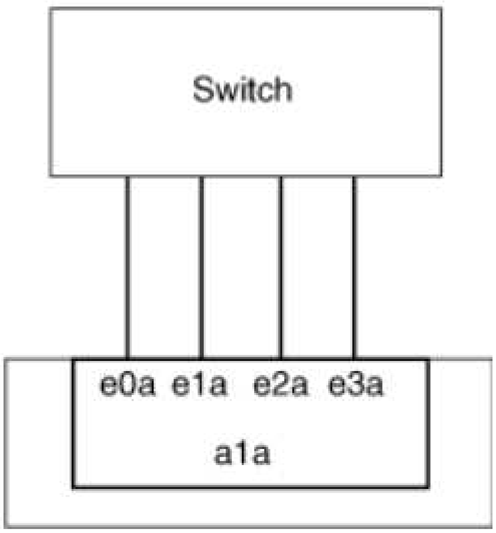
The ONTAP load balancing algorithm determines the member port to be used to transmit outbound traffic, and does not control how inbound frames are received. The switch determines the member (individual physical port) of its port channel group to be used for transmission, based on the load balancing algorithm configured in the switch’s port channel group. Therefore, the switch configuration determines the member port (individual physical port) of the storage system to receive traffic. For more information about configuring the switch, see the documentation from your switch vendor.

If an individual interface fails to receive successive LACP protocol packets, then that individual interface is marked as "lag_inactive" in the output of "ifgrp status" command. Existing traffic is automatically rerouted to any remaining active interfaces.

The following rules apply when using dynamic multimode interface groups:

- Dynamic multimode interface groups should be configured to use the port-based, IP-based, MAC-based, or round robin load balancing methods.
- In a dynamic multimode interface group, all interfaces must be active and share a single MAC address.

The following figure is an example of a dynamic multimode interface group. Interfaces e0a, e1a, e2a, and e3a are part of the a1a multimode interface group. All four interfaces in the a1a dynamic multimode interface group are active.



Load balancing in multimode interface groups

You can ensure that all interfaces of a multimode interface group are equally utilized for outgoing traffic by using the IP address, MAC address, sequential, or port-based load balancing methods to distribute network traffic equally over the network ports of a multimode interface group.

The load balancing method for a multimode interface group can be specified only when the interface group is created.

Best Practice: Port-based load balancing is recommended whenever possible. Use port-based load balancing unless there is a specific reason or limitation in the network that prevents it.

Port-based load balancing

Port-based load balancing is the recommended method.

You can equalize traffic on a multimode interface group 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.

IP address and MAC address load balancing

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

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.

Do not select the MAC address load balancing method when creating interface groups on a 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 interface group is used.

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

Sequential load balancing

You can use sequential load balancing to equally distribute packets among multiple links using a round robin algorithm. You can use the sequential option for load balancing a single connection's traffic across multiple links to increase single connection throughput.

However, because sequential load balancing may cause out-of-order packet delivery, extremely poor performance can result. Therefore, sequential load balancing is generally not recommended.

Create an interface group

You can create an interface group—single-mode, static multimode, or dynamic multimode (LACP)—to present a single interface to clients by combining the capabilities of the aggregated network ports.

About this task

- For a complete list of configuration restrictions that apply to port interface groups, see the `network port ifgrp add-port` man page.
- When creating a multimode interface group, you can specify any of the following load-balancing methods:
  - port: Network traffic is distributed on the basis of the transport layer (TCP/UDP) ports. This is the recommended load-balancing method.
  - mac: Network traffic is distributed on the basis of MAC addresses.
  - ip: Network traffic is distributed on the basis of IP addresses.
  - sequential: Network traffic is distributed as it is received.

The MAC address of an interface group is determined by the order of the underlying ports and how these ports initialize during bootup. You should therefore not assume that the ifgrp MAC address is persistent across reboots or ONTAP upgrades.

Step

Use the `network port ifgrp create` command to create an interface group.

Interface groups must be named using the syntax `a<number><letter>`. For example, a0a, a0b, a1c, and a2a are valid interface group names.

For more information about this command, see ONTAP 9 commands.

The following example shows how to create an interface group named a0a with a distribution function of port and a mode of multimode:

```
network port ifgrp create -node cluster-1-01 -ifgrp a0a -distr-func port -mode
multimode
```

Add a port to an interface group

You can add up to 16 physical ports to an interface group for all port speeds.

Step

Add network ports to the interface group:

```
network port ifgrp add-port
```

For more information about this command, see ONTAP 9 commands.

The following example shows how to add port e0c to an interface group named a0a:

```
network port ifgrp add-port -node cluster-1-01 -ifgrp a0a -port e0c
```

Beginning with ONTAP 9.8, interface groups are automatically placed into an appropriate broadcast domain about one minute after the first physical port is added to the interface group. If you do not want ONTAP to do this, and prefer to manually place the ifgrp into a broadcast domain, then specify the `-skip-broadcast -domain-placement` parameter as part of the `ifgrp add-port` command.

Remove a port from an interface group

You can remove a port from an interface group that hosts LIFs, as long as it is not the last port in the interface group. There is no requirement that the interface group must not host LIFs or that the interface group must not be the home port of a LIF considering that you are not removing the last port from the interface group. However, if you are removing the last port, then you must migrate or move the LIFs from the interface group first.

About this task

You can remove up to 16 ports (physical interfaces) from an interface group.

Step

Remove network ports from an interface group:

```
network port ifgrp remove-port
```

The following example shows how to remove port e0c from an interface group named a0a:

```
network port ifgrp remove-port -node cluster-1-01 -ifgrp a0a -port e0c
```

Delete an interface group

You can delete interface groups if you want to configure LIFs directly on the underlying physical ports or decide to change the interface group mode or distribution function.

Before you begin

- The interface group must not be hosting a LIF.
- The interface group must be neither the home port nor the failover target of a LIF.

Step

Use the `network port ifgrp delete` command to delete an interface group.

For more information about this command, see ONTAP 9 commands.

The following example shows how to delete an interface group named a0b:

```
network port ifgrp delete -node cluster-1-01 -ifgrp a0b
```

Configure VLANs over physical ports

VLANs provide logical segmentation of networks by creating separate broadcast domains that are defined on a switch port basis as opposed to the traditional broadcast domains, defined on physical boundaries.

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.

You can manage VLANs by creating, deleting, or displaying information about them.

> You should not create a VLAN on a network interface with the same identifier as the native VLAN of the switch. For example, if the network interface e0b is on native VLAN 10, you should not create a VLAN e0b-10 on that interface.

Create a VLAN

You can create a VLAN for maintaining separate broadcast domains within the same network domain by using the `network port vlan create` command.

Before you begin

Your network administrator must have confirmed that the following requirements have been met:

- The switches deployed in the network must either comply with IEEE 802.1Q standards or have a vendor-specific implementation of VLANs.
- For supporting multiple VLANs, an end-station must be statically configured to belong to one or more VLANs.
- The VLAN is not attached to a port hosting a cluster LIF.
- The VLAN is not attached to ports assigned to the Cluster IPspace.
- The VLAN is not created on an interface group port that contains no member ports.

About this task

In certain circumstances, if you want to create the VLAN port on a degraded port without correcting the hardware issue or any software misconfiguration, then you can set the `-ignore- health-status` parameter of the `network port modify` command as true.

Creating a VLAN attaches the VLAN to the network port on a specified node in a cluster.

When you configure a VLAN over a port for the first time, the port might go down, resulting in a temporary disconnection of the network. Subsequent VLAN additions to the same port do not affect the port state.

> You should not create a VLAN on a network interface with the same identifier as the native VLAN of the switch. For example, if the network interface e0b is on native VLAN 10, you should not create a VLAN e0b-10 on that interface.

Step

1. Use the `network port vlan create` command to create a VLAN.
2. You must specify either the `vlan-name` or the `port` and `vlan-id` options when creating a VLAN.
   The VLAN name is a combination of the name of the port (or interface group) and the network switch VLAN identifier, with a hyphen in between. For example, `e0c-24` and `e1c-80` are valid VLAN names.

The following example shows how to create a VLAN `e1c-80` attached to network port `e1c` on the node `cluster-1-01`:

```
network port vlan create -node cluster-1-01 -vlan-name e1c-80
```

Beginning with ONTAP 9.8, VLANs are automatically placed into appropriate broadcast domains about one minute after their creation. If you do not want ONTAP to do this, and prefer to manually place the VLAN into a broadcast domain, then specify the `-skip-broadcast-domain-placement` parameter as part of the `vlan create` command.

For more information about this command, see ONTAP 9 commands.

Delete a VLAN

You might have to delete a VLAN before removing a NIC from its slot. When you delete a VLAN, it is automatically removed from all of the failover rules and groups that use it.

Before you begin

Make sure there are no LIFs associated with the VLAN.

About this task

Deletion of the last VLAN from a port might cause a temporary disconnection of the network from the port.

Step

Use the `network port vlan delete` command to delete a VLAN.

The following example shows how to delete VLAN `e1c-80` from network port `e1c` on the node `cluster-1-01`:

```
network port vlan delete -node cluster-1-01 -vlan-name e1c-80
```

Modify network port attributes

You can modify the autonegotiation, duplex, flow control, speed, and health settings of a physical network port.

Before you begin

The port that you want to modify must not be hosting any LIFs.

About this task

- It is not recommended to modify the administrative settings of the 100 GbE, 40 GbE, 10 GbE or 1 GbE network interfaces.

  The values that you set for duplex mode and port speed are referred to as administrative settings. Depending on network limitations, the administrative settings can differ from the operational settings (that is, the duplex mode and speed that the port actually uses).

- It is not recommended to modify the administrative settings of the underlying physical ports in an interface group.

  The `-up-admin` parameter (available at the advanced privilege level) modifies the administrative settings of the port.

- It is not recommended to set the `-up-admin` administrative setting to false for all ports on a node, or for the port that hosts the last operational cluster LIF on a node.
- It is not recommended to modify the MTU size of the management port, `e0M`.
- The MTU size of a port in a broadcast domain cannot be changed from the MTU value that is set for the broadcast domain.
- The MTU size of a VLAN cannot exceed the value of the MTU size of its base port.

Steps

1. Modify the attributes of a network port:

   `network port modify`

2. You can set the `-ignore-health-status` field to true for specifying that the system can ignore the network port health status of a specified port.

   The network port health status is automatically changed from degraded to healthy, and this port can now be used for hosting LIFs. You should set the flow control of cluster ports to `none`. By default, the flow control is set to `full`.

The following command disables the flow control on port e0b by setting the flow control to none:

```
network port modify -node cluster-1-01 -port e0b -flowcontrol-admin none
```

Modify MTU setting for interface group ports

To modify the MTU setting for interface groups, you must modify the MTU of the broadcast domain.

VLAN MTU size should match the broadcast domain MTU of the underlying interface groups and physical ports. If a different VLAN setting is needed for a VLAN, it must not exceed the size specified by the underlying broadcast domain.

Steps

1. Modify the broadcast domain settings:

   `broadcast-domain modify -broadcast-domain broadcast_domain_name -mtu mtu_setting`

   The following warning message is displayed:

   ```
   Warning: Changing broadcast domain settings will cause a momentary data-
   serving interruption.
   Do you want to continue? {y|n}: y
   ```

2. Enter y to continue.
3. Verify that the MTU setting were modified correctly:

   `network port show`

```
network port show
(network port show)
Node: vsim-01
                                                               Ignore
                                         Speed(Mbps) Health   Health
Port IPspace Broadcast Domain  Link  MTU Admin/Oper  Status   Status
---- ------- ----------------  ---- ---- ----------- -------- ------
a0a  Default Default-1         up   1300 auto/1000   healthy  false
e0a  Default Default-1         up   1300 auto/1000   healthy  false
e0b  Default Default           up   1500 auto/1000   healthy  false
e0c  Default Default           up   1500 auto/1000   healthy  false
e0d  Default Default           up   1500 auto/1000   healthy  false
5 entries were displayed.
```

Monitor the health of network ports

ONTAP management of network ports includes automatic health monitoring and a set of health monitors to help you identify network ports that might not be suitable for hosting LIFs.

About this task

If a health monitor determines that a network port is unhealthy, it warns administrators through an EMS message or marks the port as degraded. ONTAP avoids hosting LIFs on degraded network ports if there are healthy alternative failover targets for that LIF. A port can become degraded because of a soft failure event, such as link flapping (links bouncing quickly between up and down) or network partitioning:

- Network ports in the cluster IPspace are marked as degraded when they experience link flapping or loss of layer 2 (L2) reachability to other network ports in the broadcast domain.
- Network ports in non-cluster IPspaces are marked as degraded when they experience link flapping.

You must be aware of the following behaviors of a degraded port:

- A degraded port cannot be included in a VLAN or an interface group.

  If a member port of an interface group is marked as degraded, but the interface group is still marked as healthy, LIFs can be hosted on that interface group.

- LIFs are automatically migrated from degraded ports to healthy ports.
- During a failover event, a degraded port is not considered as the failover target. If no healthy ports are available, degraded ports host LIFs according to the normal failover policy.
- You cannot create, migrate, or revert a LIF to a degraded port.

  You can modify the `ignore-health-status` setting of the network port to `true`. You can then host a LIF on the healthy ports.

Steps

1. Log in to the advanced privilege mode:

   ```
   set -privilege advanced
   ```

2. Check which health monitors are enabled for monitoring network port health:

   ```
   network options port-health-monitor show
   ```

   The health status of a port is determined by the value of health monitors.

   The following health monitors are available and enabled by default in ONTAP:

   - Link-flapping health monitor: Monitors link flapping

     If a port has link flapping more than once in five minutes, this port is marked as degraded.

   - L2 reachability health monitor: Monitors whether all ports configured in the same broadcast domain have L2 reachability to each other

     This health monitor reports L2 reachability issues in all IPspaces; however, it marks only the ports in the cluster IPspace as degraded.

   - CRC monitor: Monitors the CRC statistics on the ports

     This health monitor does not mark a port as degraded but generates an EMS message when a very high CRC failure rate is observed.

3. Enable or disable any of the health monitors for an IPspace as desired by using the `network options port-health-monitor modify` command.
4. View the detailed health of a port:

   ```
   network port show -health
   ```

The command output displays the health status of the port, `ignore health status` setting, and list of reasons the port is marked as degraded.

A port health status can be `healthy` or `degraded`.

If the `ignore health status` setting is `true`, it indicates that the port health status has been modified from `degraded` to `healthy` by the administrator.

If the `ignore health status` setting is `false`, the port health status is determined automatically by the system.

Monitor the reachability of network ports in ONTAP 9.8 and later

Reachability monitoring is built into ONTAP 9.8 and later. Use this monitoring to identify when the physical network topology does not match the ONTAP configuration. In some cases, ONTAP can repair port reachability. In other cases, additional steps are required.

About this task

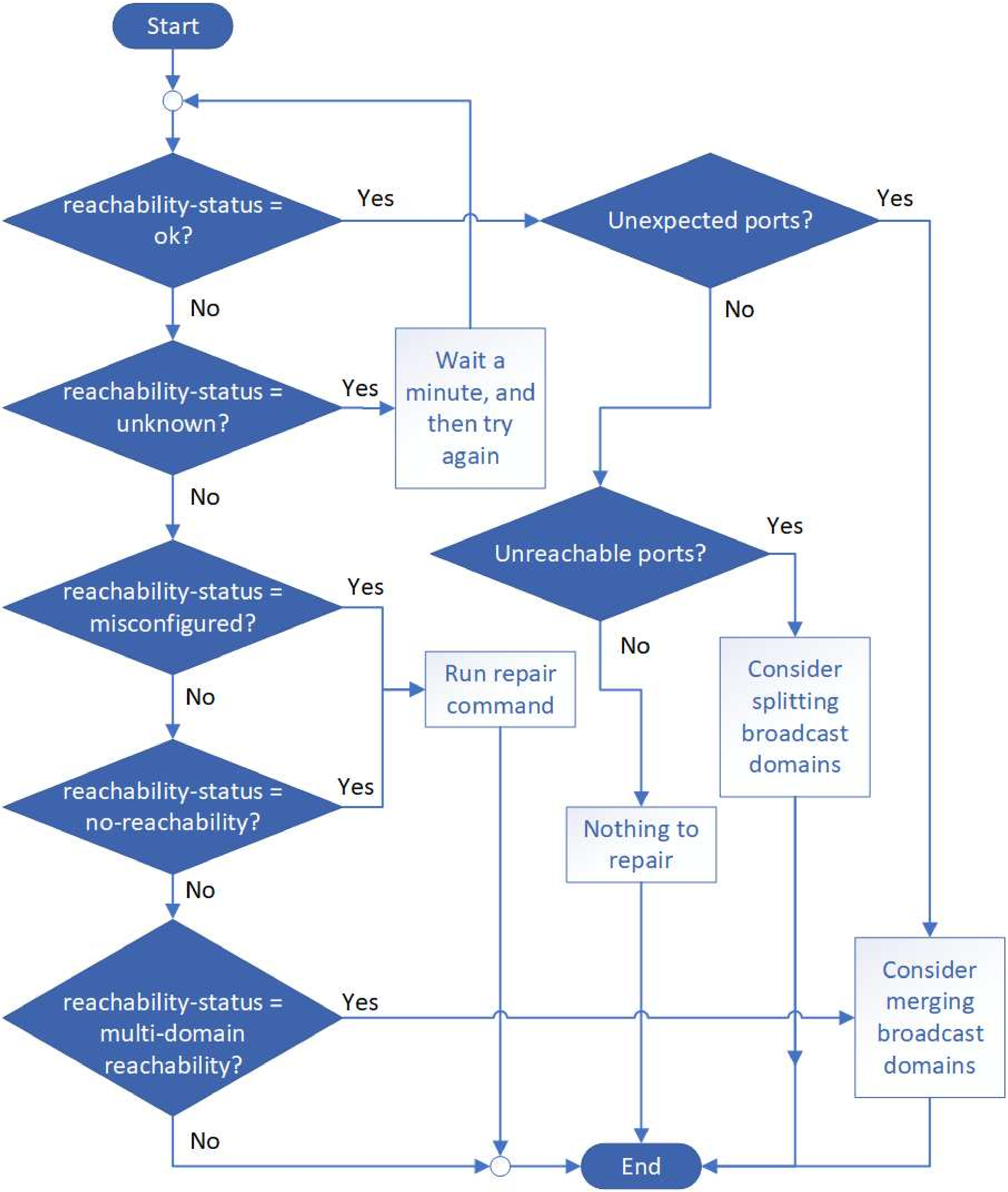
Use these commands to verify, diagnose, and repair network misconfigurations that stem from the ONTAP configuration not matching either the physical cabling or the network switch configuration.

Step

1. View port reachability:

   ```
   network port reachability show
   ```

2. Use the following decision tree and table to determine the next step, if any.



Reachability-status	Description

ok	The port has layer 2 reachability to its assigned broadcast domain. If the reachability-status is "ok", but there are "unexpected ports", consider merging one or more broadcast domains. For more information, see the following *Unexpected ports* row. If the reachability-status is "ok", but there are "unreachable ports", consider splitting one or more broadcast domains. For more information, see the following *Unreachable ports* row. If the reachability-status is "ok", and there are no unexpected or unreachable ports, your configuration is correct.
Unexpected ports	The port has layer 2 reachability to its assigned broadcast domain; however, it also has layer 2 reachability to at least one other broadcast domain. Examine the physical connectivity and switch configuration to determine if it is incorrect or if the port's assigned broadcast domain needs to be merged with one or more broadcast domains. For more information, see Merge broadcast domains.
Unreachable ports	If a single broadcast domain has become partitioned into two different reachability sets, you can split a broadcast domain to synchronize the ONTAP configuration with the physical network topology. Typically, the list of unreachable ports defines the set of ports that should be split into another broadcast domain after you have verified that the physical and switch configuration is accurate. For more information, see Split broadcast domains.
misconfigured-reachability	The port does not have layer 2 reachability to its assigned broadcast domain; however, the port does have layer 2 reachability to a different broadcast domain. You can repair the port reachability. When you run the following command, the system will assign the port to the broadcast domain to which it has reachability: `network port reachability repair -node -port` For more information, see Repair port reachability.
no-reachability	The port does not have layer 2 reachability to any existing broadcast domain. You can repair the port reachability. When you run the following command, the system will assign the port to a new automatically created broadcast domain in the Default IPspace: `network port reachability repair -node -port` For more information, see Repair port reachability.

multi-domain-reachability	The port has layer 2 reachability to its assigned broadcast domain; however, it also has layer 2 reachability to at least one other broadcast domain. Examine the physical connectivity and switch configuration to determine if it is incorrect or if the port's assigned broadcast domain needs to be merged with one or more broadcast domains. For more information, see Merge broadcast domains or Repair port reachability.
unknown	If the reachability-status is "unknown", then wait a few minutes and try the command again.

After you repair a port, you need to check for and resolve displaced LIFs and VLANs. If the port was part of an interface group, you also need to understand what happened to that interface group. For more information, see Repair port reachability.

Convert 40GbE NIC ports into multiple 10GbE ports for 10GbE connectivity

You can convert the X1144A-R6 and the X91440A-R6 40GbE Network Interface Cards (NICs) to support four 10GbE ports.

If you are connecting a hardware platform that supports one of these NICs to a cluster that supports 10GbE cluster interconnect and customer data connections, the NIC must be converted to provide the necessary 10GbE connections.

Before you begin

You must be using a supported breakout cable.

About this task

For a complete list of platforms that support NICs, see the Hardware Universe.

> On the X1144A-R6 NIC, only port A can be converted to support the four 10GbE connections. Once port A is converted, port e is not available for use.

Steps

1. Enter maintenance mode.
2. Convert the NIC from 40GbE support to 10GbE support.

   ```
   nicadmin convert -m [40G | 10G] [port-name]
   ```

3. After using the convert command, halt the node.
4. Install or change the cable.
5. Depending on the hardware model, use the SP (Service Processor) or BMC (Baseboard Management Controller) to power-cycle the node for the conversion to take effect.

Removing a NIC from the node on ONTAP 9.7 or earlier

This topic applies to ONTAP 9.7 or earlier. You might have to remove a faulty NIC from its slot or move the NIC to another slot for maintenance purposes.

Before you begin

- All LIFs hosted on the NIC ports must have been migrated or deleted.
- None of the NIC ports can be the home ports of any LIFs.
- You must have advanced privileges to delete the ports from a NIC.

Steps

1. Delete the ports from the NIC:

   `network port delete`

2. Verify that the ports have been deleted:

   `network port show`

3. Repeat step 1, if the output of the network port show command still shows the deleted port.

Removing a NIC from the node on ONTAP 9.8 or later

This topic applies to ONTAP 9.8 or later. You might have to remove a faulty NIC from its slot or move the NIC to another slot for maintenance purposes.

Steps

1. Power down the node.
2. Physically remove the NIC from its slot.
3. Power on the node.
4. Verify that the port has been deleted:

   ```
   network port show
   ```

   > ONTAP automatically removes the port from any interface groups. If the port was the only member of an interface group, the interface group is deleted.

5. If the port had any VLANs configured on it, they are displaced. You can view displaced VLANs using the following command:

   ```
   cluster controller-replacement network displaced-vlans show
   ```

   > The `displaced-interface show`, `displaced-vlans show`, and `displaced-vlans restore` commands are unique and do not require the fully qualified command name, which starts with `cluster controller-replacement network`.

6. These VLANs are deleted, but can be restored using the following command:

```
displaced-vlans restore
```

7. If the port had any LIFs configured on it, ONTAP automatically chooses new home ports for those LIFs on another port in the same broadcast domain. If no suitable home port is found on the same filer, those LIFs are considered displaced. You can view displaced LIFs using the following command:

   `displaced-interface show`

8. When a new port is added to the broadcast domain on the same node, the home ports for the LIFs are automatically restored. Alternatively, you can either set the home port using `network interface modify -home-port -home-node or use the displaced- interface restore` command.

Configure IPspaces (cluster administrators only)

Overview

IPspaces enable you to configure a single ONTAP cluster so that it can be accessed by clients from more than one administratively separate network domain, even if those clients are using the same IP address subnet range. This allows for separation of client traffic for privacy and security.

An IPspace defines a distinct IP address space in which storage virtual machines (SVMs) reside. Ports and IP addresses defined for an IPspace are applicable only within that IPspace. A distinct routing table is maintained for each SVM within an IPspace; therefore, no cross-SVM or cross- IPspace traffic routing occurs.

> IPspaces support both IPv4 and IPv6 addresses on their routing domains.

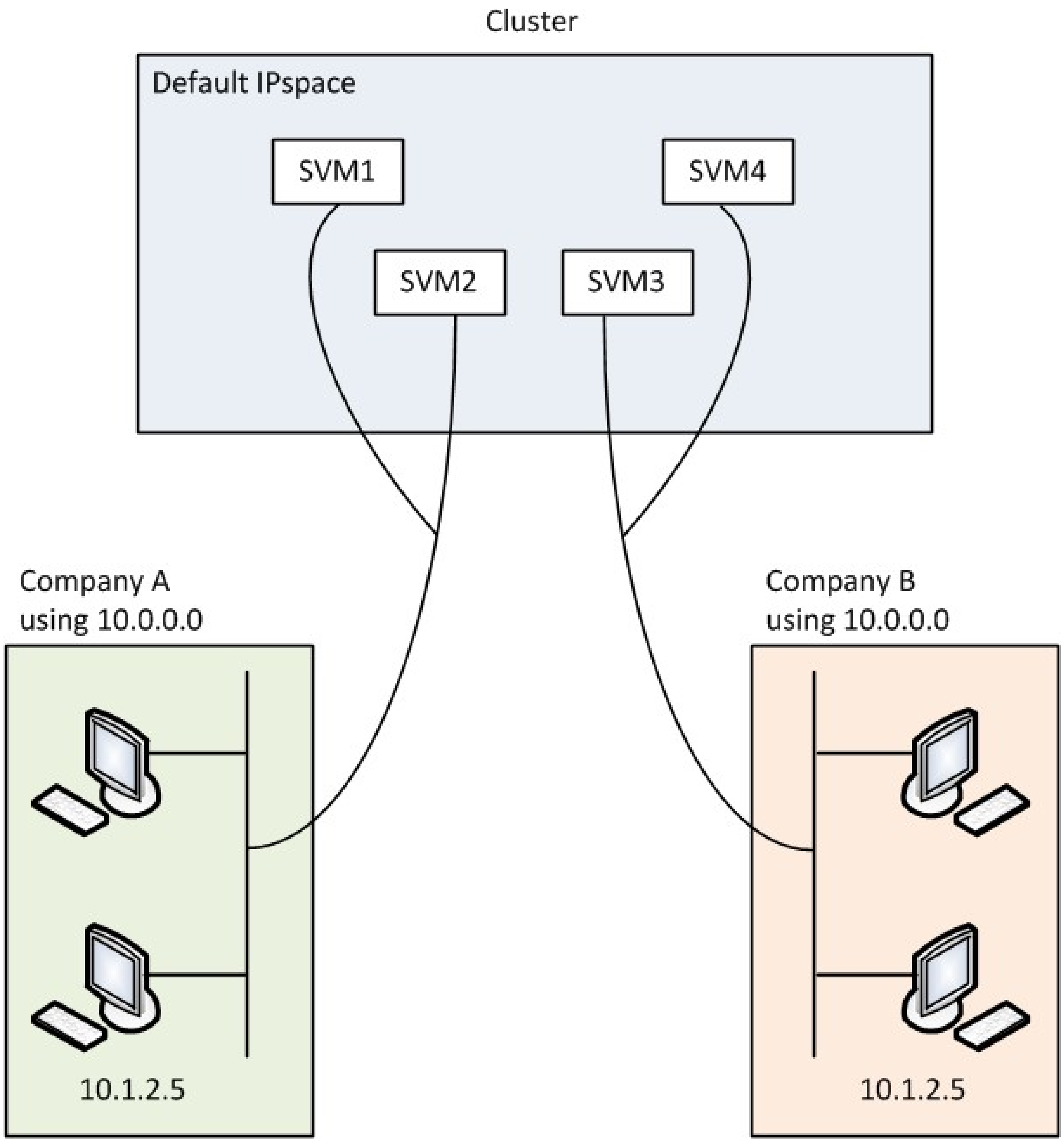
If you are managing storage for a single organization, then you do not need to configure IPspaces. If you are managing storage for multiple companies on a single ONTAP cluster, and you are certain that none of your customers have conflicting networking configurations, then you also do not need to use IPspaces. In many cases, the use of storage virtual machines (SVMs), with their own distinct IP routing tables, can be used to segregate unique networking configurations instead of using IPspaces.

Example of using IPspaces

A common application for using IPspaces is when a Storage Service Provider (SSP) needs to connect customers of companies A and B to an ONTAP cluster on the SSP’s premises and both companies are using the same private IP address ranges.

The SSP creates SVMs on the cluster for each customer and provides a dedicated network path from two SVMs to company A’s network and from the other two SVMs to company B’s network.

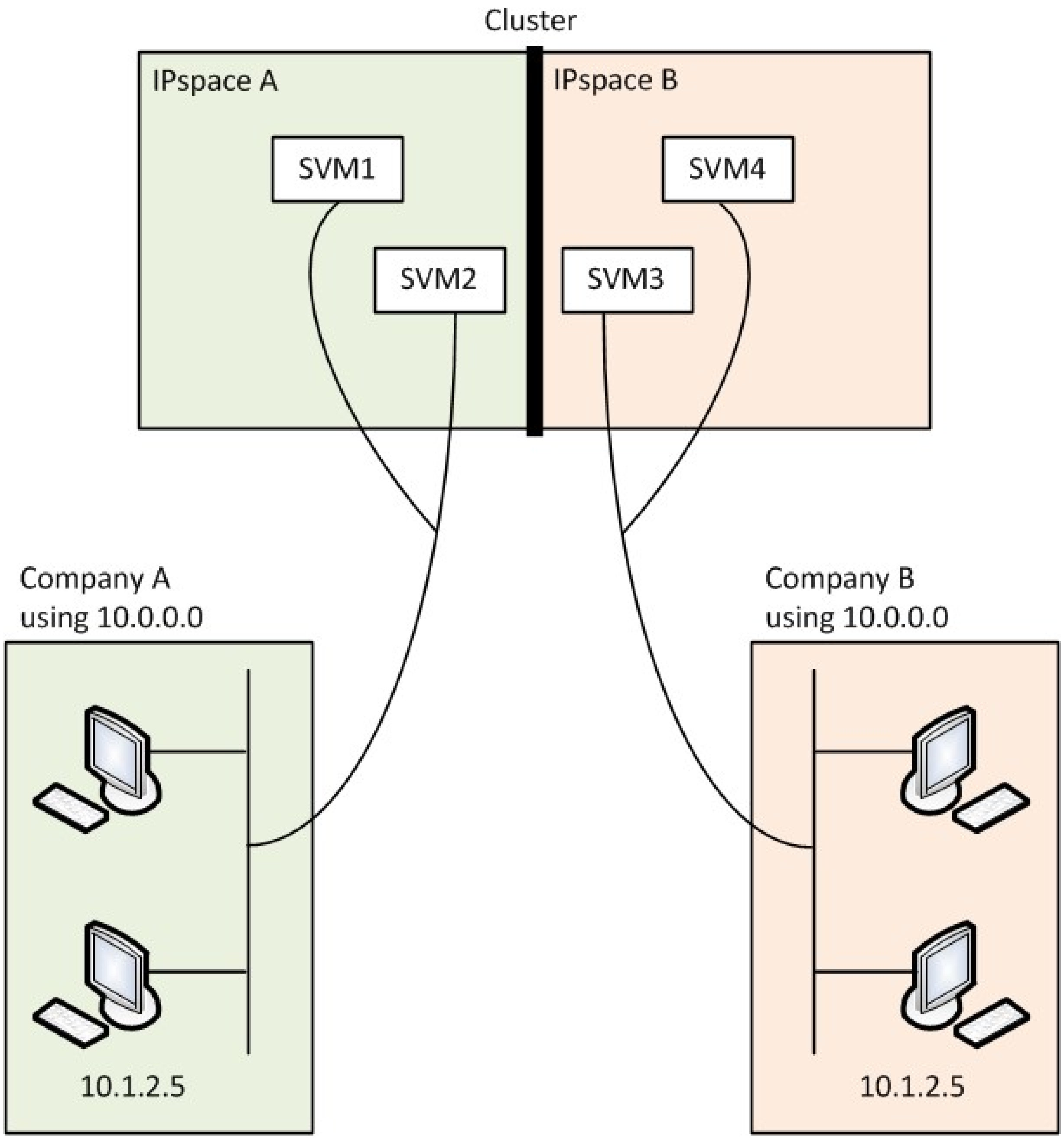
This type of deployment is shown in the following illustration, and it works if both companies use non-private IP address ranges. However, the illustration shows both companies using the same private IP address ranges, which causes problems.



Both companies use the private IP address subnet 10.0.0.0, causing the following problems:

- The SVMs in the cluster at the SSP location have conflicting IP addresses if both companies decide to use the same IP address for their respective SVMs.
- Even if the two companies agree on using different IP addresses for their SVMs, problems can arise.
- For example, if any client in A's network has the same IP address as a client in B's network, packets destined for a client in A's address space might get routed to a client in B's address space, and vice versa.
- If the two companies decide to use mutually exclusive address spaces (for example, A uses 10.0.0.0 with a network mask of 255.128.0.0 and B uses 10.128.0.0 with a network mask of 255.128.0.0), the SSP needs to configure static routes on the cluster to route traffic appropriately to A's and B's networks.
- This solution is neither scalable (because of static routes) nor secure (broadcast traffic is sent to all interfaces of the cluster).To overcome these problems, the SSP defines two IPspaces on the cluster—one for each company. Because no cross-IPspace traffic is routed, the data for each company is securely routed to its respective network even if all of the SVMs are configured in the 10.0.0.0 address space, as

shown in the following illustration:



Additionally, the IP addresses referred to by the various configuration files, such as the `/etc/ hosts` file, the `/etc/hosts.equiv` file, and `the /etc/rc` file, are relative to that IPspace. Therefore, the IPspaces enable the SSP to configure the same IP address for the configuration and authentication data for multiple SVMs, without conflict.

Standard properties of IPspaces

Special IPspaces are created by default when the cluster is first created. Additionally, special storage virtual machines (SVMs) are created for each IPspace.

Two IPspaces are created automatically when the cluster is initialized:

- "Default" IPspace

This IPspace is a container for ports, subnets, and SVMs that serve data. If your configuration does not need separate IPspaces for clients, all SVMs can be created in this IPspace. This IPspace also contains the cluster management and node management ports.

- "Cluster" IPspace

  This IPspace contains all cluster ports from all nodes in the cluster. It is created automatically when the cluster is created. It provides connectivity to the internal private cluster network. As additional nodes join the cluster, cluster ports from those nodes are added to the "Cluster" IPspace.

A "system" SVM exists for each IPspace. When you create an IPspace, a default system SVM of the same name is created:

- The system SVM for the "Cluster" IPspace carries cluster traffic between nodes of a cluster on the internal private cluster network.

  It is managed by the cluster administrator, and it has the name "Cluster".

- The system SVM for the "Default" IPspace carries management traffic for the cluster and nodes, including the intercluster traffic between clusters.

  It is managed by the cluster administrator, and it uses the same name as the cluster.

- The system SVM for a custom IPspace that you create carries management traffic for that SVM.

  It is managed by the cluster administrator, and it uses the same name as the IPspace.

One or more SVMs for clients can exist in an IPspace. Each client SVM has its own data volumes and configurations, and it is administered independently of other SVMs.

Create IPspaces

IPspaces are distinct IP address spaces in which storage virtual machines (SVMs) reside. You can create IPspaces when you need your SVMs to have their own secure storage, administration, and routing.

About this task

There is a cluster-wide limit of 512 IPspaces. The cluster-wide limit is reduced to 256 IPspaces for clusters that contain nodes with 6 GB of RAM or less for platforms such as FAS2220 or FAS2240. See the Hardware Universe to determine whether additional limits apply to your platform.

NetApp Hardware Universe

> An IPspace name cannot be "all" because "all" is a system-reserved name.

Step

Create an IPspace:

```
network ipspace create -ipspace ipspace_name
```

`ipspace_name` is the name of the IPspace that you want to create. The following command creates the IPspace ipspace1 on a cluster:

```
network ipspace create -ipspace ipspace1
```

After you finish

If you create an IPspace in a cluster with a MetroCluster configuration, IPspace objects must be manually replicated to the partner clusters. Any SVMs that are created and assigned to an IPspace before the IPspace is replicated will not be replicated to the partner clusters.

Broadcast domains are created automatically in the "Default" IPspace and can be moved between IPspaces using the following command:

```
network port broadcast-domain move
```

For example, if you want to move a broadcast domain from "Default" to "ips1", using the following command:

```
network port broadcast-domain move -ipspace Default -broadcast-domain
Default -to-ipspace ips1
```

Display IPspaces

You can display the list of IPspaces that exist in a cluster, and you can view the storage virtual machines (SVMs), broadcast domains, and ports that are assigned to each IPspace.

Step

Display the IPspaces and SVMs in a cluster:

```
network ipspace show [-ipspace ipspace_name]
```

The following command displays all of the IPspaces, SVMs, and broadcast domains in the cluster:

```
network ipspace show
IPspace        Vserver List             Broadcast Domains
-------------  -----------------------  -------------------
Cluster
               Cluster                  Cluster
Default
               vs1, cluster-1            Default
ipspace1
               vs3, vs4, ipspace1       bcast1
```

The following command displays the nodes and ports that are part of IPspace ipspace1:

```
network ipspace show -ipspace ipspace1
IPspace name: ipspace1
Ports: cluster-1-01:e0c, cluster-1-01:e0d, cluster-1-01:e0e, cluster-1-
02:e0c, cluster-1-02:e0d, cluster-1-02:e0e
Broadcast Domains: Default-1
Vservers: vs3, vs4, ipspace1
```

Delete an IPspace

If you no longer need an IPspace, you can delete it.

Before you begin

There must be no broadcast domains, network interfaces, or SVMs associated with the IPspace you want to delete.

The system-defined "Default" and "Cluster" IPspaces cannot be deleted.

Step

Delete an IPspace:

```
network ipspace delete -ipspace ipspace_name
```

The following command deletes IPspace ipspace1 from the cluster:

```
network ipspace delete -ipspace ipspace1
```

Configure broadcast domains (cluster administrators only)

ONTAP 9.8 and later

About broadcast domains for ONTAP 9.8 and later

Broadcast domains are intended to group network ports that belong to the same layer 2 network. The ports in the group can then be used by a storage virtual machine (SVM) for data or management traffic.

A broadcast domain resides in an IPspace. During cluster initialization, the system creates two default broadcast domains:

- The "Default" broadcast domain contains ports that are in the "Default" IPspace.

  These ports are used primarily to serve data. Cluster management and node management ports are also in this broadcast domain.

- The "Cluster" broadcast domain contains ports that are in the "Cluster" IPspace.

  These ports are used for cluster communication and include all cluster ports from all nodes in the cluster.

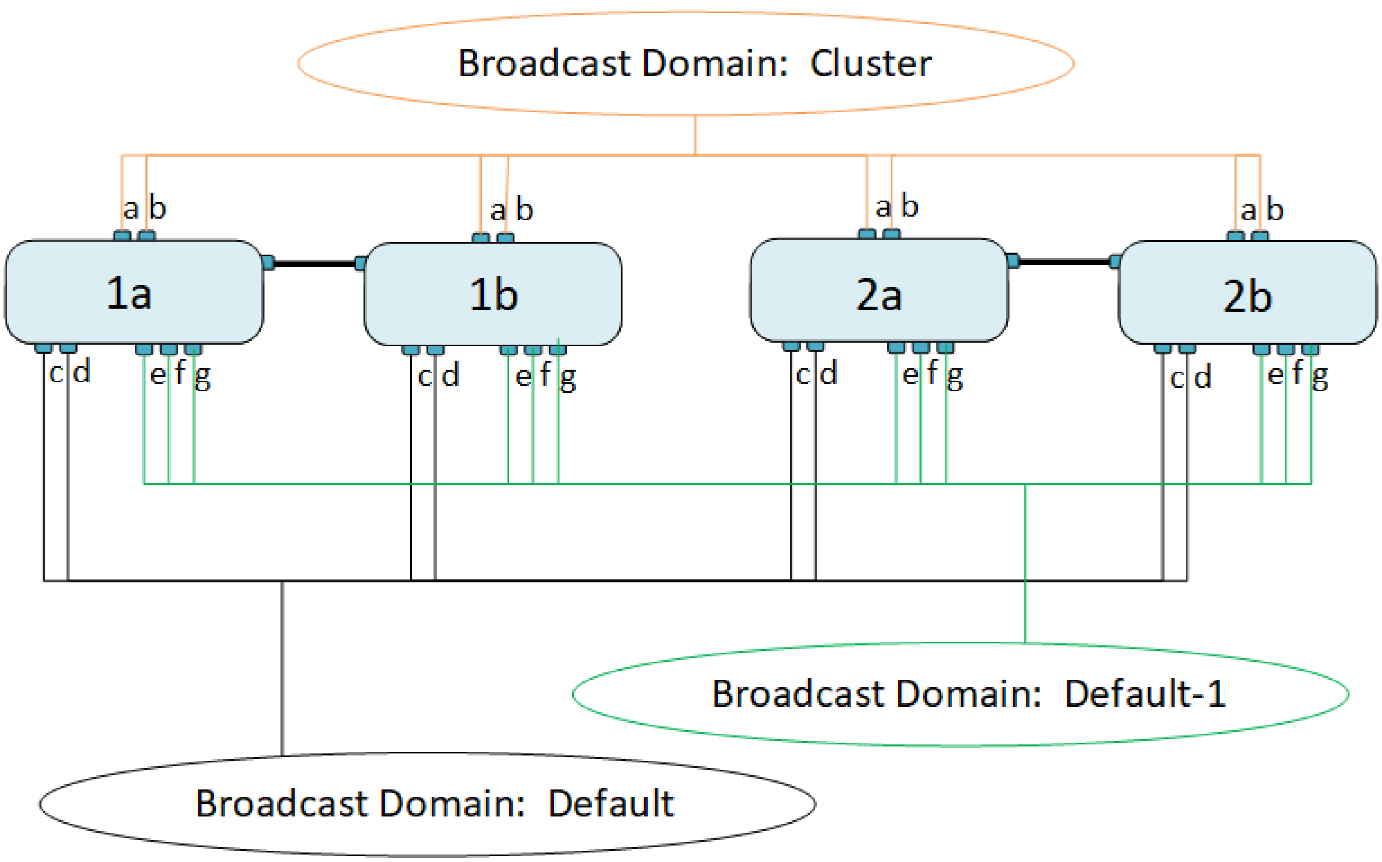
  The system creates additional broadcast domains in the Default IPspace when necessary. The "Default" broadcast domain contains the home-port of the management LIF, plus any other ports that have layer 2 reachability to that port. Additional broadcast domains are named "Default-1", "Default-2", and so forth.

Example of using broadcast domains

A broadcast domain is a set of network ports in the same IPspace that also has layer 2 reachability to one another, typically including ports from many nodes in the cluster.

The illustration shows the ports assigned to three broadcast domains in a four-node cluster:

- The "Cluster" broadcast domain is created automatically during cluster initialization, and it contains ports a and b from each node in the cluster.
- The "Default" broadcast domain is also created automatically during cluster initialization, and it contains ports c and d from each node in the cluster.
- The system automatically creates any additional broadcast domains during cluster initialization based on layer 2 network reachability. These additional broadcast domains are named Default-1, Default-2, and so forth.



A failover group of the same name and with the same network ports as each of the broadcast domains is created automatically. This failover group is automatically managed by the system, meaning that as ports are added or removed from the broadcast domain, they are automatically added or removed from this failover group.

Add or remove ports from a broadcast domain

Broadcast domains are automatically created during the cluster create or join operation. You do not need to manually remove ports from broadcast domains.

If network port reachability has changed, either through physical network connectivity or switch configuration, and a network port belongs in a different broadcast domain, see the following topic:

Repair port reachability

Split broadcast domains

If network port reachability has changed, either through physical network connectivity or switch configuration, and a group of network ports previously configured in a single broadcast domain has become partitioned into two different reachability sets, you can split a broadcast domain to synchronize the ONTAP configuration with the physical network topology.

To determine if a network port broadcast domain is partitioned into more than one reachability set, use the `network port reachability show -details` command and pay attention to which ports do not have connectivity to one another ("Unreachable ports"). Typically, the list of unreachable ports defines the set of ports that should be split into another broadcast domain, after you have verified that the physical and switch configuration is accurate.

Step

Split a broadcast domain into two broadcast domains:

```
network port broadcast-domain split -ipspace <ipspace_name> -broadcast
-domain <broadcast_domain_name> -new-broadcast-domain
<broadcast_domain_name> -ports <node:port,node:port>
```

- `ipspace_name` is the name of the ipspace where the broadcast domain resides.
- `-broadcast-domain` is the name of the broadcast domain that will be split.
- `-new-broadcast-domain` is the name of the new broadcast domain that will be created.
- `-ports` is the node name and port to be added to the new broadcast domain.

Merge broadcast domains

If network port reachability has changed, either through physical network connectivity or switch configuration, and two group of network ports previously configured in multiple broadcast domains now all share reachability, then merging two broadcast domains can be used to synchronize the ONTAP configuration with the physical network topology.

To determine if multiple broadcast domains belong to one reachability set, use the "network port reachability show -details" command and pay attention to which ports that are configured in another broadcast domain actually have connectivity to one another ("Unexpected ports"). Typically, the list of unexpected ports defines the set of ports that should be merged into the broadcast domain after you have verified that the physical and switch configuration is accurate.

Step

Merge the ports from one broadcast domain into an existing broadcast domain:

```
network port broadcast-domain merge -ipspace <ipspace_name> -broadcast
-domain <broadcast_domain_name> -into-broadcast-domain
<broadcast_domain_name>
```

- `ipspace_name` is the name of the ipspace where the broadcast domains reside.
- `-broadcast-domain` is the name of the broadcast domain that will be merged.
- `-into-broadcast-domain` is the name of the broadcast domain that will receive additional ports.

Change the MTU value for ports in a broadcast domain

You can modify the MTU value for a broadcast domain to change the MTU value for all ports in that broadcast domain. This can be done to support topology changes that have been made in the network.

Before you begin

The MTU value must match all the devices connected to that layer 2 network except for the e0M port handling management traffic.

About this task

Changing the MTU value causes a brief interruption in traffic over the affected ports. The system displays a prompt that you must answer with y to make the MTU change.

Step

Change the MTU value for all ports in a broadcast domain:

```
network port broadcast-domain modify -broadcast-domain
<broadcast_domain_name> -mtu <mtu_value> [-ipspace <ipspace_name>]
```

- `broadcast_domain` is the name of the broadcast domain.
- `mtu` is the MTU size for IP packets; 1500 and 9000 are typical values.
- `ipspace` is the name of the IPspace in which this broadcast domain resides. The "Default" IPspace is used unless you specify a value for this option. The following command changes the MTU to 9000 for all ports in the broadcast domain bcast1:

```
network port broadcast-domain modify -broadcast-domain <Default-1> -mtu <
9000 >
Warning: Changing broadcast domain settings will cause a momentary data-
serving interruption.
Do you want to continue? {y|n}: <y>
```

Display broadcast domains

You can display the list of broadcast domains within each IPspace in a cluster. The output also shows the list of ports and the MTU value for each broadcast domain.

Step

Display the broadcast domains and associated ports in the cluster:

```
network port broadcast-domain show
```

The following command displays all the broadcast domains and associated ports in the cluster:

```
network port broadcast-domain show
IPspace Broadcast                                         Update
Name    Domain Name  MTU   Port List                 Status Details
------- ----------- -----  --------------------- --------------
Cluster Cluster      9000
                           cluster-1-01:e0a       complete
                           cluster-1-01:e0b       complete
                           cluster-1-02:e0a       complete
                           cluster-1-02:e0b       complete
Default Default      1500
                           cluster-1-01:e0c       complete
                           cluster-1-01:e0d       complete
                           cluster-1-02:e0c       complete
                           cluster-1-02:e0d       complete
        Default-1    1500
                           cluster-1-01:e0e       complete
                           cluster-1-01:e0f       complete
                           cluster-1-01:e0g       complete
                           cluster-1-02:e0e       complete
                           cluster-1-02:e0f       complete
                           cluster-1-02:e0g       complete
```

The following command displays the ports in the Default-1 broadcast domain that have an update status of error, which indicate that the port could not be updated properly:

```
network port broadcast-domain show -broadcast-domain Default-1 -port
-update-status error

IPspace Broadcast                                      Update
Name    Domain Name  MTU   Port List              Status Details
------- ----------- -----  --------------------- --------------
Default Default-1   1500
                           cluster-1-02:e0g       error
```

For more information, see ONTAP 9 commands.

Delete a broadcast domain

If you no longer need a broadcast domain, you can delete it. This moves the ports associated with that broadcast domain to the "Default" IPspace.

Before you begin

There must be no subnets, network interfaces, or SVMs associated with the broadcast domain you want to delete.

About this task

- The system-created "Cluster" broadcast domain cannot be deleted.
- All failover groups related to the broadcast domain are removed when you delete the broadcast domain.

Step

Delete a broadcast domain:

```
network port broadcast-domain delete -broadcast-domain
<broadcast_domain_name> [-ipspace <ipspace_name>]
```

The following command deletes broadcast domain Default-1 in IPspace ipspace1:

```
network port broadcast-domain delete -broadcast-domain <Default-1>
-ipspace <ipspace1>
```

ONTAP 9.7 and earlier

Overview for ONTAP 9.7 and earlier

Broadcast domains are intended to group network ports that belong to the same layer 2 network. The ports in the group can then be used by a storage virtual machine (SVM) for data or management traffic.

A broadcast domain resides in an IPspace. During cluster initialization, the system creates two default broadcast domains:

- The Default broadcast domain contains ports that are in the Default IPspace.
  These ports are used primarily to serve data. Cluster management and node management ports are also in this broadcast domain.
- The Cluster broadcast domain contains ports that are in the Cluster IPspace.
  These ports are used for cluster communication and include all cluster ports from all nodes in the cluster.

If you have created unique IPspaces to separate client traffic, then you need to create a broadcast domain in each of those IPspaces.

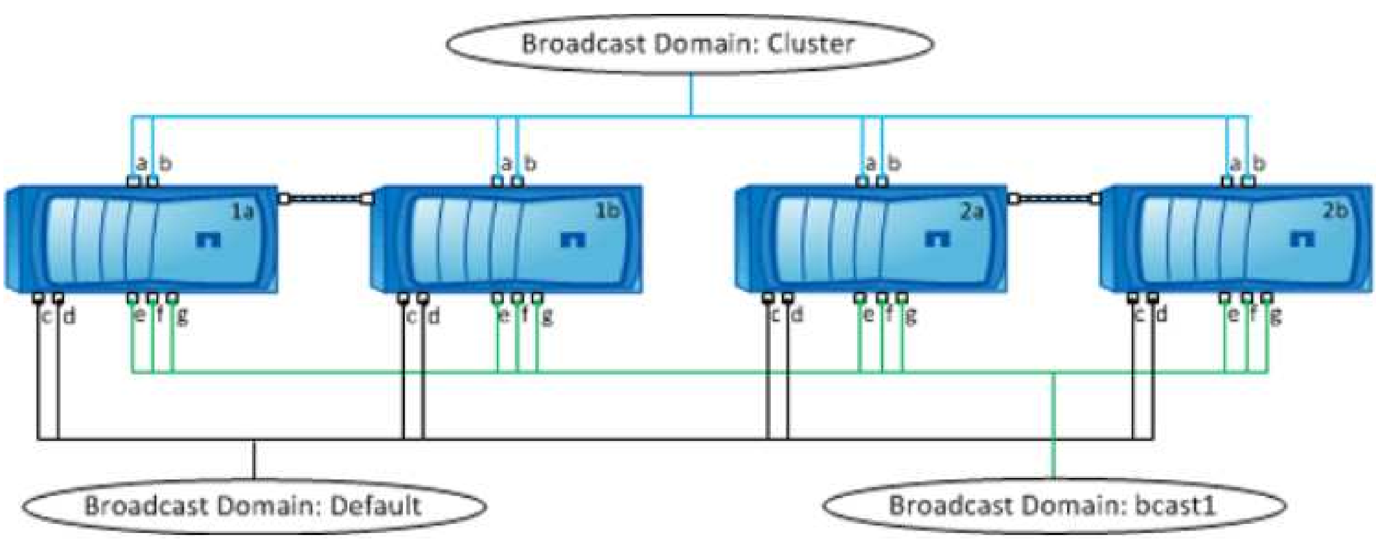
> ⓘ Create a broadcast domain to group network ports in the cluster that belong to the same layer 2 network. The ports can then be used by SVMs.

Example of using broadcast domains

A broadcast domain is a set of network ports in the same IPspace that also has layer 2 reachability to one another, typically including ports from many nodes in the cluster.

The illustration shows the ports assigned to three broadcast domains in a four-node cluster:

- The Cluster broadcast domain is created automatically during cluster initialization, and it contains ports a and b from each node in the cluster.
- The Default broadcast domain is also created automatically during cluster initialization, and it contains ports c and d from each node in the cluster.
- The bcast1 broadcast domain has been created manually, and it contains ports e, f, and g from each node in the cluster.
  This broadcast domain was created by the system administrator specifically for a new client to access data through a new SVM.



A failover group of the same name and with the same network ports as each of the broadcast domains is created automatically. This failover group is automatically managed by the system, meaning that as ports are added or removed from the broadcast domain, they are automatically added or removed from this failover group.

Create a broadcast domain

In ONTAP 9.7 and earlier, you create a broadcast domain to group network ports in the cluster that belong to the same layer 2 network. The ports can then be used by SVMs.

Before you begin

Beginning with ONTAP 9.8, broadcast domains are automatically created during the cluster create or join operation. If you are running ONTAP 9.8 or later, these steps are not needed.

In ONTAP 9.7 and earlier, the ports you plan to add to the broadcast domain must not belong to another broadcast domain.

About this task

- All broadcast domain names must be unique within an IPspace.
- The ports added to a broadcast domain can be physical network ports, VLANs, or interface groups (ifgrps).
- If the ports you want to use belong to another broadcast domain, but are unused, you use the `network port broadcast-domain remove-ports` command to remove the ports from the existing broadcast domain.
- The MTU of the ports added to a broadcast domain are updated to the MTU value set in the broadcast domain.
- The MTU value must match all of the devices connected to that layer 2 network except for the e0M port handling management traffic.
- If you do not specify an IPspace name, the broadcast domain is created in the "Default" IPspace.

To make system configuration easier, a failover group of the same name is created automatically that contains the same ports.

Steps

1. View the ports that are not currently assigned to a broadcast domain:

   ```
   network port show
   ```

   If the display is large, use the `network port show -broadcast-domain` command to view only unassigned ports.

2. Create a broadcast domain:

   ```
   network port broadcast-domain create -broadcast-domain broadcast_domain_name
   -mtu mtu_value [-ipspace ipspace_name] [-ports ports_list]
   ```

   - *`broadcast_domain_name`* is the name of the broadcast domain you want to create.
   - *`mtu_value`* is the MTU size for IP packets; 1500 and 9000 are typical values.

     This value is applied to all ports that are added to this broadcast domain.
   - *`ipspace_name`* is the name of the IPspace to which this broadcast domain will be added.

     The "Default" IPspace is used unless you specify a value for this parameter.
   - *`ports_list`* is the list of ports that will be added to the broadcast domain.

The ports are added in the format `node_name:port_number`, for example, `node1:e0c`.

3. Verify that the broadcast domain was created as desired:
   `network port show -instance -broadcast-domain new_domain`

Example

The following command creates broadcast domain bcast1 in the Default IPspace, sets the MTU to 1500, and adds four ports:

```
network port broadcast-domain create -broadcast-domain bcast1 -mtu 1500 -ports
cluster1-01:e0e,cluster1-01:e0f,cluster1-02:e0e,cluster1-02:e0f
```

After you finish

You can define the pool of IP addresses that will be available in the broadcast domain by creating a subnet, or you can assign SVMs and interfaces to the IPspace at this time. For more information, see Cluster and SVM peering.

If you need to change the name of an existing broadcast domain, you use the `network port broadcast-domain rename` command.

Add or remove ports from a broadcast domain

You can add network ports when initially creating a broadcast domain, or you can add ports to, or remove ports from, a broadcast domain that already exists. This allows you to efficiently use all the ports in the cluster.

Before you begin

- Ports you plan to add to a broadcast domain must not belong to another broadcast domain.
- Ports that already belong to an interface group cannot be added individually to a broadcast domain.

About this task

The following rules apply when adding and removing network ports:

When adding ports…	When removing ports…
The ports can be network ports, VLANs, or interface groups (ifgrps).	N/A
The ports are added to the system-defined failover group of the broadcast domain.	The ports are removed from all failover groups in the broadcast domain.
The MTU of the ports is updated to the MTU value set in the broadcast domain.	The MTU of the ports is unchanged.
The IPspace of the ports is updated to the IPspace value of the broadcast domain.	The ports are moved to the 'Default' IPspace with no broadcast domain attribute.

> If you remove the last member port of an interface group using the `network port ifgrp remove-port` command, it causes the interface group port to be removed from the broadcast domain because an empty interface group port is not allowed in a broadcast domain.

Steps

1. Display the ports that are currently assigned or unassigned to a broadcast domain by using the `network port show` command.
2. Add or remove network ports from the broadcast domain:

If you want to…	Use…
Add ports to a broadcast domain	`network port broadcast-domain add-ports`
Remove ports from a broadcast domain	`network port broadcast-domain remove-ports`

For more information about these commands, see ONTAP 9 commands.

Examples of adding and removing ports

The following command adds port e0g on node cluster-1-01 and port e0g on node cluster-1-02 to broadcast domain bcast1 in the Default IPspace:

```
cluster-1::> network port broadcast-domain add-ports -broadcast-domain bcast1
-ports cluster-1-01:e0g,cluster1-02:e0g
```

The following command adds two cluster ports to broadcast domain Cluster in the Cluster IPspace:

```
cluster-1::> network port broadcast-domain add-ports -broadcast-domain Cluster
-ports cluster-2-03:e0f,cluster2-04:e0f -ipspace Cluster
```

The following command removes port e0e on node cluster1-01 from broadcast domain bcast1 in the Default IPspace:

```
cluster-1::> network port broadcast-domain remove-ports -broadcast-domain bcast1
-ports cluster-1-01:e0e
```

Split broadcast domains

You can modify an existing broadcast domain by splitting it into two different broadcast domains, with each broadcast domain containing some of the original ports assigned to the original broadcast domain.

About this task

- If the ports are in a failover group, all of the ports in a failover group must be split.
- If the ports have LIFs associated with them, the LIFs cannot be part of a subnet’s ranges.

Step

Split a broadcast domain into two broadcast domains:

```
network port broadcast-domain split -ipspace <ipspace_name> -broadcast
-domain <broadcast_domain_name> -new-broadcast-domain
<broadcast_domain_name> -ports <node:port,node:port>
```

- `ipspace_name` is the name of the IPspace where the broadcast domain resides.
- `-broadcast-domain` is the name of the broadcast domain that will be split.
- `-new-broadcast-domain` is the name of the new broadcast domain that will be created.
- `-ports` is the node name and port to be added to the new broadcast domain.

Merge broadcast domains

You can move all of the ports from one broadcast domain into an existing broadcast domain using the merge command.

This operation reduces the steps required if you were to remove all ports from a broadcast domain and then add the ports to an existing broadcast domain.

Step

Merge the ports from one broadcast domain into an existing broadcast domain:

```
network port broadcast-domain merge -ipspace <ipspace_name> -broadcast
-domain <broadcast_domain_name> -into-broadcast-domain
<broadcast_domain_name>
```

- `ipspace_name` is the name of the IPspace where the broadcast domains reside.
- `-broadcast-domain` is the name of the broadcast domain that will be merged.
- `-into-broadcast-domain` is the name of the broadcast domain that will receive additional ports.

Example

The following example merges broadcast domain bd-data1 into broadcast domain bd-data2:

```
network port -ipspace Default broadcast-domain bd-data1 into-broadcast-domain bd-
data2
```

Change the MTU value for ports in a broadcast domain

You can modify the MTU value for a broadcast domain to change the MTU value for all ports in that broadcast domain. This can be done to support topology changes that have been made in the network.

Before you begin

The MTU value must match all the devices connected to that layer 2 network except for the e0M port handling management traffic.

About this task

Changing the MTU value causes a brief interruption in traffic over the affected ports. The system displays a prompt that you must answer with y to make the MTU change.

Step

Change the MTU value for all ports in a broadcast domain:

```
network port broadcast-domain modify -broadcast-domain
<broadcast_domain_name> -mtu <mtu_value> [-ipspace <ipspace_name>]
```

- `broadcast_domain` is the name of the broadcast domain.
- `mtu` is the MTU size for IP packets; 1500 and 9000 are typical values.
- `ipspace` is the name of the IPspace in which this broadcast domain resides. The "Default" IPspace is used unless you specify a value for this option. The following command changes the MTU to 9000 for all ports in the broadcast domain bcast1:

```
network port broadcast-domain modify -broadcast-domain <Default-1> -mtu <
9000 >
Warning: Changing broadcast domain settings will cause a momentary data-
serving interruption.
Do you want to continue? {y|n}: <y>
```

Display broadcast domains

You can display the list of broadcast domains within each IPspace in a cluster. The output also shows the list of ports and the MTU value for each broadcast domain.

Step

Display the broadcast domains and associated ports in the cluster:

```
network port broadcast-domain show
```

The following command displays all the broadcast domains and associated ports in the cluster:

```
network port broadcast-domain show
IPspace Broadcast                                         Update
Name    Domain Name  MTU   Port List                      Status Details
------- ----------- -----  --------------------- --------------
Cluster Cluster      9000
                           cluster-1-01:e0a       complete
                           cluster-1-01:e0b       complete
                           cluster-1-02:e0a       complete
                           cluster-1-02:e0b       complete
Default Default      1500
                           cluster-1-01:e0c       complete
                           cluster-1-01:e0d       complete
                           cluster-1-02:e0c       complete
                           cluster-1-02:e0d       complete
        bcast1       1500
                           cluster-1-01:e0e       complete
                           cluster-1-01:e0f       complete
                           cluster-1-01:e0g       complete
                           cluster-1-02:e0e       complete
                           cluster-1-02:e0f       complete
                           cluster-1-02:e0g       complete
```

The following command displays the ports in the bcast1 broadcast domain that have an update status of error, which indicate that the port could not be updated properly:

```
network port broadcast-domain show -broadcast-domain bcast1 -port-update
-status error

IPspace Broadcast                                         Update
Name    Domain Name  MTU   Port List                      Status Details
------- ----------- -----  --------------------- --------------
Default bcast1       1500
                           cluster-1-02:e0g       error
```

For more information, see ONTAP 9 commands.

Delete a broadcast domain

If you no longer need a broadcast domain, you can delete it. This moves the ports associated with that broadcast domain to the "Default" IPspace.

Before you begin

There must be no subnets, network interfaces, or SVMs associated with the broadcast domain you want to delete.

About this task

- The system-created "Cluster" broadcast domain cannot be deleted.
- All failover groups related to the broadcast domain are removed when you delete the broadcast domain.

Step

Delete a broadcast domain:

```
network port broadcast-domain delete -broadcast-domain
<broadcast_domain_name> [-ipspace <ipspace_name>]
```

The following command deletes broadcast domain bcast1 in IPspace ipspace1:

```
network port broadcast-domain delete -broadcast-domain <bcast1> -ipspace
<ipspace1>
```

Configure failover groups and policies for LIFs

Overview

LIF failover refers to the automatic migration of a LIF to a different network port in response to a link failure on the LIF's current port. This is a key component to providing high availability for the connections to SVMs. Configuring LIF failover involves creating a failover group, modifying the LIF to use the failover group, and specifying a failover policy.

A failover group contains a set of network ports (physical ports, VLANs, and interface groups) from one or more nodes in a cluster. The network ports that are present in the failover group define the failover targets available for the LIF. A failover group can have cluster management, node management, intercluster, and NAS data LIFs assigned to it.

> When a LIF is configured without a valid failover target, an outage occurs when the LIF attempts to fail over. You can use the "network interface show -failover" command to verify the failover configuration.

When you create a broadcast domain, a failover group of the same name is created automatically that contains the same network ports. This failover group is automatically managed by the system, meaning that as ports are added or removed from the broadcast domain, they are automatically added or removed from this failover group. This is provided as an efficiency for administrators who do not want to manage their own failover groups.

Create a failover group

You create a failover group of network ports so that a LIF can automatically migrate to a different port if a link failure occurs on the LIF's current port. This enables the system to reroute network traffic to other available ports in the cluster.

About this task

You use the `network interface failover-groups create` command to create the group and to add ports to the group.

- The ports added to a failover group can be network ports, VLANs, or interface groups (ifgrps).
- All the ports added to the failover group must belong to the same broadcast domain.
- A single port can reside in multiple failover groups.
- If you have LIFs in different VLANs or broadcast domains, you must configure failover groups for each VLAN or broadcast domain.
- Failover groups do not apply in SAN iSCSI or FC environments.

Step

Create a failover group:

`network interface failover-groups create -vserver` *`vserver_name`* `-failover-group` *`failover_group_name`* `-targets` *`ports_list`*

- *`vserver_name`* is the name of the SVM that can use the failover group.
- *`failover_group_name`* is the name of the failover group you want to create.
- *`ports_list`* is the list of ports that will be added to the failover group.
  Ports are added in the format *node_name>:<port_number>*, for example, node1:e0c.

The following command creates failover group fg3 for SVM vs3 and adds two ports:

```
network interface failover-groups create -vserver vs3 -failover-group fg3
-targets cluster1-01:e0e,cluster1-02:e0e
```

After you finish

- You should apply the failover group to a LIF now that the failover group has been created.
- Applying a failover group that does not provide a valid failover target for a LIF results in a warning message.

  If a LIF that does not have a valid failover target attempts to fail over, an outage might occur.

Configure failover settings on a LIF

You can configure a LIF to fail over to a specific group of network ports by applying a failover policy and a failover group to the LIF. You can also disable a LIF from failing over to another port.

About this task

- When a LIF is created, LIF failover is enabled by default, and the list of available target ports is determined by the default failover group and failover policy based on the LIF type and service policy.

  Beginning with 9.5, you can specify a service policy for the LIF that defines which network services can use the LIF. Some network services impose failover restrictions on a LIF.

> If a LIF's service policy is changed in a way that further restricts failover, the LIF's failover policy is automatically updated by the system.

- You can modify the failover behavior of LIFs by specifying values for the -failover-group and -failover-policy parameters in the network interface modify command.
- Modification of a LIF that results in the LIF having no valid failover target results in a warning message.

  If a LIF that does not have a valid failover target attempts to fail over, an outage might occur.

- Beginning with ONTAP 9.11.1, on All SAN Array (ASA) platforms, iSCSI LIF failover is automatically enabled on newly created iSCSI LIFs on newly created storage VMs.

  Additionally, you can manually enable iSCSI LIF failover on pre-existing iSCSI LIFs, meaning LIFs that were created prior to upgrading to ONTAP 9.11.1 or later.
  iSCSI LIF failover for ASA platforms

- The following list describes how the -failover-policy setting affects the target ports that are selected from the failover group:

> For iSCSI LIF failover, only the failover policies `local-only`, `sfo-partner-only` and `disabled` are supported.

- `broadcast-domain-wide` applies to all ports on all nodes in the failover group.
- `system-defined` applies to only those ports on the LIF's home node and one other node in the cluster, typically a non- SFO partner, if it exists.
- `local-only` applies to only those ports on the LIF's home node.
- `sfo-partner-only` applies to only those ports on the LIF's home node and its SFO partner.
- `disabled` indicates the LIF is not configured for failover.

Step

Configure failover settings for an existing interface:

```
network interface modify -vserver <vserver_name> -lif <lif_name> -failover
-policy <failover_policy> -failover-group <failover_group>
```

Examples of configuring failover settings and disabling failover

The following command sets the failover policy to broadcast-domain-wide and uses the ports in failover group fg3 as failover targets for LIF data1 on SVM vs3:

```
network interface modify -vserver vs3 -lif data1 failover-policy
broadcast-domain-wide - failover-group fg3

network interface show -vserver vs3 -lif * -fields failover-
group,failover-policy

vserver lif             failover-policy       failover-group
------- -------------- ---------------        --------------
vs3     data1          broadcast-domain-wide  fg3
```

The following command disables failover for LIF data1 on SVM vs3:

```
network interface modify -vserver vs3 -lif data1 failover-policy disabled
```

Commands for managing failover groups and policies

You can use the `network interface failover-groups` commands to manage failover groups. You use the `network interface modify` command to manage the failover groups and failover policies that are applied to a LIF.

If you want to…	Use this command…
Add network ports to a failover group	`network interface failover-groups add-targets`
Remove network ports from a failover group	`network interface failover-groups remove-targets`
Modify network ports in a failover group	`network interface failover-groups modify`
Display the current failover groups	`network interface failover-groups show`
Configure failover on a LIF	`network interface modify -failover -group -failover-policy`
Display the failover group and failover policy that is being used by each LIF	`network interface show -fields failover-group, failover-policy`
Rename a failover group	`network interface failover-groups rename`

Delete a failover group	`network interface failover-groups delete`

> ⓘ Modifying a failover group such that it does not provide a valid failover target for any LIF in the cluster can result in an outage when a LIF attempts to fail over.

For more information, see the man pages for the `network interface failover-groups` and `network interface modify` commands.

Configure subnets (cluster administrators only)

Overview

Subnets enable you to allocate specific blocks, or pools, of IP addresses for your ONTAP network configuration. This enables you to create LIFs more easily when using the `network interface create` command, by specifying a subnet name instead of having to specify IP address and network mask values.

A subnet is created within a broadcast domain, and it contains a pool of IP addresses that belong to the same layer 3 subnet. IP addresses in a subnet are allocated to ports in the broadcast domain when LIFs are created. When LIFs are removed, the IP addresses are returned to the subnet pool and are available for future LIFs.

It is recommended that you use subnets because they make the management of IP addresses much easier, and they make the creation of LIFs a simpler process. Additionally, if you specify a gateway when defining a subnet, a default route to that gateway is added automatically to the SVM when a LIF is created using that subnet.

Create a subnet

After you create the broadcast domain, you can create a subnet to allocate specific blocks of IPv4 or IPv6 addresses to be used later when you create LIFs for the SVM.

This enables you to create LIFs more easily by specifying a subnet name instead of having to specify IP address and network mask values for each LIF.

Before you begin

You must be a cluster administrator to perform this task.

Steps

1. Create a subnet.

   ```
   network subnet create -broadcast-domain ipspace1 -ipspace ipspace1
   -subnet-name ipspace1 -subnet 10.0.0.0/24 -gateway 10.0.0.1 -ip-ranges
   "10.0.0.128-10.0.0.130,10.0.0.132"
   ```

   The subnet name can be either a subnet IP value such as `192.0.2.0/24` or a string such as `ipspace1` like the one used in this example.

2. Verify that the subnet configuration is correct.

   The output from this example shows information about the subnet named ipspace1 in the ipspace1 IPspace. The subnet belongs to the broadcast domain name ipspace1. You can assign the IP addresses in this subnet to data LIFs for SVMs created in the ipspace1 IPspace.

   `network subnet show -ipspace ipspace1`

Add or remove IP addresses from a subnet

You can add IP addresses when initially creating a subnet, or you can add IP addresses to a subnet that already exists. You can also remove IP addresses from an existing subnet. This enables you to allocate only the required IP addresses for SVMs.

About this task

When adding IP addresses, you will receive an error if any service processor or network interfaces are using the IP addresses in the range being added. If you want to associate any manually addressed interfaces with the current subnet, you can set the "-force-update-lif-associations" option to true.

When removing IP addresses, you will receive an error if any service processor or network interfaces are using the IP addresses being removed. If you want the interfaces to continue to use the IP addresses after they are removed from the subnet, you can set the "-force-update-lif-associations" option to true.

Step

Add or remove IP addresses from a subnet:

If you want to…	Use this command…
Add IP addresses to a subnet	network subnet add-ranges
Remove IP addresses from a subnet	network subnet remove-ranges

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

The following command adds IP addresses 192.0.2.82 through 192.0.2.85 to subnet sub1:

```
network subnet add-ranges -subnet-name <sub1> -ip-ranges <192.0.2.82-
192.0.2.85>
```

The following command removes IP address 198.51.100.9 from subnet sub3:

```
network subnet remove-ranges -subnet-name <sub3> -ip-ranges <198.51.100.9>
```

If the current range includes 1 through 10 and 20 through 40, and you want to add 11 through 19 and 41 through 50 (basically allowing 1 through 50), you can overlap the existing range of addresses by using the following command. This command adds only the new addresses and does not affect the existing addresses:

```
network subnet add-ranges -subnet-name <sub3> -ip-ranges <198.51.10.1-
198.51.10.50>
```

Change subnet properties

You can change the subnet address and mask value, gateway address, or range of IP addresses in an existing subnet.

About this task

- When modifying IP addresses, you must ensure there are no overlapping IP addresses in the network so that different subnets, or hosts, do not attempt to use the same IP address.
- If you add or change the gateway IP address, the modified gateway is applied to new SVMs when a LIF is created in them using the subnet. A default route to the gateway is created for the SVM if the route does not already exist. You may need to manually add a new route to the SVM when you change the gateway IP address.

Step

Modify subnet properties:

```
network subnet modify -subnet-name <subnet_name> [-ipspace <ipspace_name>]
[-subnet <subnet_address>] [-gateway <gateway_address>] [-ip-ranges
<ip_address_list>] [-force-update-lif-associations <true>]
```

- `subnet_name` is the name of the subnet you want to modify.
- `ipspace` is the name of the IPspace where the subnet resides.
- `subnet` is the new address and mask of the subnet, if applicable; for example, 192.0.2.0/24.
- `gateway` is the new gateway of the subnet, if applicable; for example, 192.0.2.1. Entering **""** removes the gateway entry.
- `ip_ranges` is the new list, or range, of IP addresses that will be allocated to the subnet, if applicable. The IP addresses can be individual addresses, a range or IP addresses, or a combination in a comma-separated list. The range specified here replaces the existing IP addresses.
- `force-update-lif-associations` is required when you change the IP address range. You can set the value to **true** for this option when modifying the range of IP addresses. This command fails if any service processor or network interfaces are using the IP addresses in the specified range. Setting this value to **true** associates any manually addressed interfaces with the current subnet and allows the command to succeed.

The following command modifies the gateway IP address of subnet sub3:

```
network subnet modify -subnet-name <sub3> -gateway <192.0.3.1>
```

Display subnets

You can display the list of IP addresses that are allocated to each subnet within an IPspace. The output also shows the total number of IP addresses that are available in each subnet, and the number of addresses that are currently being used.

Step

Display the list of subnets and the associated IP address ranges that are used in those subnets:

```
network subnet show
```

The following command displays the subnets and the subnet properties:

```
network subnet show

IPspace: Default
Subnet                 Broadcast               Avail/
Name   Subnet          Domain    Gateway       Total   Ranges
-----  --------------- --------- ------------ --------
-----------------------
sub1   192.0.2.0/24     bcast1   192.0.2.1     5/9     192.0.2.92-
192.0.2.100
sub3   198.51.100.0/24  bcast3   198.51.100.1   3/3
198.51.100.7,198.51.100.9
```

Delete a subnet

If you no longer need a subnet and want to deallocate the IP addresses that were assigned to the subnet, you can delete it.

About this task

You will receive an error if any service processor or network interfaces are currently using IP addresses in the specified ranges. If you want the interfaces to continue to use the IP addresses even after the subnet is deleted, you can set the -force-update-lif-associations option to true to remove the subnet's association with the LIFs.

Step

Delete a subnet:

```
network subnet delete -subnet-name subnet_name [-ipspace ipspace_name] [-
force-update-lif- associations true]
```

The following command deletes subnet sub1 in IPspace ipspace1:

```
network subnet delete -subnet-name sub1 -ipspace ipspace1
```

Configure LIFs (cluster administrators only)

Overview

A LIF (logical interface) represents a network access point to a node in the cluster. You can configure LIFs on ports over which the cluster sends and receives communications over the network.

A cluster administrator can create, view, modify, migrate, revert, or delete LIFs. An SVM administrator can only view the LIFs associated with the SVM.

A LIF is an IP address or WWPN with associated characteristics, such as a service policy, a home port, a home node, a list of ports to fail over to, and a firewall policy. You can configure LIFs on ports over which the cluster sends and receives communications over the network.

LIFs can be hosted on the following ports:

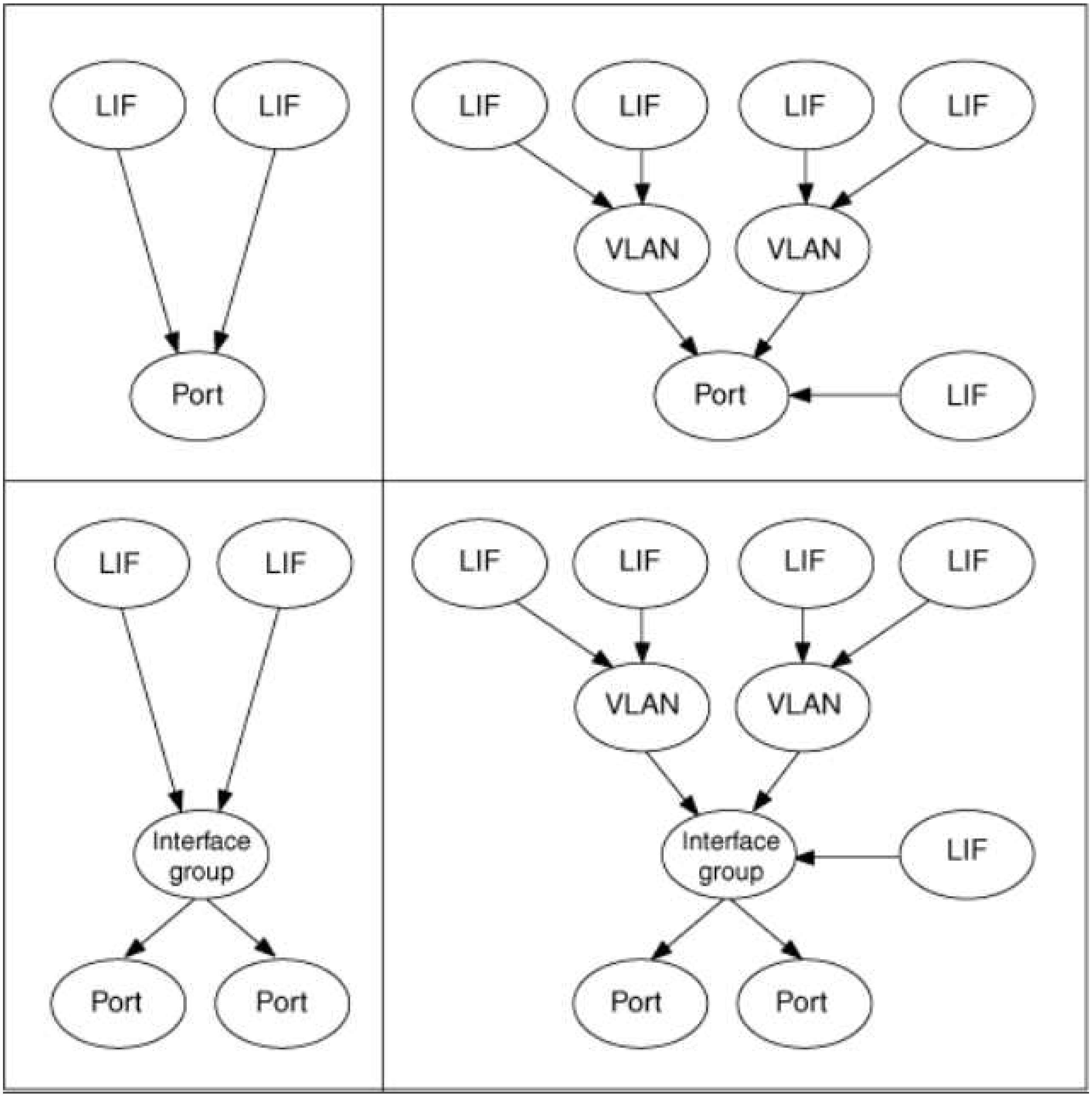
- Physical ports that are not part of interface groups
- Interface groups
- VLANs
- Physical ports or interface groups that host VLANs
- Virtual IP (VIP) ports

  Beginning with ONTAP 9.5, VIP LIFs are supported and are hosted on VIP ports.

While configuring SAN protocols such as FC on a LIF, it will be associated with a WWPN.

SAN administration

The following figure illustrates the port hierarchy in an ONTAP system:



LIF compatibility with port types

LIFs can have different characteristics to support different port types.

> When intercluster and management LIFs are configured in the same subnet, the management traffic might be blocked by an external firewall and the AutoSupport and NTP connections might fail. You can recover the system by running the `network interface modify -vserver` *`vserver name`* `-lif` *`intercluster LIF`* `-status-admin up|down` command to toggle the intercluster LIF. However, you should set the intercluster LIF and management LIF in different subnets to avoid this issue.

LIF	Description

Data LIF	A LIF that is associated with a storage virtual machine (SVM) and is used for communicating with clients. You can have multiple data LIFs on a port. These interfaces can migrate or fail over throughout the cluster. You can modify a data LIF to serve as an SVM management LIF by modifying its firewall policy to mgmt. Sessions established to NIS, LDAP, Active Directory, WINS, and DNS servers use data LIFs.
Cluster LIF	A LIF that is used to carry intracluster traffic between nodes in a cluster. Cluster LIFs must always be created on cluster ports. Cluster LIFs can fail over between cluster ports on the same node, but they cannot be migrated or failed over to a remote node. When a new node joins a cluster, IP addresses are generated automatically. However, if you want to assign IP addresses manually to the cluster LIFs, you must ensure that the new IP addresses are in the same subnet range as the existing cluster LIFs.
Cluster management LIF	LIF that provides a single management interface for the entire cluster. A cluster management LIF can fail over to any node in the cluster. It cannot fail over to cluster or intercluster ports
Intercluster LIF	A LIF that is used for cross-cluster communication, backup, and replication. You must create an intercluster LIF on each node in the cluster before a cluster peering relationship can be established. These LIFs can only fail over to ports in the same node. They cannot be migrated or failed over to another node in the cluster.
Node management LIF	A LIF that provides a dedicated IP address for managing a particular node in a cluster. Node management LIFs are created at the time of creating or joining the cluster. These LIFs are used for system maintenance, for example, when a node becomes inaccessible from the cluster.
VIP LIF	A VIP LIF is any data LIF created on a VIP port. To learn more, see Configure virtual IP (VIP) LIFs.

LIF roles in ONTAP 9.5 and earlier

LIFs with different roles have different characteristics. A LIF role determines the kind of traffic that is supported over the interface, along with the failover rules that apply, the firewall restrictions that are in place, the security, the load balancing, and the routing behavior for each LIF. A LIF can have any one of the following roles: cluster, cluster management, data, intercluster, node management, and undef (undefined). The undef role is used for BGP LIFs.

Beginning with ONTAP 9.6, LIF roles are deprecated. You should specify service policies for LIFs instead of a role. It is not necessary to specify a LIF role when creating a LIF with a service policy.

LIF security

	Data LIF	Cluster LIF	Node management LIF	Cluster management LIF	Intercluster LIF
Require private IP subnet?	No	Yes	No	No	No
Require secure network?	No	Yes	No	No	Yes
Default firewall policy	Very restrictive	Completely open	Medium	Medium	Very restrictive
Is firewall customizable?	Yes	No	Yes	Yes	Yes

LIF failover

	Data LIF	Cluster LIF	Node management LIF	Cluster management LIF	Intercluster LIF
Default behavior	Only those ports in the same failover group that are on the LIF's home node and on a non-SFO partner node	Only those ports in the same failover group that are on the LIF's home node	Only those ports in the same failover group that are on the LIF's home node	Any port in the same failover group	Only those ports in the same failover group that are on the LIF's home node
Is customizable?	Yes	No	Yes	Yes	Yes

LIF routing

	Data LIF	Cluster LIF	Node management LIF	Cluster management LIF	Intercluster LIF
When is a default route needed?	When clients or domain controller are on different IP subnet	Never	When any of the primary traffic types require access to a different IP subnet	When administrator is connecting from another IP subnet	When other intercluster LIFs are on a different IP subnet
When is a static route to a specific IP subnet needed?	Rare	Never	Rare	Rare	When nodes of another cluster have their intercluster LIFs in different IP subnets

When is a static host route to a specific server needed?	To have one of the traffic types listed under node management LIF, go through a data LIF rather than a node management LIF. This requires a corresponding firewall change.	Never	Rare	Rare	Rare

LIF rebalancing

	Data LIF	Cluster LIF	Node management LIF	Cluster management LIF	Intercluster LIF
DNS: use as DNS server?	Yes	No	No	No	No
DNS: export as zone?	Yes	No	No	No	No

LIF primary traffic types

	Data LIF	Cluster LIF	Node management LIF	Cluster management LIF	Intercluster LIF
Primary traffic types	NFS server, CIFS server, NIS client, Active Directory, LDAP, WINS, DNS client and server, iSCSI and FC server	Intracluster	SSH server, HTTPS server, NTP client, SNMP, AutoSupport client, DNS client, loading software updates	SSH server, HTTPS server	Cross-cluster replication

LIFs and service policies in ONTAP 9.6 and later

You can assign service policies (instead of LIF roles) to LIFs that determine the kind of traffic that is supported for the LIFs. Service policies define a collection of network services supported by a LIF. ONTAP provides a set of built-in service policies that can be associated with a LIF.

You can display service policies and their details using the following command:
`network interface service-policy show`

Service policies for system SVMs

The admin SVM and any system SVM contain service policies that can be used for LIFs in that SVM, including management and intercluster LIFs. These policies are automatically created by the system when an IPspace is created.

The following table lists the built-in policies for LIFs in system SVMs as of ONTAP 9.11.1. For other releases, display the service policies and their details using the following command:

```
network interface service-policy show
```

Policy	Included services	Equivalent role	Description
default-intercluster	intercluster-core, management-https	intercluster	Used by LIFs carrying intercluster traffic. Note: Service intercluster-core is available from ONTAP 9.5 with the name net-intercluster service policy.
default-route-announce	management-bgp	-	Used by LIFs carrying BGP peer connections Note: Available from ONTAP 9.5 with the name net-route-announce service policy.
default-management	management-core, management-https, management-http, management-ssh, management-autosupport, management-ems, management-dns-client, management-ad-client, management-ldap-client, management-nis-client, management-ntp-client	node-mgmt, or cluster-mgmt	Use this system scoped management policy to create node- and cluster-scoped management LIFs owned by a system SVM. These LIFs can be used for outbound connections to DNS, AD, LDAP, or NIS servers as well as some additional connections to support applications that run on behalf of the entire system.

The following table lists the services that LIFs can use on a system SVM as of ONTAP 9.11.1:

Service	Failover limitations	Description
intercluster-core	home-node-only	Core intercluster services
management-core	-	Core management services
management-ssh	-	Services for SSH management access
management-http	-	Services for HTTP management access
management-https	-	Services for HTTPS management access

management-autosupport	-	Services related to posting AutoSupport payloads
management-bgp	home-port-only	Services related to BGP peer interactions
backup-ndmp-control	-	Services for NDMP backup controls
management-ems	-	Services for management messaging access
management-ntp-client	-	Introduced in ONTAP 9.10.1. Services for NTP client access.
management-ntp-server	-	Introduced in ONTAP 9.11.1. Services for NTP server management access
management-portmap	-	Services for portmap management
management-rsh-server	-	Services for rsh server management
management-snmp-server	-	Services for SNMP server management
management-telnet-server	-	Services for telnet server management

Service policies for data SVMs

All data SVMs contain service policies that can be used by LIFs in that SVM.

The following table lists the built-in policies for LIFs in data SVMs as of ONTAP 9.11.1. For other releases, display the service policies and their details using the following command:

```
network interface service-policy show
```

Policy	Included services	Equivalent data protocol	Description
default-management	management-https, management-http, management-ssh, management-dns-client, management-ad-client, management-ldap-client, management-nis-client	none	Use this SVM-scoped management policy to create SVM management LIFs owned by a data SVM. These LIFs can be used to provide SSH or HTTPS access to SVM administrators. When necessary, these LIFs can be used for outbound connections to an external DNS, AD, LDAP, or NIS servers.

default-data-blocks	data-core, data-iscsi	iscsi	Used by LIFs carrying block-oriented SAN data traffic. Starting in ONTAP 9.10.1, the "default-data-blocks" policy is deprecated. Use the "default-data-iscsi" service policy instead.
default-data-files	data-fpolicy-client, data-dns-server, data-flexcache, data-cifs, data-nfs, management-dns-client, management-ad-client, management-ldap-client, management-nis-client	nfs, cifs, fcache	Use the default-data-files policy to create NAS LIFs supporting file-based data protocols. Sometimes there is only one LIF present in the SVM, therefore this policy allows the LIF to be used for outbound connections to an external DNS, AD, LDAP, or NIS server. You can remove these services to from this policy if you prefer these connections utilize only management LIFs.
default-data-iscsi	data-core, data-iscsi	iscsi	Used by LIFs carrying iSCSI data traffic.
default-data-nvme-tcp	data-core, data-nvme-tcp	nvme-tcp	Used by LIFs carrying NVMe/TCP data traffic.

The following table lists the services that can be used on a data SVM along with any restrictions each service imposes on a LIF's failover policy as of ONTAP 9.11.1:

Service	**Failover restrictions**	**Description**
management-ssh	-	Services for SSH management access
management-http	-	Introduced in ONTAP 9.10.1 Services for HTTP management access
management-https	-	Services for HTTPS management access
management-portmap	-	Services for portmap management access
management-snmp-server	-	Introduced in ONTAP 9.10.1 Services for SNMP server management access
data-core	-	Core data services
data-nfs	-	NFS data service
data-cifs	-	CIFS data service
data-flexcache	-	FlexCache data service

data-iscsi	home-port-only	iSCSI data service
backup-ndmp-control	-	Introduced in ONTAP 9.10.1 Backup NDMP controls data service
data-dns-server	-	Introduced in ONTAP 9.10.1 DNS server data service
data-fpolicy-client	-	File-screening policy data service
data-nvme-tcp	home-port-only	Introduced in ONTAP 9.10.1 NVMe TCP data service
data-s3-server	-	Simple Storage Service (S3) server data service

You should be aware of how the service policies are assigned to the LIFs in data SVMs:

- If a data SVM is created with a list of data services, the built-in "default-data-files" and "default-data-blocks" service policies in that SVM are created using the specified services.
- If a data SVM is created without specifying a list of data services, the built-in "default-data-files" and "default-data-blocks" service policies in that SVM are created using a default list of data services.

  The default data services list includes the iSCSI, NFS, NVMe, SMB, and FlexCache services.
- When a LIF is created with a list of data protocols, a service policy equivalent to the specified data protocols is assigned to the LIF.
- If an equivalent service policy does not exist, a custom service policy is created.
- When a LIF is created without a service policy or list of data protocols, the default-data-files service policy is assigned to the LIF by default.

Data-core service

The data-core service allows components that previously used LIFs with the data role to work as expected on clusters that have been upgraded to manage LIFs using service policies instead of LIF roles (which are deprecated in ONTAP 9.6).

Specifying data-core as a service does not open any ports in the firewall, but the service should be included in any service policy in a data SVM. For example, the default-data-files service policy contains the following services by default:

- data-core
- data-nfs
- data-cifs
- data-flexcache

The data-core service should be included in the policy to ensure all applications using the LIF work as expected, but the other three services can be removed, if desired.

Client-side LIF service

Beginning with ONTAP 9.10.1, ONTAP provides client-side LIF services for multiple applications. These services provide control over which LIFs are used for outbound connections on behalf of each application.

The following new services give administrators control over which LIFs are used as source addresses for certain applications.

Service	SVM restrictions	Description
management-ad-client	-	Beginning with ONTAP 9.11.1, ONTAP provides Active Directory client service for outbound connections to an external AD server.
management-dns-client	-	Beginning with ONTAP 9.11.1, ONTAP provides DNS client service for outbound connections to an external DNS server.
management-ldap-client	-	Beginning with ONTAP 9.11.1, ONTAP provides LDAP client service for outbound connections to an external LDAP server.
management-nis-client	-	Beginning with ONTAP 9.11.1, ONTAP provides NIS client service for outbound connections to an external NIS server.
management-ntp-client	system-only	Beginning with ONTAP 9.10.1, ONTAP provides NTP client service for outbound connections to an external NTP server.
data-fpolicy-client	data-only	Beginning with ONTAP 9.8, ONTAP provides client service for outbound FPolicy connections.

Each of the new services are automatically included in some of the built-in service policies, but administrators can remove them from the built-in policies or add them to custom policies to control which LIFs are used for outbound connections on behalf of each application.

Configure LIF service policies

You can configure LIF service policies to identify a single service or a list of services that will use a LIF.

Create a service policy for LIFs

You can create a service policy for LIFs. You can assign a service policy to one or more LIFs; thereby allowing the LIF to carry traffic for a single service or a list of services.

You need advanced privileges to run the `network interface service-policy create` command.

About this task

Built-in services and service policies are available for managing data and management traffic on both data and system SVMs. Most use cases are satisfied using a built-in service policy rather than creating a custom service policy.

You can modify these built-in service policies, if required.

Steps

1. View the services that are available in the cluster:

```
network interface service show
```

   Services represent the applications accessed by a LIF as well as the applications served by the cluster. Each service includes zero or more TCP and UDP ports on which the application is listening.

   The following additional data and management services are available:

```
cluster1::> network interface service show

Service                      Protocol:Ports
-------                      --------------
cluster-core                 -
data-cifs                    -
data-core                    -
data-flexcache               -
data-iscsi                   -
data-nfs                     -
intercluster-core            tcp:11104-11105
management-autosupport       -
management-bgp               tcp:179
management-core              -
management-https             tcp:443
management-ssh               tcp:22
12 entries were displayed.
```

2. View the service policies that exist in the cluster:

```
cluster1::> network interface service-policy show

Vserver   Policy                     Service: Allowed Addresses
--------- --------------------------
----------------------------------------
cluster1
          default-intercluster       intercluster-core: 0.0.0.0/0
                                     management-https: 0.0.0.0/0

          default-management         management-core: 0.0.0.0/0
                                     management-autosupport: 0.0.0.0/0
                                     management-ssh: 0.0.0.0/0
                                     management-https: 0.0.0.0/0

          default-route-announce     management-bgp: 0.0.0.0/0

Cluster
          default-cluster            cluster-core: 0.0.0.0/0

vs0
          default-data-blocks        data-core: 0.0.0.0/0
                                     data-iscsi: 0.0.0.0/0

          default-data-files         data-core: 0.0.0.0/0
                                     data-nfs: 0.0.0.0/0
                                     data-cifs: 0.0.0.0/0
                                     data-flexcache: 0.0.0.0/0

          default-management         data-core: 0.0.0.0/0
                                     management-ssh: 0.0.0.0/0
                                     management-https: 0.0.0.0/0

7 entries were displayed.
```

3. Create a service policy:

```
cluster1::> set -privilege advanced
Warning: These advanced commands are potentially dangerous; use them
only when directed to do so by technical support.
Do you wish to continue? (y or n): y

cluster1::> network interface service-policy create -vserver <svm_name>
-policy <service_policy_name> -services <service_name> -allowed
-addresses <IP_address/mask,...>
```

- "service_name" specifies a list of services that should be included in the policy.
- "IP_address/mask" specifies the list of subnet masks for addresses that are allowed to access the services in the service policy. By default, all specified services are added with a default allowed address list of 0.0.0.0/0, which allows traffic from all subnets. When a non-default allowed address list is provided, LIFs using the policy are configured to block all requests with a source address that does not match any of the specified masks.

  The following example shows how to create a data service policy, *svm1_data_policy*, for an SVM that includes *NFS* and *SMB* services:

  ```
  cluster1::> set -privilege advanced
  Warning: These advanced commands are potentially dangerous; use them
  only when directed to do so by technical support.
  Do you wish to continue? (y or n): y

  cluster1::> network interface service-policy create -vserver svm1
  -policy svm1_data_policy -services data-nfs,data-cifs,data-core
  ```

  The following example shows how to create an intercluster service policy:

  ```
  cluster1::> set -privilege advanced
  Warning: These advanced commands are potentially dangerous; use them
  only when directed to do so by technical support.
  Do you wish to continue? (y or n): y

  cluster1::> network interface service-policy create -vserver cluster1
  -policy intercluster1 -services intercluster-core
  ```

4. Verify that the service policy is created.

   ```
   cluster1::> network interface service-policy show
   ```

   The following output shows the service policies that are available:

```
cluster1::> network interface service-policy show

Vserver   Policy                     Service: Allowed Addresses
--------- --------------------------
----------------------------------------
cluster1
          default-intercluster       intercluster-core: 0.0.0.0/0
                                     management-https: 0.0.0.0/0

          intercluster1              intercluster-core: 0.0.0.0/0

          default-management         management-core: 0.0.0.0/0
                                     management-autosupport: 0.0.0.0/0
                                     management-ssh: 0.0.0.0/0
                                     management-https: 0.0.0.0/0

          default-route-announce     management-bgp: 0.0.0.0/0

Cluster
          default-cluster            cluster-core: 0.0.0.0/0

vs0
          default-data-blocks        data-core: 0.0.0.0/0
                                     data-iscsi: 0.0.0.0/0

          default-data-files         data-core: 0.0.0.0/0
                                     data-nfs: 0.0.0.0/0
                                     data-cifs: 0.0.0.0/0
                                     data-flexcache: 0.0.0.0/0

          default-management         data-core: 0.0.0.0/0
                                     management-ssh: 0.0.0.0/0
                                     management-https: 0.0.0.0/0

          svm1_data_policy           data-core: 0.0.0.0/0
                                     data-nfs: 0.0.0.0/0
                                     data-cifs: 0.0.0.0/0

9 entries were displayed.
```

After you finish

Assign the service policy to a LIF either at the time of creation or by modifying an existing LIF.

Assign a service policy to a LIF

You can assign a service policy to a LIF either at the time of creating the LIF or by modifying the LIF. A service policy defines the list of services that can be used with the LIF.

About this task

You can assign service policies for LIFs in the admin and data SVMs.

Step

Depending on when you want to assign the service policy to a LIF, perform one of the following actions:

If you are…	Assign the service policy…
Creating a LIF	network interface create -vserver svm_name -lif <lif_name> -home-node <node_name> -home-port <port_name> {(-address <IP_address> -netmask <IP_address>) -subnet-name <subnet_name>} -service-policy <service_policy_name>
Modifying a LIF	network interface modify -vserver <svm_name> -lif <lif_name> -service-policy <service_policy_name>

When you specify a service policy for a LIF, you need not specify the data protocol and role for the LIF. Creating LIFs by specifying the role and data protocols is also supported.

> A service policy can only be used by LIFs in the same SVM that you specified when creating the service policy.

Examples

The following example shows how to modify the service policy of a LIF to use the default- management service policy:

```
cluster1::> network interface modify -vserver cluster1 -lif lif1 -service
-policy default-management
```

Commands for managing LIF service policies

Use the `network interface service-policy` commands to manage LIF service policies.

If you want to…	Use this command…
Create a service policy (advanced privileges required)	`network interface service-policy create`
Add an additional service entry to an existing service policy (advanced privileges required)	`network interface service-policy add-service`
Clone an existing service policy (advanced privileges required)	`network interface service-policy clone`

Modify a service entry in an existing service policy (advanced privileges required)	`network interface service-policy modify-service`
Remove a service entry from an existing service policy (advanced privileges required)	`network interface service-policy remove-service`
Rename an existing service policy (advanced privileges required)	`network interface service-policy rename`
Delete an existing service policy (advanced privileges required)	`network interface service-policy delete`
Restore a built-in service-policy to its original state (advanced privileges required)	`network interface service-policy restore-defaults`
Display existing service policies	`network interface service-policy show`

Create a LIF

A LIF is an IP address associated with a physical or logical port. If there is a component failure, a LIF can fail over to or be migrated to a different physical port, thereby continuing to communicate with the network.

Before you begin

- The underlying physical or logical network port must have been configured to the administrative up status.
- If you are planning to use a subnet name to allocate the IP address and network mask value for a LIF, the subnet must already exist.

  Subnets contain a pool of IP addresses that belong to the same layer 3 subnet. They are created using the `network subnet create` command.

- The mechanism for specifying the type of traffic handled by a LIF has changed. For ONTAP 9.5 and earlier, LIFs used roles to specify the type of traffic it would handle. Beginning with ONTAP 9.6, LIFs use service policies to specify the type of traffic it would handle.

About this task

- You cannot assign NAS and SAN protocols to the same LIF.

  The supported protocols are SMB, NFS, FlexCache, iSCSI, and FC; iSCSI and FC cannot be combined with other protocols. However, NAS and Ethernet-based SAN protocols can be present on the same physical port.

- You can create both IPv4 and IPv6 LIFs on the same network port.
- All the name mapping and host-name resolution services used by an SVM, such as DNS, NIS, LDAP, and Active Directory, must be reachable from at least one LIF handling data traffic of the SVM.
- A LIF handling intracluster traffic between nodes should not be on the same subnet as a LIF handling management traffic or a LIF handling data traffic.

- Creating a LIF that does not have a valid failover target results in a warning message.
- If you have a large number of LIFs in your cluster, you can verify the LIF capacity supported on the cluster by using the `network interface capacity show` command and the LIF capacity supported on each node by using the `network interface capacity details show` command (at the advanced privilege level).
- Beginning with ONTAP 9.7, if other LIFs already exist for the SVM in the same subnet, you do not need to specify the home port of the LIF. ONTAP automatically chooses a random port on the specified home node in the same broadcast domain as the other LIFs already configured in the same subnet.

  Beginning with ONTAP 9.4, FC-NVMe is supported. If you are creating an FC-NVMe LIF you should be aware of the following:

  - The NVMe protocol must be supported by the FC adapter on which the LIF is created.
  - FC-NVMe can be the only data protocol on data LIFs.
- One LIF handling management traffic must be configured for every storage virtual machine (SVM) supporting SAN.
- NVMe LIFs and namespaces must be hosted on the same node.
- Only one NVMe LIF handling data traffic can be configured per SVM.
- When you create a network interface with a subnet, ONTAP automatically selects an available IP address from the selected subnet and assigns it to the network interface. You can change the subnet if there is more than one subnet, but you cannot change the IP address.
- Beginning with ONTAP 9.11.1, the iSCSI LIF failover feature is available on All SAN Array (ASA) platforms.

  iSCSI LIF failover is automatically enabled (the failover policy is set to `sfo-partner-only` and the auto-revert value is set to `true`) on newly created iSCSI LIFs if no iSCSI LIFs exist in the specified storage VM or if all existing iSCSI LIFs in the specified storage VM are already enabled with iSCSI LIF failover.

  If after you upgrade to ONTAP 9.11.1 or later, you have existing iSCSI LIFs in a storage VM that have not been enabled with the iSCSI LIF failover feature and you create new iSCSI LIFs in the same storage VM, the new iSCSI LIFs assume the same failover policy (`disabled`) of the existing iSCSI LIFs in the storage VM.

  iSCSI LIF failover for ASA platforms

Steps

1. Create a LIF:

   ```
   network interface create -vserver vserver_name -lif lif_name -service
   -policy service_policy_name -home-node node_name -home-port port_name {-
   address IP_address - netmask Netmask_value | -subnet-name subnet_name}
   -firewall- policy policy -auto-revert {true|false}
   ```

   - `-home-node` is the node to which the LIF returns when the `network interface revert` command is run on the LIF.

     You can also specify whether the LIF should automatically revert to the home-node and home-port with the -auto-revert option.

- `-home-port` is the physical or logical port to which the LIF returns when the `network interface revert` command is run on the LIF.
- You can specify an IP address with the `-address` and `-netmask` options, or you enable allocation from a subnet with the `-subnet_name` option.
- When using a subnet to supply the IP address and network mask, if the subnet was defined with a gateway, a default route to that gateway is added automatically to the SVM when a LIF is created using that subnet.
- If you assign IP addresses manually (without using a subnet), you might need to configure a default route to a gateway if there are clients or domain controllers on a different IP subnet. The `network route create` man page contains information about creating a static route within an SVM.
- `-auto-revert` allows you to specify whether a data LIF is automatically reverted to its home node under circumstances such as startup, changes to the status of the management database, or when the network connection is made. The default setting is `false`, but you can set it to `true` depending on network management policies in your environment.
- `-service-policy` Beginning with ONTAP 9.5, you can assign a service policy for the LIF with the `-service-policy` option.
  When a service policy is specified for a LIF, the policy is used to construct a default role, failover policy, and data protocol list for the LIF. In ONTAP 9.5, service policies are supported only for intercluster and BGP peer services. In ONTAP 9.6, you can create service policies for several data and management services.
- `-data-protocol` allows you to create a LIF that supports the Fibre Channel Protocol (FCP) or NVMe/FC protocols. This option is not required when creating an IP LIF.

2. **Optional**: If you want to assign an IPv6 address in the -address option:
   a. Use the network ndp prefix show command to view the list of RA prefixes learned on various interfaces.

      The `network ndp prefix show` command is available at the advanced privilege level.

   b. Use the format `prefix::id` to construct the IPv6 address manually.

      `prefix` is the prefix learned on various interfaces.

      For deriving the `id`, choose a random 64-bit hexadecimal number.

3. Verify that the LIF was created successfully by using the `network interface show` command.
4. Verify that the configured IP address is reachable:

To verify an…	Use…
IPv4 address	network ping
IPv6 address	network ping6

Examples

The following command creates a LIF and specifies the IP address and network mask values using the `-address` and `-netmask` parameters:

```
network interface create -vserver vs1.example.com -lif datalif1 -service
-policy default-data-files -home-node node-4 -home-port e1c -address
192.0.2.145 -netmask 255.255.255.0 -auto-revert true
```

The following command creates a LIF and assigns IP address and network mask values from the specified subnet (named client1_sub):

```
network interface create -vserver vs3.example.com -lif datalif3 -service
-policy default-data-files -home-node node-3 -home-port e1c -subnet-name
client1_sub - auto-revert true
```

The following command creates an NVMe/FC LIF and specifies the `nvme-fc` data protocol:

```
network interface create -vserver vs1.example.com -lif datalif1 -data
-protocol nvme-fc -home-node node-4 -home-port 1c -address 192.0.2.145
-netmask 255.255.255.0 -auto-revert true
```

Modify a LIF

You can modify a LIF by changing the attributes, such as home node or current node, administrative status, IP address, netmask, failover policy, firewall policy, and service policy. You can also change the address family of a LIF from IPv4 to IPv6.

About this task

- When modifying a LIF's administrative status to down, any outstanding NFSv4 locks are held until the LIF's administrative status is returned to up.

  To avoid lock conflicts that can occur when other LIFs attempt to access the locked files, you must move the NFSv4 clients to a different LIF before setting the administrative status to down.

- You cannot modify the data protocols used by an FC LIF. However, you can modify the services assigned to a service policy or change the service policy assigned to an IP LIF.

  To modify the data protocols used by a FC LIF, you must delete and re-create the LIF. To make service policy changes to an IP LIF, there is a brief outage while the updates occur.

- You cannot modify either the home node or the current node of a node-scoped management LIF.
- When using a subnet to change the IP address and network mask value for a LIF, an IP address is allocated from the specified subnet; if the LIF's previous IP address is from a different subnet, the IP address is returned to that subnet.
- To modify the address family of a LIF from IPv4 to IPv6, you must use the colon notation for the IPv6 address and add a new value for the `-netmask-length` parameter.
- You cannot modify the auto-configured link-local IPv6 addresses.
- Modification of a LIF that results in the LIF having no valid failover target results in a warning message.

If a LIF that does not have a valid failover target attempts to fail over, an outage might occur.

* Beginning with ONTAP 9.5, you can modify the service policy associated with a LIF.

  In ONTAP 9.5, service policies are supported only for intercluster and BGP peer services. In ONTAP 9.6, you can create service policies for several data and management services.

* Beginning with ONTAP 9.11.1, the iSCSI LIF failover feature is available on All SAN Array (ASA) platforms.

  For pre-existing iSCSI LIFs, meaning LIFs created prior to upgrading to 9.11.1 or later, you can modify the failover policy to enable the iSCSI LIF failover feature.

  iSCSI LIF failover for ASA platforms

Steps

1. Modify a LIF's attributes by using the "network interface modify" command.

   The following example shows how to modify the IP address and network mask of LIF datalif2 using an IP address and the network mask value from subnet client1_sub:

   ```
   network interface modify -vserver vs1 -lif datalif2 -subnet-name
   client1_sub
   ```

   The following example shows how to modify the service policy of a LIF.

   ```
   network interface modify -vserver siteA -lif node1_inter1 -service
   -policy example
   ```

2. Verify that the IP addresses are reachable.

If you are using…	Then use…
IPv4 addresses	`network ping`
IPv6 addresses	`network ping6`

Migrate a LIF

You might have to migrate a LIF to a different port on the same node or a different node within the cluster, if the port is either faulty or requires maintenance. Migrating a LIF is similar to LIF failover, but LIF migration is a manual operation, while LIF failover is the automatic migration of a LIF in response to a link failure on the LIF's current network port.

Before you begin

* A failover group must have been configured for the LIFs.
* The destination node and ports must be operational and must be able to access the same network as the source port.

About this task

- BGP LIFs reside on the home-port and cannot be migrated to any other node or port.
- You must migrate LIFs hosted on the ports belonging to a NIC to other ports in the cluster, before removing the NIC from the node.
- You must execute the command for migrating a cluster LIF from the node where the cluster LIF is hosted.
- A node-scoped LIF, such as a node-scoped management LIF, cluster LIF, intercluster LIF, cannot be migrated to a remote node.
- When an NFSv4 LIF is migrated between nodes, a delay of up to 45 seconds results before the LIF is available on a new port.

  To work around this problem, use NFSv4.1 where no delay is encountered.

- You can migrate iSCSI LIFs on All SAN Array (ASA) platforms running ONTAP 9.11.1 or later.

  Migrating iSCSI LIFs is limited to ports on the home-node or the HA partner.

  You can also use System Manager to migrate iSCSI LIFs.
  iSCSI LIF failover for ASA platforms

- If your platform is not an All SAN Array (ASA) platform running ONTAP version 9.11.1 or later, you cannot migrate iSCSI LIFs from one node to another node.

  To work around this restriction, you must create an iSCSI LIF on the destination node. For information about guidelines for creating an iSCSI LIF, see SAN administration.

- VMware VAAI copy offload operations fail when you migrate the source or the destination LIF. For more information about VMware VAAI, see NFS reference or SAN administration.

Step

Depending on whether you want to migrate a specific LIF or all the LIFs, perform the appropriate action:

If you want to migrate…	Enter the following command…
A specific LIF	`network interface migrate`
All the data and cluster-management LIFs on a node	`network interface migrate-all`
All of the LIFs off of a port	`network interface migrate-all -node <node> -port <port>`

The following example shows how to migrate a LIF named datalif1 on the SVM vs0 to the port e0d on node0b:

```
network interface migrate -vserver vs0 -lif datalif1 -dest-node node0b
-dest-port e0d
```

The following example shows how to migrate all the data and cluster-management LIFs from the current (local) node:

```
network interface migrate-all -node local
```

Revert a LIF to its home port

You can revert a LIF to its home port after it fails over or is migrated to a different port either manually or automatically. If the home port of a particular LIF is unavailable, the LIF remains at its current port and is not reverted.

About this task

- If you administratively bring the home port of a LIF to the up state before setting the automatic revert option, the LIF is not returned to the home port.
- The LIF does not automatically revert unless the value of the "auto-revert" option is set to true.
- You must ensure that the "auto-revert" option is enabled for the LIFs to revert to their home ports.

Step

Revert a LIF to its home port manually or automatically:

If you want to revert a LIF to its home port…	Then enter the following command…
Manually	network interface revert -vserver vserver_name -lif lif_name
Automatically	network interface modify -vserver vserver_name -lif lif_name -auto-revert true

ONTAP 9.8 and later: Recover from an incorrectly configured cluster LIF

A cluster cannot be created when the cluster network is cabled to a switch but not all of the ports configured in the Cluster IPspace can reach the other ports configured in the Cluster IPspace.

About this task

In a switched cluster, if a cluster network interface (LIF) is configured on the wrong port, or if a cluster port is wired into the wrong network, the `cluster create` command can fail with the following error:

```
Not all local cluster ports have reachability to one another.
Use the "network port reachability show -detail" command for more details.
```

The results of the `network port show` command might show that several ports are added to the Cluster IPspace because they are connected to a port that is configured with a cluster LIF. However, the results of the `network port reachability show -detail` command reveal which ports do not have connectivity to one another.

To recover from a cluster LIF configured on a port that is not reachable to the other ports configured with cluster LIFs, perform the following steps:

Steps

1. Reset the home port of the cluster LIF to the correct port:

```
network port modify -home-port
```

2. Remove the ports that do not have cluster LIFs configured on them from the cluster broadcast domain:

```
network port broadcast-domain remove-ports
```

3. Create the cluster:

```
cluster create
```

Result

When you complete the cluster creation, the system detects the correct configuration and places the ports into the correct broadcast domains.

Delete a LIF

You can delete a network interface (LIF) that is no longer required.

Before you begin

LIFs to be deleted must not be in use.

Steps

1. Mark the LIFs you want to delete as administratively down using the following command:

```
network interface modify -vserver vserver_name -lif lif_name -status
-admin down
```

2. Use the `network interface delete` command to delete one or all LIFs:

If you want to delete…	Enter the command …
A specific LIF	`network interface delete -vserver vserver_name -lif lif_name`
All LIFs	`network interface delete -vserver vserver_name -lif *`

The following command deletes the LIF mgmtlif2:

```
network interface delete -vserver vs1 -lif mgmtlif2
```

3. Use the `network interface show` command to confirm that the LIF is deleted.

Configure virtual IP (VIP) LIFs

Some next-generation data centers use Network-Layer-3 mechanisms that require LIFs to be failed over across subnets. Beginning with ONTAP 9.5, VIP data LIFs and the associated routing protocol, border gateway protocol (BGP), are supported, which enable ONTAP to participate in these next-generation networks.

About this task

A VIP data LIF is a LIF that is not part of any subnet and is reachable from all ports that host a BGP LIF in the same IPspace. A VIP data LIF eliminates the dependency of a host on individual network interfaces. Because multiple physical adapters carry the data traffic, the entire load is not concentrated on a single adapter and the associated subnet. The existence of a VIP data LIF is advertised to peer routers through the routing protocol, Border Gateway Protocol (BGP).

VIP data LIFs provide the following advantages:

- LIF portability beyond a broadcast domain or subnet: VIP data LIFs can fail over to any subnet in the network by announcing the current location of each VIP data LIF to routers through BGP.
- Aggregate throughput: VIP data LIFs can support aggregate throughput that exceeds the bandwidth of any individual port because the VIP LIFs can send or receive data from multiple subnets or ports simultaneously.

Set up border gateway protocol (BGP)

Before creating VIP LIFs, you must set up BGP, which is the routing protocol used for announcing the existence of a VIP LIF to peer routers.

Beginning with ONTAP 9.9.1, VIP BGP provides default route automation using BGP peer grouping to simplify configuration.

ONTAP has a simple way to learn default routes using the BGP peers as next-hop routers when the BGP peer is on the same subnet. To use the feature, set the `-use-peer-as-next-hop` attribute to `true`. By default, this attribute is `false`.

If you have static routes configured, those are still preferred over these automated default routes.

Before you begin

The peer router must be configured to accept a BGP connection from the BGP LIF for the configured autonomous system number (ASN).

> ONTAP does not process any incoming route announcements from the router; therefore, you should configure the peer router to not send any route updates to the cluster.

About this task

Setting up BGP involves optionally creating a BGP configuration, creating a BGP LIF, and creating a BGP peer group. ONTAP automatically creates a default BGP configuration with default values when the first BGP peer group is created on a given node. A BGP LIF is used to establish BGP TCP sessions with peer routers. For a peer router, a BGP LIF is the next hop to reach a VIP LIF. Failover is disabled for the BGP LIF. A BGP peer group advertises the VIP routes for all the SVMs in the peer group’s IPspace.

Beginning with ONTAP 9.8, these fields have been added to the `network bgp peer-group` command:

- -asn-prepend-type
- -asn-prepend-count
- -community

These BGP attributes allows you to configure the AS Path and community attributes for the BGP peer group.

Beginning with ONTAP 9.9.1, these fields have been added:

- -asn or -peer-asn (4-byte value)
  The attribute itself is not new, but it now uses a 4-byte integer.
- -med
- -use-peer-as-next-hop

You can make advanced route selections with Multi-Exit Discriminator (MED) support for path prioritization. MED is an optional attribute in the BGP update message that tells routers to select the best route for the traffic. The MED is an unsigned 32-bit integer (0 - 4294967295); lower values are preferred.

> While ONTAP supports the above BGP attributes, routers need not honor them. NetApp highly recommends you confirm which attributes are supported by your router and configure BGP peer-groups accordingly. For details, refer to the BGP documentation provided by your router.

Steps

1. Log in to the advanced privilege level:

   `set -privilege advanced`

2. Optional: Create a BGP configuration or modify the default BGP configuration of the cluster by performing one of the following actions:

   a. Create a BGP configuration:

   ```
   network bgp config create -node {node_name | local} -asn asn_integer
   -holdtime
   hold_time -routerid local_router_IP_address
   ```

   Sample with a 2-byte ASN:

   ```
   network bgp config create -node node1 -asn 65502 -holdtime 180
   -routerid 1.1.1.1
   ```

   Sample with a 4-byte ASN:

   ```
   network bgp config create -node node1 -asn 85502 -holdtime 180
   -routerid 1.1.1.1
   ```

b. Modify the default BGP configuration:

```
network bgp defaults modify -asn asn_integer -holdtime hold_time
network bgp defaults modify -asn 65502
```

- `asn_integer` specifies the ASN. Beginning with ONTAP 9.8, ASN for BGP supports a 2-byte non-negative integer. This is a 16-bit number (1 - 65534 available values). Beginning with ONTAP 9.9.1, ASN for BGP supports a 4-byte non-negative integer (1 - 4294967295). The default ASN is 65501. ASN 23456 is reserved for ONTAP session establishment with peers that do not announce 4-byte ASN capability.
- `hold_time` specifies the hold time in seconds. The default value is 180s.

3. Create a BGP LIF for the system SVM:

```
network interface create -vserver system_svm -lif lif_name -service
-policy default-route-announce -home-node home_node -home-port home_port
-address ip_address -netmask netmask
```

You can use the `default-route-announce` service policy for the BGP LIF or any custom service policy which contains the "management-bgp" service.

```
network interface create -vserver cluster1 -lif bgp1 -service-policy
default-route-announce -home-node cluster1-01 -home-port e0c -address
10.10.10.100 -netmask 255.255.255.0
```

4. Create a BGP peer group that is used to establish BGP sessions with the remote peer routers and configure the VIP route information that is advertised to the peer routers:

Sample 1: Create a peer group without an auto default route

In this case, the admin has to create a static route to the BGP peer.

```
network bgp peer-group create -peer-group group_name -ipspace
ipspace_name -bgp-lif bgp_lif -peer-address peer-router_ip_address -peer
-asn 65502 -route-preference integer
-asn-prepend-type <ASN_prepend_type> -asn-prepend-count integer -med
integer -community BGP community list <0-65535>:<0-65535>
```

```
network bgp peer-group create -peer-group group1 -ipspace Default -bgp
-lif bgp1 -peer-address 10.10.10.1 -peer-asn 65502 -route-preference 100
-asn-prepend-type local-asn -asn-prepend-count 2 -med 100 -community
9000:900,8000:800
```

Sample 2: Create a peer group with an auto default route

```
network bgp peer-group create -peer-group group_name -ipspace
ipspace_name -bgp-lif bgp_lif -peer-address peer-router_ip_address -peer
-asn 65502 -use-peer-as-next-hop true -route-preference integer -asn
-prepend-type <ASN_prepend_type> -asn-prepend-count integer -med integer
-community BGP community list <0-65535>:<0-65535>
```

```
network bgp peer-group create -peer-group group1 -ipspace Default -bgp
-lif bgp1 -peer-address 10.10.10.1 -peer-asn 65502 -use-peer-as-next-hop
true -route-preference 100 -asn-prepend-type local-asn -asn-prepend
-count 2 -med 100 -community 9000:900,8000:800
```

Create a virtual IP (VIP) data LIF

The existence of a VIP data LIF is advertised to peer routers through the routing protocol, Border Gateway Protocol (BGP).

Before you begin

- The BGP peer group must be set up and the BGP session for the SVM on which the LIF is to be created must be active.
- A static route to the BGP router or any other router in the BGP LIF's subnet must be created for any outgoing VIP traffic for the SVM.
- You should turn on multipath routing so that the outgoing VIP traffic can utilize all the available routes.

  If multipath routing is not enabled, all the outgoing VIP traffic goes from a single interface.

Steps

1. Create a VIP data LIF:

   ```
   network interface create -vserver svm_name -lif lif_name -role data
   -data-protocol
   {nfs|cifs|iscsi|fcache|none|fc-nvme} -home-node home_node -address
   ip_address -is-vip true
   ```

   A VIP port is automatically selected if you do not specify the home port with the `network interface create` command.

   By default, the VIP data LIF belongs to the system-created broadcast domain named 'Vip', for each IPspace. You cannot modify the VIP broadcast domain.

   A VIP data LIF is reachable simultaneously on all ports hosting a BGP LIF of an IPspace. If there is no active BGP session for the VIP's SVM on the local node, the VIP data LIF fails over to the next VIP port on the node that has a BGP session established for that SVM.

2. Verify that the BGP session is in the up status for the SVM of the VIP data LIF:

```
network bgp vserver-status show

Node        Vserver  bgp status
        ----------  -------- ---------
        node1       vs1      up
```

If the BGP status is `down` for the SVM on a node, the VIP data LIF fails over to a different node where the BGP status is up for the SVM. If BGP status is `down` on all the nodes, the VIP data LIF cannot be hosted anywhere, and has LIF status as down.

Commands for managing the BGP

Beginning with ONTAP 9.5, you use the `network bgp` commands to manage the BGP sessions in ONTAP.

Manage BGP configuration

If you want to…	Use this command…
Create a BGP configuration	network bgp config create
Modify BGP configuration	network bgp config modify
Delete BGP configuration	network bgp config delete
Display BGP configuration	network bgp config show
Displays the BGP status for the SVM of the VIP LIF	network bgp vserver-status show

Manage BGP default values

If you want to…	Use this command…
Modify BGP default values	network bgp defaults modify
Display BGP default values	network bgp defaults show

Manage BGP peer groups

If you want to…	Use this command…
Create a BGP peer group	network bgp peer-group create
Modify a BGP peer group	network bgp peer-group modify
Delete a BGP peer group	network bgp peer-group delete
Display BGP peer groups information	network bgp peer-group show
Rename a BGP peer group	network bgp peer-group rename

Related information

ONTAP 9 commands

Configure host-name resolution

Overview

ONTAP must be able to translate host names to numerical IP addresses in order to provide access to clients and to access services. You must configure storage virtual machines (SVMs) to use local or external name services to resolve host information. ONTAP supports configuring an external DNS server or configuring the local hosts file for host name resolution.

When using an external DNS server, you can configure Dynamic DNS (DDNS), which automatically sends new or changed DNS information from your storage system to the DNS server. 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.

Configure DNS for host-name resolution

You use DNS to access either local or remote sources for host information. You must configure DNS to access one or both of these sources.

ONTAP must be able to look up host information to provide proper access to clients. You must configure name services to enable ONTAP to access local or external DNS services to obtain the host information.

ONTAP stores name service configuration information in a table that is the equivalent of the `/etc/nsswitch.conf` file on UNIX systems.

Configure an SVM and data LIFs for host-name resolution using an external DNS server

You can use the `vserver services name-service dns` command to enable DNS on an SVM, and configure it to use DNS for host-name resolution. Host names are resolved using external DNS servers.

Before you begin

A site-wide DNS server must be available for host name lookups.

You should configure more than one DNS server to avoid a single-point-of-failure. The `vserver services name-service dns create` command issues a warning if you enter only one DNS server name.

About this task

See Configure dynamic DNS services for more information about configuring dynamic DNS on the SVM.

Steps

1. Enable DNS on the SVM:

   ```
   vserver services name-service dns create -vserver vserver_name -domains
   domain_name - name-servers ip_addresses -state enabled
   ```

   The following command enables external DNS server servers on the SVM vs1:

```
vserver services name-service dns create -vserver <vs1.example.com>
-domains <example.com> -name-servers <192.0.2.201,192.0.2.202> -state
<enabled>
```

> The vserver services name-service dns create command performs an automatic configuration validation and reports an error message if ONTAP cannot contact the name server.

2. Enable DNS on LIFs owned by the SVM:

If you are	Use this command:
Modifying an existing LIF zone-name	`network interface modify -lif lifname -dns-zone`
Creating a new LIF zone-name	`network interface create -lif lifname -dns-zone`

```
vserver services name-service dns create -vserver <vs1> -domains
<example.com> -name-servers <192.0.2.201, 192.0.2.202> -state <enabled>
network interface modify -lif <datalif1> -dns-zone
<zonename.whatever.com>
```

3. Validate the status of the name servers by using the `vserver services name-service dns check` command.

```
vserver services name-service dns check -vserver vs1.example.com
VserverName       Server      Status    Status Details
----------------  ----------  -------   --------------------------
vs1.example.com   10.0.0.50   up        Response time (msec): 2
vs1.example.com   10.0.0.51   up        Response time (msec): 2
```

Configure the Name Service Switch Table for Host-Name Resolution

You must configure the name service switch table correctly to enable ONTAP to consult local or external name service to retrieve host information.

Before you begin

You must have decided which name service to use for host mapping in your environment.

Steps

1. Add the necessary entries to the name service switch table:

```
vserver services name-service <ns-switch> create -vserver <vserver_name>
-database <database_name> -source <source_names>
```

2. Verify that the name service switch table contains the expected entries in the desired order:

```
vserver services name-service <ns-switch> show -vserver <vserver_name>
```

Example

The following example creates an entry in the name service switch table for SVM vs1 to first use the local hosts file and then an external DNS server to resolve host names:

```
vserver services name-service ns-switch create -vserver vs1 -database
hosts -sources files dns
```

Manage the hosts table (cluster administrators only)

A cluster administrator can add, modify, delete, and view the host name entries in the hosts table of the admin storage virtual machine (SVM). An SVM administrator can configure the host name entries only for the assigned SVM.

Commands for managing local host-name entries

You can use the `vserver services name-service dns hosts` command to create, modify, or delete DNS host table entries.

When you are creating or modifying the DNS host-name entries, you can specify multiple alias addresses separated by commas.

If you want to…	Use this command…
Create a DNS host-name entry	`vserver services name-service dns hosts create`
Modify a DNS host-name entry	`vserver services name-service dns hosts modify`
Delete a DNS host-name entry	`vserver services name-service dns hosts delete`

For more information, see the ONTAP 9 commands for the `vserver services name-service dns hosts` commands.

Balance network loads to optimize user traffic (cluster administrators only)

Overview

You can configure your cluster to serve client requests from appropriately loaded LIFs. This results in a more balanced utilization of LIFs and ports, which in turn allows for better performance of the cluster.

DNS load balancing helps in selecting an appropriately loaded data LIF and balancing user network traffic across all available ports (physical, interface groups, and VLANs).

With DNS load balancing, LIFs are associated with the load balancing zone of an SVM. A site-wide DNS server is configured to forward all DNS requests and return the least-loaded LIF based on the network traffic and the availability of the port resources (CPU usage, throughput, open connections, and so on). DNS load balancing provides the following benefits:

- New client connections balanced across available resources.
- No manual intervention required for deciding which LIFs to use when mounting a particular SVM.
- DNS load balancing supports NFSv3, NFSv4, NFSv4.1, SMB 2.0, SMB 2.1, and SMB 3.0.

How DNS load balancing works

Clients mount an SVM by specifying an IP address (associated with a LIF) or a host name (associated with multiple IP addresses). By default, LIFs are selected by the site-wide DNS server in a round-robin manner, which balances the workload across all LIFs.

Round-robin load balancing can result in overloading some LIFs, so you have the option of using a DNS load balancing zone that handles the host-name resolution in an SVM. Using a DNS load balancing zone, ensures better balance of the new client connections across available resources, leading to improved performance of the cluster.

A DNS load balancing zone is a DNS server inside the cluster that dynamically evaluates the load on all LIFs and returns an appropriately loaded LIF. In a load balancing zone, DNS assigns a weight (metric), based on the load, to each LIF.

Every LIF is assigned a weight based on its port load and CPU utilization of its home node. LIFs that are on less-loaded ports have a higher probability of being returned in a DNS query. Weights can also be manually assigned.

Create a DNS load balancing zone

You can create a DNS load balancing zone to facilitate the dynamic selection of a LIF based on the load, that is, the number of clients mounted on a LIF. You can create a load balancing zone while creating a data LIF.

Before you begin

The DNS forwarder on the site-wide DNS server must be configured to forward all requests for the load balancing zone to the configured LIFs.

The Knowledgebase article How to set up DNS load balancing in Cluster-Mode on the NetApp Support Site contains more information about configuring DNS load balancing using conditional forwarding.

About this task

- Any data LIF can respond to DNS queries for a DNS load balancing zone name.
- A DNS load balancing zone must have a unique name in the cluster, and the zone name must meet the following requirements:
  - It should not exceed 256 characters.
  - It should include at least one period.
  - The first and the last character should not be a period or any other special character.
  - It cannot include any spaces between characters.
  - Each label in the DNS name should not exceed 63 characters.

    A label is the text appearing before or after the period. For example, the DNS zone named storage.company.com has three labels.

Step

Use the `network interface create` command with the `dns-zone` option to create a DNS load balancing zone.

If the load balancing zone already exists, the LIF is added to it. For more information about the command, see ONTAP 9 commands.

The following example demonstrates how to create a DNS load balancing zone named storage.company.com while creating the LIF `lif1`:

```
network interface create -vserver vs0 -lif lif1 -home-node node1
-home-port e0c -address 192.0.2.129 -netmask 255.255.255.128 -dns-zone
```

Add or remove a LIF from a load balancing zone

You can add or remove a LIF from the DNS load balancing zone of a virtual machine (SVM). You can also remove all the LIFs simultaneously from a load balancing zone.

Before you begin

- All the LIFs in a load balancing zone should belong to the same SVM.
- A LIF can be a part of only one DNS load balancing zone.
- Failover groups for each subnet must have been set up, if the LIFs belong to different subnets.

About this task

A LIF that is in the administrative down status is temporarily removed from the DNS load balancing zone. When the LIF returns to the administrative up status, the LIF is automatically added to the DNS load balancing zone.

Step

Add a LIF to or remove a LIF from a load balancing zone:

If you want to…	Enter…

Add a LIF	`network interface modify -vserver` *`vserver_name`* `-lif` *`lif_name`* `-dns-zone` *`zone_name`* Example: `network interface modify -vserver vs1 -lif data1 -dns -zone cifs.company.com`

Remove a single LIF	`network interface modify -vserver` *`vserver_name`* `-lif` *`lif_name`* `-dns-zone none`
	Example:
	`network interface modify -vserver vs1 -lif data1 -dns -zone none`

Remove all LIFs	`network interface modify -vserver` *`vserver_name`* `-lif * -dns-zone none`
	Example:
	`network interface modify -vserver vs0 -lif * -dns-zone none`
	You can remove an SVM from a load balancing zone by removing all the LIFs in the SVM from that zone.

Secure your network

Configure network security using federal information processing standards (FIPS)

ONTAP is compliant in the Federal Information Processing Standards (FIPS) 140-2 for all SSL connections. You can turn on and off SSL FIPS mode, set SSL protocols globally, and turn off any weak ciphers such as RC4 within ONTAP.

By default, SSL on ONTAP is set with FIPS compliance disabled and SSL protocol enabled with the following:

- TLSv1.3 (beginning in ONTAP 9.11.1)
- TLSv1.2
- TLSv1.1
- TLSv1

When SSL FIPS mode is enabled, SSL communication from ONTAP to external client or server components outside of ONTAP will use FIPS compliant crypto for SSL.

If you want administrator accounts to access SVMs with an SSH public key, you must ensure that the host key algorithm is supported before enabling SSL FIPS mode.

Note: Host key algorithm support has changed in ONTAP 9.11.1 and later releases.

ONTAP release	Supported key types	Unsupported key types

9.11.1 and later	ecdsa-sha2-nistp256	rsa-sha2-512 rsa-sha2-256 ssh-ed25519 ssh-dss ssh-rsa
9.10.1 and earlier	ecdsa-sha2-nistp256 ssh-ed25519	ssh-dss ssh-rsa

Existing SSH public key accounts without the supported key algorithms must be reconfigured with a supported key type before enabling FIPS, or the administrator authentication will fail.

For more information, see Enable SSH public key accounts.

For more information about SSL FIPS mode configuration, see the `security config modify` man page.

ONTAP 9.11.1RC1 consideration

Due to a change in ONTAP version 9.11.1RC1, FIPS 140-2 compliance management mode no longer uses FIPS 140-2 validated software module.

ONTAP 9.11.1RC1 upgraded the OpenSSL version used for management and control plane connections for HTTPS. This version of OpenSSL (OpenSSL 3.x FIPS Provider) has not yet completed the FIPS 140-2 Cryptographic Module Validation Program (CMVP) validation process.

When FIPS compliance mode is enabled, encryption algorithms used for HTTPS connections are identical to the OpenSSL Project OpenSSL 3.x FIPS Provider algorithms that were issued in Cryptographic Algorithm Validation Program (CAVP) certificate A1938. **This change only affects ONTAP systems configured in FIPS compliance mode.**

This issue will be fixed once the upgraded OpenSSL module present in ONTAP 9.11.1RC1 completes FIPS 140-2 validation with NIST. If your environment requires ONTAP cluster management control plane run with a FIPS 140-2 CMVP validated module, then it is recommended to not upgrade to 9.11.1RC1.

This does not affect NetApp encryption at rest technologies like NSE, NVE, and NAE, as those features use a different cryptographic module than the one provided by OpenSSL in ONTAP.

For more information, see Upgrading to ONTAP 9.11.1RC1 results in FIPS 140-2 compliance management configuration that is not validated.

Enable FIPS

It is recommended that all secure users adjust their security configuration immediately after system installation or upgrade. When SSL FIPS mode is enabled, SSL communication from ONTAP to external client or server components outside of ONTAP will use FIPS compliant crypto for SSL.

> When FIPS is enabled, you cannot install or create a certificate with an RSA key length of 4096.

Steps

1. Change to advanced privilege level:

   ```
   set -privilege advanced
   ```

2. Enable FIPS:

```
security config modify -interface SSL -is-fips-enabled true
```

3. When prompted to continue, enter `y`
4. If you are running ONTAP 9.8 or earlier manually reboot each node in the cluster one by one. Beginning in ONTAP 9.9.1, rebooting is not required.

Example

If you are running ONTAP 9.9.1 or later, you will not see the warning message.

```
security config modify -interface SSL -is-fips-enabled true

Warning: This command will enable FIPS compliance and can potentially
cause some non-compliant components to fail. MetroCluster and Vserver DR
require FIPS to be enabled on both sites in order to be compatible.
Do you want to continue? {y|n}: y

Warning: When this command completes, reboot all nodes in the cluster.
This is necessary to prevent components from failing due to an
inconsistent security configuration state in the cluster. To avoid a
service outage, reboot one node at a time and wait for it to completely
initialize before rebooting the next node. Run "security config status
show" command to monitor the reboot status.
Do you want to continue? {y|n}: y
```

Disable FIPS

If you are still running an older system configuration and want to configure ONTAP with backward compatibility, you can turn on SSLv3 only when FIPS is disabled.

Steps

1. Change to advanced privilege level:

```
set -privilege advanced
```

2. Disable FIPS by typing:

```
security config modify -interface SSL -is-fips-enabled false
```

3. When prompted to continue, enter `y`.
4. If you are running ONTAP 9.8 or earlier, manually reboot each node in the cluster. Beginning in ONTAP 9.9.1, rebooting is not required.

Example

If you are running ONTAP 9.9.1 or later, you will not see the warning message.

```
security config modify -interface SSL -supported-protocols SSLv3

Warning: Enabling the SSLv3 protocol may reduce the security of the
interface, and is not recommended.
Do you want to continue? {y|n}: y

Warning: When this command completes, reboot all nodes in the cluster.
This is necessary to prevent components from failing due to an
inconsistent security configuration state in the cluster. To avoid a
service outage, reboot one node at a time and wait for it to completely
initialize before rebooting the next node. Run "security config status
show" command to monitor the reboot status.
Do you want to continue? {y|n}: y
```

View FIPS compliance status

You can see whether the entire cluster is running the current security configuration settings.

Steps

1. One by one, reboot each node in the cluster.

   Do not reboot all cluster nodes simultaneously. A reboot is required to make sure that all applications in the cluster are running the new security configuration, and for all changes to FIPS on/off mode, protocols, and ciphers.

2. View the current compliance status:

   ```
   security config show
   ```

Example

```
security config show

          Cluster                                              Cluster
Security
Interface FIPS Mode  Supported Protocols     Supported Ciphers Config
Ready
--------- ---------- ----------------------- -----------------
----------------
SSL       false      TLSv1_2, TLSv1_1, TLSv1 ALL:!LOW:!aNULL:  yes
                                             !EXP:!eNULL
```

Configure IP security (IPsec) over wire encryption

Beginning with ONTAP 9.8, ONTAP uses the IPsec protocol in transport mode to ensure data is continuously secure and encrypted, even while in transit. IPsec offers data encryption for all IP traffic including the NFS, iSCSI, and SMB protocols. IPsec provides the only encryption in flight option for iSCSI traffic.

Beginning with ONTAP 9.9.1, the encryption algorithms used by IPsec are FIPS 140-2 validated. The algorithms are generated by the NetApp Cryptographic Module in ONTAP which carries the FIPS 140-2 validation.

Beginning with ONTAP 9.10.1, you can use either pre-shared keys (PSKs) or certificates for authentication with IPsec. Previously, only PSKs were supported with IPsec.

After IPsec is configured, network traffic between the client and ONTAP is protected with preventive measures to combat replay and man-in-the-middle (MITM) attacks.

For NetApp SnapMirror and cluster peering traffic encryption, cluster peering encryption (CPE), transport layer security (TLS) is still recommended over IPsec for secure in-transit over the wire. This is because TLS has better performance than IPsec.

While IPsec capability is enabled on the cluster, the network requires a Security Policy Database (SPD) entry to match the to-be-protected traffic and to specify protection details (such as cipher suite and authentication method) before traffic can flow. A corresponding SPD entry is also needed on each client. The SPD requirement is needed for both PSK and certification authentication methods.

Enable IPsec on the cluster

You can enable IPsec on the cluster to ensure data is continuously secure and encrypted, even while in transit.

Steps

1. Discover if IPsec is enabled already:

   ```
   security ipsec config show
   ```

   If the result includes `IPsec Enabled: false`, proceed to the next step.

2. Enable IPsec:

   ```
   security ipsec config modify -is-enabled true
   ```

3. Run the discovery command again:

   ```
   security ipsec config show
   ```

   The result now includes `IPsec Enabled: true`.

Preparing for IPsec policy creation with certificate authentication

You can skip this step if you are only using pre-shared keys PSKs for authentication and will not use certificate authentication.

Before creating an IPsec policy that uses certificates for authentication you must ensure that the following pre-requisites are met:

- Both ONTAP and the client must have the other party's CA certificate installed so that the end entity (either ONTAP or the client) certificates are verifiable by both sides

- A certificate is installed for the ONTAP LIF that participates in the policy

> ONTAP LIFs can share certificates. A one-to-one mapping between certificates and LIFs is not required.

Steps

1. You must install all CA certificates used during the mutual authentication, including both ONTAP-side and client-side CAs, to ONTAP certificate management unless it is already installed (as is the case of an ONTAP self-signed root-CA).
   Sample command
   ```
   cluster::> security certificate install -vserver svm_name -type server-ca
   -cert-name my_ca_cert
   ```
2. To ensure that the CA installed is within the IPsec CA searching path during authentication, add the ONTAP certificate management CAs to the IPsec module using the “security ipsec ca-certificate add” command.
   Sample command
   ```
   cluster::> security ipsec ca-certificate add -vserver svm_name -ca-certs
   my_ca_cert
   ```
3. Create and install a certificate for use by the ONTAP LIF. The issuer CA of this certificate must already be installed to ONTAP and added to IPsec.
   Sample command
   ```
   cluster::> security certificate install -vserver svm_name -type server -cert
   -name my_nfs_server_cert
   ```

For more information about certificates in ONTAP, see the security certificate commands in the ONTAP 9 documentation.

Define the security policy database (SPD)

IPsec requires an SPD entry before allowing traffic to flow on the network. This is true whether you are using a PSK or a certificate for authentication.

Step

1. Use the `security ipsec policy create` command to:
   a. Select the ONTAP IP address or subnet of IP addresses to participate in the IPsec transport.
   b. Select the client IP addresses that will connect to the ONTAP IP addresses.

      > The client must support Internet Key Exchange version 2 (IKEv2) with a pre-shared key (PSK).

   c. Optional. Select the upper layer protocols (UDP, TCP, ICMP, etc.), the local port numbers, and the remote port numbers to protect. The corresponding parameters are `protocols`, `local-ports` and `remote-ports` respectively.

      Skip this step to protect all traffic between the ONTAP IP address and client IP address. Protecting all traffic is the default.

   d. Either enter PSK or PKI for the `auth-method` parameter for the desired authentication method.
      i. If you enter a PSK, after finishing all other optional parameters, hit <enter> for the prompt to enter and verify the pre-shared key.

ii. If you enter a PKI, you need to also enter the `cert-name`, `local-identity`, `remote-identity` parameters. If the remote side certificate's identity is unknown or if multiple client identities are expected, enter the special word `ANYTHING`.

Sample command for PSK authentications

```
security ipsec policy create -vserver <vs1> -name <test34> -local-ip
-subnets <192.168.134.34/32> -remote-ip-subnets <192.168.134.44/32>
Enter the preshared key for IPsec Policy _test34_ on Vserver _vs1_:
```

Sample command for certificate authentications

```
security ipsec policy create -vserver vs1 -name test34 -local-ip-subnets
192.168.134.34/32 -remote-ip-subnets 192.168.134.44/32 -local-ports 2049
-protocols tcp -auth-method PKI -cert-name my_nfs_server_cert -local
-identity CN=netapp.ipsec.lif1.vs0 -remote-identity ANYTHING
```

IP traffic cannot flow between the client and server until both ONTAP and the client have setup the matching IPsec policies, and authentication credentials (either PSK or certificate) are in place on both sides. For details, see the client side's IPsec configuration.

Use IPsec identities

For the pre-shared key authentication method, identities are optional unless required by an IPsec client (such as Libreswan). For the PKI/certificate authentication method, both local and remote identities are mandatory. The identities specify what identity is certified within each side's certificate and are used in the verification process. If the remote-identity is unknown or if it could be many different identities, use the special identity `ANYTHING`.

About this task

Within ONTAP, identities are specified by modifying the SPD entry or during SPD policy creation. The SPD can be an IP address or string format identity name.

Step

To modify an existing SPD's identity settings, use the following command:

`security ipsec policy modify`

Sample command

`security ipsec policy modify -vserver` *`vs1`* `-name` *`test34`* `-local-identity` *`192.168.134.34`* `-remote-identity` *`client.fooboo.com`*

IPsec multiple client configuration

When a small number of clients need to leverage IPsec, using a single SPD entry for each client is sufficient. However, when hundreds or even thousands of clients need to leverage IPsec, NetApp recommends using an IPsec multiple client configuration.

About this task

ONTAP supports connecting multiple clients across many networks to a single SVM IP address with IPsec enabled. You can accomplish this using one of the following methods:

- **Subnet configuration**

  To allow all clients on a particular subnet (192.168.134.0/24 for example) to connect to a single SVM IP address using a single SPD policy entry, you must specify the `remote-ip-subnets` in subnet form. Additionally, you must specify the `remote-identity` field with the correct client side identity.

  > When using a single policy entry in a subnet configuration, IPsec clients in that subnet share the IPsec identity and pre-shared key (PSK). However, this is not true with certificate authentication. When using certificates each client can use either their own unique certificate or a shared certificate to authenticate. ONTAP IPsec checks the validity of the certificate based on the CAs installed on its local trust store. ONTAP also supports certificate revocation list (CRL) checking.

- **Allow all clients configuration**

  To allow any client, regardless of their source IP address, to connect to the SVM IPsec-enabled IP address, use the `0.0.0.0/0` wild card when specifying the `remote-ip-subnets` field.

  Additionally, you must specify the `remote-identity` field with the correct client side identity. For certificate authentication, you can enter `ANYTHING`.

  Also, when the `0.0.0.0/0` wild card is used, you must configure a specific local or remote port number to use. For example, `NFS port 2049`.

Step

1. Use one of the following commands to configure IPsec for multiple clients:

   a. If you are using a **subnet configuration** to support multiple IPsec clients:

   ```
   security ipsec policy create -vserver vserver_name -name policy_name
   -local-ip-subnets IPsec_IP_address/32 -remote-ip-subnets
   IP_address/subnet -local-identity local_id -remote-identity remote_id
   ```

   Sample command

   ```
   security ipsec policy create -vserver vs1 -name subnet134 -local-ip
   -subnets 192.168.134.34/32 -remote-ip-subnets 192.168.134.0/24 -local
   -identity ontap_side_identity -remote-identity client_side_identity
   ```

   b. If you are using an **allow all clients configuration** to support multiple IPsec clients:

   ```
   security ipsec policy create -vserver vserver_name -name policy_name
   -local-ip-subnets IPsec_IP_address/32 -remote-ip-subnets 0.0.0.0/0 -local
   -ports port_number -local-identity local_id -remote-identity remote_id
   ```

   Sample command

   ```
   security ipsec policy create -vserver vs1 -name test35 -local-ip-subnets
   IPsec_IP_address/32 -remote-ip-subnets 0.0.0.0/0 -local-ports 2049 -local
   -identity ontap_side_identity -remote-identity client_side_identity
   ```

IPsec statistics

Through negotiation, a security channel called an IKE Security Association (SA) can be established between the ONTAP SVM IP address and the client IP address. IPsec SAs are installed on both endpoints to do the actual data encryption and decryption work.

You can use statistics commands to check the status of both IPsec SAs and IKE SAs.

Sample commands

IKE SA sample command:

`security ipsec show-ikesasa -node` *`hosting_node_name_for_svm_ip`*

IPsec SA sample command and output:

`security ipsec show-ipsecsa -node` *`hosting_node_name_for_svm_ip`*

```
cluster1::> security ipsec show-ikesa -node cluster1-node1
            Policy Local           Remote
Vserver     Name   Address         Address         Initator-SPI     State
----------- ------ --------------- --------------- ----------------
-----------
vs1         test34
                   192.168.134.34  192.168.134.44  c764f9ee020cec69
ESTABLISHED
```

IPsec SA sample command and output:

```
security ipsec show-ipsecsa -node hosting_node_name_for_svm_ip

cluster1::> security ipsec show-ipsecsa -node cluster1-node1
            Policy  Local           Remote          Inbound  Outbound
Vserver     Name    Address         Address         SPI      SPI
State
----------- ------- --------------- --------------- -------- --------
---------
vs1         test34
                    192.168.134.34  192.168.134.44  c4c5b3d6 c2515559
INSTALLED
```

Configure firewall policies for LIFs

Setting up a firewall enhances the security of the cluster and helps prevent unauthorized access to the storage system. By default, the onboard firewall is configured to allow remote access to a specific set of IP services for data, management, and intercluster LIFs.

Beginning with ONTAP 9.10.1:

- Firewall service policies are deprecated and are replaced by LIF service policies. Previously, the onboard firewall was managed using firewall policies. This functionality is now accomplished using a LIF service policy.
- All firewall policies are empty and do not open any ports in the underlying firewall. Instead, all ports must be opened using a LIF service policy.
- No action is required after an upgrade to 9.10.1 or later to transition from firewall service policies to LIF service policies. The system automatically constructs LIF service policies consistent with the firewall service policies in use in the previous ONTAP release. If you use scripts or other tools that create and manage custom firewall policies, you might need to upgrade those scripts to create custom service policies instead.

To learn more, see LIFs and service policies in ONTAP 9.6 and later.

Firewall policies can be used to control access to management service protocols such as SSH, HTTP, HTTPS, Telnet, NTP, NDMP, NDMPS, RSH, DNS, or SNMP. Firewall policies cannot be set for data protocols such as NFS or SMB.

You can manage firewall service and policies in the following ways:

- Enabling or disabling firewall service
- Displaying the current firewall service configuration
- Creating a new firewall policy with the specified policy name and network services
- Applying a firewall policy to a logical interface
- Creating a new firewall policy that is an exact copy of an existing policy

  You can use this to make a policy with similar characteristics within the same SVM, or to copy the policy to a different SVM.
- Displaying information about firewall policies
- Modifying the IP addresses and netmasks that are used by a firewall policy
- Deleting a firewall policy that is not being used by a LIF

Firewall policies and LIFs

LIF firewall policies are used to restrict access to the cluster over each LIF. You need to understand how the default firewall policy affects system access over each type of LIF, and how you can customize a firewall policy to increase or decrease security over a LIF.

When configuring a LIF using the `network interface create` or `network interface modify` command, the value specified for the `-firewall-policy` parameter determines the service protocols and IP addresses that are allowed access to the LIF.

In many cases you can accept the default firewall policy value. In other cases, you might need to restrict access to certain IP addresses and certain management service protocols. The available management service protocols include SSH, HTTP, HTTPS, Telnet, NTP, NDMP, NDMPS, RSH, DNS, and SNMP.

The firewall policy for all cluster LIFs defaults to `""` and cannot be modified.

The following table describes the default firewall policies that are assigned to each LIF, depending on their role

(ONTAP 9.5 and earlier) or service policy (ONTAP 9.6 and later), when you create the LIF:

Firewall policy	Default service protocols	Default access	LIFs applied to
mgmt	dns, http, https, ndmp, ndmps, ntp, snmp, ssh	Any address (0.0.0.0/0)	Cluster management, SVM management, and node management LIFs
mgmt-nfs	dns, http, https, ndmp, ndmps, ntp, portmap, snmp, ssh	Any address (0.0.0.0/0)	Data LIFs that also support SVM management access
intercluster	https, ndmp, ndmps	Any address (0.0.0.0/0)	All intercluster LIFs
data	dns, ndmp, ndmps, portmap	Any address (0.0.0.0/0)	All data LIFs

Portmap service configuration

The portmap service maps RPC services to the ports on which they listen.

The portmap service was always accessible in ONTAP 9.3 and earlier, became configurable in ONTAP 9.4 through ONTAP 9.6, and is managed automatically beginning with ONTAP 9.7.

- In ONTAP 9.3 and earlier, the portmap service (rpcbind) was always accessible on port 111 in network configurations that relied on the built-in ONTAP firewall rather than a third-party firewall.
- From ONTAP 9.4 through ONTAP 9.6, you can modify firewall policies to control whether the portmap service is accessible on particular LIFs.
- Beginning with ONTAP 9.7, the portmap firewall service is eliminated. Instead, the portmap port is opened automatically for all LIFs that support the NFS service.

Portmap service is configurable in the firewall in ONTAP 9.4 through ONTAP 9.6.

The remainder of this topic discusses how to configure the portmap firewall service for ONTAP 9.4 through ONTAP 9.6 releases.

Depending on your configuration, you may be able to disallow access to the service on specific types of LIFs, typically management and intercluster LIFs. In some circumstances, you might even be able to disallow access on data LIFs.

What behavior you can expect

The ONTAP 9.4 through ONTAP 9.6 behavior is designed to provide a seamless transition on upgrade. If the portmap service is already being accessed over specific types of LIFs, it will continue to be accessible over those types of LIFs. As in previous ONTAP versions, you can specify the services accessible within the firewall in the firewall policy for the LIF type.

All nodes in the cluster must be running ONTAP 9.4 through ONTAP 9.6 for the behavior to take effect. Only inbound traffic is affected.

The new rules are as follows:

- On upgrade to release 9.4 through 9.6, ONTAP adds the portmap service to all existing firewall policies, default or custom.
- When you create a new cluster or new IPspace, ONTAP adds the portmap service only to the default data policy, not to the default management or intercluster policies.
- You can add the portmap service to default or custom policies as needed, and remove the service as needed.

How to add or remove the portmap service

To add the portmap service to an SVM or cluster firewall policy (make it accessible within the firewall), enter:

```
system services firewall policy create -vserver SVM -policy
mgmt|intercluster|data|custom -service portmap
```

To remove the portmap service from an SVM or cluster firewall policy (make it inaccessible within the firewall), enter:

```
system services firewall policy delete -vserver SVM -policy
mgmt|intercluster|data|custom -service portmap
```

You can use the network interface modify command to apply the firewall policy to an existing LIF. For complete command syntax, see ONTAP 9 commands.

Create a firewall policy and assigning it to a LIF

Default firewall policies are assigned to each LIF when you create the LIF. In many cases, the default firewall settings work well and you do not need to change them. If you want to change the network services or IP addresses that can access a LIF, you can create a custom firewall policy and assign it to the LIF.

About this task

- You cannot create a firewall policy with the `policy` name `data`, `intercluster`, `cluster`, or `mgmt`.

  These values are reserved for the system-defined firewall policies.

- You cannot set or modify a firewall policy for cluster LIFs.

  The firewall policy for cluster LIFs is set to 0.0.0.0/0 for all services types.

- If you need to remove a service from a policy, you must delete the existing firewall policy and create a new policy.
- If IPv6 is enabled on the cluster, you can create firewall policies with IPv6 addresses.

  After IPv6 is enabled, `data`, `intercluster`, and `mgmt` firewall policies include ::/0, the IPv6 wildcard, in their list of accepted addresses.

- When using System Manager to configure data protection functionality across clusters, you must ensure that the intercluster LIF IP addresses are included in the allowed list, and that HTTPS service is allowed on both the intercluster LIFs and on your company-owned firewalls.

  By default, the `intercluster` firewall policy allows access from all IP addresses (0.0.0.0/0, or ::/0 for IPv6) and enables HTTPS, NDMP, and NDMPS services. If you modify this default policy, or if you create your own firewall policy for intercluster LIFs, you must add each intercluster LIF IP address to the allowed list and enable HTTPS service.

- Beginning with ONTAP 9.6, the HTTPS and SSH firewall services are not supported.

  In ONTAP 9.6, the `management-https` and `management-ssh` LIF services are available for HTTPS and SSH management access.

Steps

1. Create a firewall policy that will be available to the LIFs on a specific SVM:

   `system services firewall policy create -vserver` *`vserver_name`* `-policy` *`policy_name`* `-service` *`network_service`* `-allow-list` *`ip_address/mask`*

   You can use this command multiple times to add more than one network service and list of allowed IP addresses for each service in the firewall policy.

2. Verify that the policy was added correctly by using the `system services firewall policy show` command.
3. Apply the firewall policy to a LIF:

   `network interface modify -vserver` *`vserver_name`* `-lif` *`lif_name`* `-firewall-policy` *`policy_name`*

4. Verify that the policy was added correctly to the LIF by using the `network interface show -fields firewall-policy` command.

Example of creating a firewall policy and applying it to a LIF

The following command creates a firewall policy named data_http that enables HTTP and HTTPS protocol access from IP addresses on the 10.10 subnet, applies that policy to the LIF named data1 on SVM vs1, and then shows all of the firewall policies on the cluster:

```
system services firewall policy create -vserver vs1 -policy data_http
-service http - allow-list 10.10.0.0/16
```

```
system services firewall policy show

Vserver Policy       Service    Allowed
------- ------------ ---------- -------------------
cluster-1
        data
                     dns        0.0.0.0/0
                     ndmp       0.0.0.0/0
                     ndmps      0.0.0.0/0
cluster-1
        intercluster
                     https      0.0.0.0/0
                     ndmp       0.0.0.0/0
                     ndmps      0.0.0.0/0
cluster-1
        mgmt
                     dns        0.0.0.0/0
                     http       0.0.0.0/0
                     https      0.0.0.0/0
                     ndmp       0.0.0.0/0
                     ndmps      0.0.0.0/0
                     ntp        0.0.0.0/0
                     snmp       0.0.0.0/0
                     ssh        0.0.0.0/0
vs1
        data_http
                     http       10.10.0.0/16
                     https      10.10.0.0/16

network interface modify -vserver vs1 -lif data1 -firewall-policy
data_http

network interface show -fields firewall-policy

vserver  lif                  firewall-policy
-------  -------------------- ---------------
Cluster  node1_clus_1
Cluster  node1_clus_2
Cluster  node2_clus_1
Cluster  node2_clus_2
cluster-1 cluster_mgmt         mgmt
cluster-1 node1_mgmt1          mgmt
cluster-1 node2_mgmt1          mgmt
vs1      data1                data_http
vs3      data2                data
```

Commands for managing firewall service and policies

You can use the `system services firewall` commands to manage firewall service, the `system services firewall policy` commands to manage firewall policies, and the `network interface modify` command to manage firewall settings for LIFs.

If you want to…	Use this command…
Enable or disable firewall service	`system services firewall modify`
Display the current configuration for firewall service	`system services firewall show`
Create a firewall policy or add a service to an existing firewall policy	`system services firewall policy create`
Apply a firewall policy to a LIF	`network interface modify -lif lifname -firewall-policy`
Modify the IP addresses and netmasks associated with a firewall policy	`system services firewall policy modify`
Display information about firewall policies	`system services firewall policy show`
Create a new firewall policy that is an exact copy of an existing policy	`system services firewall policy clone`
Delete a firewall policy that is not used by a LIF	`system services firewall policy delete`

For more information, see the man pages for the `system services firewall`, `system services firewall policy`, and `network interface modify` commands in ONTAP 9 commands.

Configure QoS marking (cluster administrators only)

Overview

Network Quality of Service (QoS) marking helps you to prioritize different traffic types based on the network conditions to effectively utilize the network resources. You can set the differentiated services code point (DSCP) value of the outgoing IP packets for the supported traffic types per IPspace.

DSCP marking for UC compliance

You can enable differentiated services code point (DSCP) marking on outgoing (egress) IP packet traffic for a given protocol with a default or user-provided DSCP code. DSCP marking is a mechanism for classifying and managing network traffic and is a component of Unified Capability (UC) compliance.

DSCP marking (also known as *QoS marking* or *quality of service marking*) is enabled by providing an IPspace, protocol, and DSCP value. The protocols on which DSCP marking can be applied are NFS, SMB, iSCSI, SnapMirror, NDMP, FTP, HTTP/HTTPS, SSH, Telnet, and SNMP.

If you do not provide a DSCP value when enabling DSCP marking for a given protocol, a default is used:

- The default value for data protocols/traffic is 0x0A (10).
- The default value for control protocols/traffic is 0x30 (48).

Modify QoS marking values

You can modify the Quality of Service (QoS) marking values for different protocols, for each IPspace.

Before you begin

All nodes in the cluster must be running the same version of ONTAP.

Step

Modify QoS marking values by using the `network qos-marking modify` command.

- The `–ipspace` parameter specifies the IPspace for which the QoS marking entry is to be modified.
- The `–protocol` parameter specifies the protocol for which the QoS marking entry is to be modified. The `network qos-marking modify` man page describes the possible values of the protocol.
- The `–dscp` parameter specifies the Differentiated Services Code Point (DSCP) value. The possible values ranges from 0 through 63.
- The `-is-enabled` parameter is used to enable or disable the QoS marking for the specified protocol in the IPspace provided by the `–ipspace` parameter.

The following command enables the QoS marking for the NFS protocol in default IPspace:

```
network qos-marking modify -ipspace Default -protocol NFS -is-enabled true
```

The following command sets the DSCP value to 20 for the NFS protocol in the default IPspace:

```
network qos-marking modify -ipspace Default -protocol NFS -dscp 20
```

Display QoS marking values

You can display the QoS marking values for different protocols, for each IPspace.

Step

Display QoS marking values by using the `network qos-marking show` command.

The following command displays the QoS marking for all protocols in the default IPspace:

```
network qos-marking show -ipspace Default
IPspace             Protocol          DSCP  Enabled?
------------------- ----------------- -----  --------
Default
                    CIFS                 10  false
                    FTP                  48  false
                    HTTP-admin           48  false
                    HTTP-filesrv         10  false
                    NDMP                 10  false
                    NFS                  10  true
                    SNMP                 48  false
                    SSH                  48  false
                    SnapMirror           10  false
                    Telnet               48  false
                    iSCSI                10  false
11 entries were displayed.
```

Manage SNMP on the cluster (cluster administrators only)

Overview

You can configure SNMP to monitor SVMs in your cluster to avoid issues before they occur, and to respond to issues if they do occur. Managing SNMP involves configuring SNMP users and configuring SNMP traphost destinations (management workstations) for all SNMP events. SNMP is disabled by default on data LIFs.

You can create and manage read-only SNMP users in the data SVM. Data LIFs must be configured to receive SNMP requests on the SVM.

SNMP network management workstations, or managers, can query the SVM SNMP agent for information. The SNMP agent gathers information and forwards it to the SNMP managers. The SNMP agent also generates trap notifications whenever specific events occur. The SNMP agent on the SVM has read-only privileges; it cannot be used for any set operations or for taking a corrective action in response to a trap. ONTAP provides an SNMP agent compatible with SNMP versions v1, v2c, and v3. SNMPv3 offers advanced security by using passphrases and encryption.

For more information about SNMP support in ONTAP systems, see TR-4220: SNMP Support in Data ONTAP.

What MIBs are

A MIB (Management Information Base) is a text file that describes SNMP objects and traps.

MIBs describe the structure of the management data of the storage system and they use a hierarchical namespace containing object identifiers (OIDs). Each OID identifies a variable that can be read by using SNMP.

Because MIBs are not configuration files and ONTAP does not read these files, SNMP functionality is not affected by MIBs. ONTAP provides the following MIB file:

* A NetApp custom MIB (`netapp.mib`)

ONTAP supports IPv6 (RFC 2465), TCP (RFC 4022), UDP (RFC 4113), and ICMP (RFC 2466) MIBs, which show both IPv4 and IPv6 data, are supported.

ONTAP also provides a short cross-reference between object identifiers (OIDs) and object short names in the `traps.dat` file.

> The latest versions of the ONTAP MIBs and `traps.dat `files are available on the NetApp Support Site. However, the versions of these files on the support site do not necessarily correspond to the SNMP capabilities of your ONTAP version. These files are provided to help you evaluate SNMP features in the latest ONTAP version.

SNMP traps

SNMP traps capture system monitoring information that is sent as an asynchronous notification from the SNMP agent to the SNMP manager.

There are three types of SNMP traps: standard, built-in, and user-defined. User-defined traps are not supported in ONTAP.

A trap can be used to check periodically for operational thresholds or failures that are defined in the MIB. If a threshold is reached or a failure is detected, the SNMP agent sends a message (trap) to the traphosts alerting them of the event.

> ONTAP supports SNMPv1 traps and, staring in ONTAP 9.1, SNMPv3 traps. ONTAP does not support SNMPv2c traps and INFORMs.

Standard SNMP traps

These traps are defined in RFC 1215. There are five standard SNMP traps that are supported by ONTAP: coldStart, warmStart, linkDown, linkUp, and authenticationFailure.

> The authenticationFailure trap is disabled by default. You must use the `system snmp authtrap` command to enable the trap. For more informatin, see the man pages: ONTAP 9 commands

Built-in SNMP traps

Built-in traps are predefined in ONTAP and are automatically sent to the network management stations on the traphost list if an event occurs. These traps, such as diskFailedShutdown, cpuTooBusy, and volumeNearlyFull, are defined in the custom MIB.

Each built-in trap is identified by a unique trap code.

Create an SNMP community and assigning it to a LIF

You can create an SNMP community that acts as an authentication mechanism between the management station and the storage virtual machine (SVM) when using SNMPv1 and

SNMPv2c.

By creating SNMP communities in a data SVM, you can execute commands such as `snmpwalk` and `snmpget` on the data LIFs.

About this task

- In new installations of ONTAP, SNMPv1 and SNMPv2c are disabled by default.

  SNMPv1 and SNMPv2c are enabled after you create an SNMP community.

- ONTAP supports read-only communities.
- By default, the "data" firewall policy that is assigned to data LIFs has SNMP service set to `deny`.

  You must create a new firewall policy with SNMP service set to `allow` when creating an SNMP user for a data SVM.

- You can create SNMP communities for SNMPv1 and SNMPv2c users for both the admin SVM and the data SVM.
- Because an SVM is not part of the SNMP standard, queries on data LIFs must include the NetApp root OID (1.3.6.1.4.1.789)—for example, `snmpwalk -v 2c -c snmpNFS 10.238.19.14 1.3.6.1.4.1.789`.

Steps

1. Create an SNMP community by using the `system snmp community add` command. The following command shows how to create an SNMP community in the admin SVM cluster-1:

   ```
   system snmp community add -type ro -community-name comty1 -vserver
   cluster-1
   ```

   The following command shows how to create an SNMP community in the data SVM vs1:

   ```
   system snmp community add -type ro -community-name comty2 -vserver vs1
   ```

2. Verify that the communities have been created by using the system snmp community show command.

   The following command shows the two communities created for SNMPv1 and SNMPv2c:

   ```
   system snmp community show
   cluster-1
   rocomty1
   vs1
   rocomty2
   ```

3. Check whether SNMP is allowed as a service in the "data" firewall policy by using the `system services firewall policy show` command.

   The following command shows that the snmp service is not allowed in the default "data" firewall policy (the snmp service is allowed in the "mgmt" firewall policy only):

```
system services firewall policy show
Vserver Policy       Service    Allowed
------- ------------ ---------- -------------------
cluster-1
        data
                     dns        0.0.0.0/0
                     ndmp       0.0.0.0/0
                     ndmps      0.0.0.0/0
cluster-1
        intercluster
                     https      0.0.0.0/0
                     ndmp       0.0.0.0/0
                     ndmps      0.0.0.0/0
cluster-1
        mgmt
                     dns        0.0.0.0/0
                     http       0.0.0.0/0
                     https      0.0.0.0/0
                     ndmp       0.0.0.0/0
                     ndmps      0.0.0.0/0
                     ntp        0.0.0.0/0
                     snmp       0.0.0.0/0
                     ssh        0.0.0.0/0
```

4. Create a new firewall policy that allows access using the `snmp` service by using the `system services firewall policy create` command.

   The following commands create a new data firewall policy named "data1" that allows the `snmp`

```
system services firewall policy create -policy data1 -service snmp
-vserver  vs1 -allow-list 0.0.0.0/0

cluster-1::> system services firewall policy show -service snmp
Vserver  Policy       Service    Allowed
-------  ------------ ---------- -------------------
cluster-1
         mgmt
                      snmp       0.0.0.0/0
vs1
         data1
                      snmp       0.0.0.0/0
```

5. Apply the firewall policy to a data LIF by using the `network interface modify `command with the -firewall -policy parameter.

The following command assigns the new "data1" firewall policy to LIF "datalif1":

```
network interface modify -vserver vs1 -lif datalif1 -firewall-policy
data1
```

Configure SNMPv3 users in a cluster

SNMPv3 is a secure protocol when compared to SNMPv1 and SNMPv2c. To use SNMPv3, you must configure an SNMPv3 user to run the SNMP utilities from the SNMP manager.

Step

Use the "security login create command" to create an SNMPv3 user.

You are prompted to provide the following information:

- Engine ID: Default and recommended value is local Engine ID
- Authentication protocol
- Authentication password
- Privacy protocol
- Privacy protocol password

Result

The SNMPv3 user can log in from the SNMP manager by using the user name and password and run the SNMP utility commands.

SNMPv3 security parameters

SNMPv3 includes an authentication feature that, when selected, requires users to enter their names, an authentication protocol, an authentication key, and their desired security level when invoking a command.

The following table lists the SNMPv3 security parameters :

Parameter	Command-line option	Description
engineID	-e EngineID	Engine ID of the SNMP agent. Default value is local EngineID (recommended).
securityName	-u Name	User name must not exceed 32 characters.
authProtocol	-a {none | MD5 | SHA | SHA-256}	Authentication type can be none, MD5, SHA, or SHA-256.
authKey	-A PASSPHRASE	Passphrase with a minimum of eight characters.

securityLevel	-l {authNoPriv | AuthPriv | noAuthNoPriv}	Security level can be Authentication, No Privacy; Authentication, Privacy; or no Authentication, no Privacy.
privProtocol	-x { none | des | aes128}	Privacy protocol can be none, des, or aes128
privPassword	-X password	Password with a minimum of eight characters.

Examples for different security levels

This example shows how an SNMPv3 user created with different security levels can use the SNMP client-side commands, such as `snmpwalk`, to query the cluster objects.

For better performance, you should retrieve all objects in a table rather than a single object or a few objects from the table.

> You must use `snmpwalk` 5.3.1 or later when the authentication protocol is SHA.

Security level: authPriv

The following output shows the creation of an SNMPv3 user with the authPriv security level.

```
security login create -username snmpv3user -application snmp -authmethod
usm
Enter the authoritative entity's EngineID [local EngineID]:
Which authentication protocol do you want to choose  (none, md5, sha)
[none]:sha
```

FIPS mode

```
Which authentication protocol do you want to choose (sha, sha2-256) [sha]

Enter authentication protocol password (minimum 8 characters long):
Enter authentication protocol password again:
Which privacy protocol do you want to choose  (none, des) [none]: des
Enter privacy protocol password (minimum 8 characters long):
Enter privacy protocol password again:
```

snmpwalk Test

The following output shows the SNMPv3 user running the snmpwalk command:

For better performance, you should retrieve all objects in a table rather than a single object or a few objects from the table.

```
$ snmpwalk -v 3 -u snmpv3user -a SHA -A password1! -x DES -X password1! -l
authPriv 192.0.2.62 .1.3.6.1.4.1.789.1.5.8.1.2
Enterprises.789.1.5.8.1.2.1028 = "vol0"
Enterprises.789.1.5.8.1.2.1032 = "vol0"
Enterprises.789.1.5.8.1.2.1038 = "root_vs0"
Enterprises.789.1.5.8.1.2.1042 = "root_vstrap"
Enterprises.789.1.5.8.1.2.1064 = "vol1"
```

Security level: authNoPriv

The following output shows the creation of an SNMPv3 user with the authNoPriv security level.

```
security login create -username snmpv3user1 -application snmp -authmethod
usm -role admin
Enter the authoritative entity's EngineID [local EngineID]:
Which authentication protocol do you want to choose (none, md5, sha)
[none]: md5
```

FIPS Mode

```
Which privacy protocol do you want to choose (aes128) [aes128]

Enter authentication protocol password (minimum 8 characters long):
Enter authentication protocol password again:
Which privacy protocol do you want to choose (none, des) [none]: none
```

snmpwalk Test

The following output shows the SNMPv3 user running the snmpwalk command:

For better performance, you should retrieve all objects in a table rather than a single object or a few objects from the table.

```
$ snmpwalk -v 3 -u snmpv3user1 -a MD5 -A password1!  -l authNoPriv
192.0.2.62 .1.3.6.1.4.1.789.1.5.8.1.2
Enterprises.789.1.5.8.1.2.1028 = "vol0"
Enterprises.789.1.5.8.1.2.1032 = "vol0"
Enterprises.789.1.5.8.1.2.1038 = "root_vs0"
Enterprises.789.1.5.8.1.2.1042 = "root_vstrap"
Enterprises.789.1.5.8.1.2.1064 = "vol1"
```

Security level: noAuthNoPriv

The following output shows the creation of an SNMPv3 user with the noAuthNoPriv security level.

```
security login create -username snmpv3user2 -application snmp -authmethod
usm -role admin
Enter the authoritative entity's EngineID [local EngineID]:
Which authentication protocol do you want to choose (none, md5, sha)
[none]: none
```

FIPS Mode

FIPS will not allow you to choose none

snmpwalk Test

The following output shows the SNMPv3 user running the snmpwalk command:

For better performance, you should retrieve all objects in a table rather than a single object or a few objects from the table.

```
$ snmpwalk -v 3 -u snmpv3user2 -l noAuthNoPriv 192.0.2.62
.1.3.6.1.4.1.789.1.5.8.1.2
Enterprises.789.1.5.8.1.2.1028 = "vol0"
Enterprises.789.1.5.8.1.2.1032 = "vol0"
Enterprises.789.1.5.8.1.2.1038 = "root_vs0"
Enterprises.789.1.5.8.1.2.1042 = "root_vstrap"
Enterprises.789.1.5.8.1.2.1064 = "vol1"
```

Configure traphosts to receive SNMP notifications

You can configure the traphost (SNMP manager) to receive notifications (SNMP trap PDUs) when SNMP traps are generated in the cluster. You can specify either the host name or the IP address (IPv4 or IPv6) of the SNMP traphost.

Before you begin

- SNMP and SNMP traps must be enabled on the cluster.

> ⓘ SNMP and SNMP traps are enabled by default.

- DNS must be configured on the cluster for resolving the traphost names.
- IPv6 must be enabled on the cluster to configure SNMP traphosts by using IPv6 addresses.
- For ONTAP 9.1 and later versions, you must have specified the authentication of a predefined User-based Security Model (USM) and privacy credentials when creating traphosts.

Step

Add an SNMP traphost:

```
system snmp traphost add
```

> Traps can be sent only when at least one SNMP management station is specified as a traphost.

The following command adds a new SNMPv3 traphost named yyy.example.com with a known USM user:

```
system snmp traphost add -peer-address yyy.example.com -usm-username
MyUsmUser
```

The following command adds a traphost using the IPv6 address of the host:

```
system snmp traphost add -peer-address 2001:0db8:1:1:209:6bff:feae:6d67
```

Commands for managing SNMP

You can use the `system snmp` commands to manage SNMP, traps, and traphosts. You can use the `security` commands to manage SNMP users per SVM. You can use the `event` commands to manage events related to SNMP traps.

Commands for configuring SNMP

If you want to…	Use this command…
Enable SNMP on the cluster	`options -option-name snmp.enable -option-value on` The SNMP service must be allowed under the management (mgmt) firewall policy. You can verify whether SNMP is allowed by using the system services firewall policy show command.
Disable SNMP on the cluster	`options -option-name snmp.enable -option-value off`

Commands for managing SNMP v1, v2c, and v3 users

If you want to…	Use this command…
Configure SNMP users	`security login create`
Display SNMP users	`security snmpusers and security login show -application snmp`

Delete SNMP users	`security login delete`
Modify the access-control role name of a login method for SNMP users	`security login modify`

Commands for providing contact and location information

If you want to…	Use this command…
Display or modify the contact details of the cluster	`system snmp contact`
Display or modify the location details of the cluster	`system snmp location`

Commands for managing SNMP communities

If you want to…	Use this command…
Add a read-only (ro) community for an SVM or for all SVMs in the cluster	`system snmp community add`
Delete a community or all communities	`system snmp community delete`
Display the list of all communities	`system snmp community show`

Because SVMs are not part of the SNMP standard, queries on data LIFs must include the NetApp root OID (1.3.6.1.4.1.789), for example, `snmpwalk -v 2c -c snmpNFS 10.238.19.14 1.3.6.1.4.1.789`.

Command for displaying SNMP option values

If you want to…	Use this command…
Display the current values of all SNMP options, including cluster contact, contact location, whether the cluster is configured to send traps, the list of traphosts, and list of communities and access control type	`system snmp show`

Commands for managing SNMP traps and traphosts

If you want to…	Use this command…
Enable SNMP traps sent from the cluster	`system snmp init -init 1`
Disable SNMP traps sent from the cluster	`system snmp init -init 0`

Add a traphost that receives SNMP notifications for specific events in the cluster	`system snmp traphost add`
Delete a traphost	`system snmp traphost delete`
Display the list of traphosts	`system snmp traphost show`

Commands for managing events related to SNMP traps

If you want to…	Use this command…
Display the events for which SNMP traps (built-in) are generated	`event route show` Use the `-snmp-support true` parameter to view only SNMP-related events. Use the `instance -messagename <message>` parameter to view a detailed description why an event might have occurred, and any corrective action. Routing of individual SNMP trap events to specific traphost destinations is not supported. All SNMP trap events are sent to all traphost destinations.
Display a list of SNMP trap history records, which are event notifications that have been sent to SNMP traps	`event snmphistory show`
Delete an SNMP trap history record	`event snmphistory delete`

For more information about the `system snmp`, `security`, and `event` commands, see the man pages: ONTAP 9 commands

Manage routing in an SVM

Overview

The routing table for an SVM determines the network path the SVM uses to communicate with a destination. It's important to understand how routing tables work so that you can prevent network problems before they occur.

Routing rules are as follows:

- ONTAP routes traffic over the most specific available route.
- ONTAP routes traffic over a default gateway route (having 0 bits of netmask) as a last resort, when more specific routes are not available.

In the case of routes with the same destination, netmask, and metric, there is no guarantee that the system will use the same route after a reboot or after an upgrade. This is especially an issue if you have configured multiple default routes.

It is a best practice to configure one default route only for an SVM. To avoid disruption, you should ensure that the default route is able to reach any network address that is not reachable by a more specific route. For more information, see the Knowledgebase article SU134: Network access might be disrupted by incorrect routing configuration in clustered ONTAP

Create a static route

You can create static routes within a storage virtual machine (SVM) to control how LIFs use the network for outbound traffic.

When you create a route entry associated with an SVM, the route will be used by all LIFs that are owned by the specified SVM and that are on the same subnet as the gateway.

Step

Use the `network route create` command to create a route.

```
network route create -vserver vs0 -destination 0.0.0.0/0 -gateway
10.61.208.1
```

Enable multipath routing

If multiple routes have the same metric for a destination, only one of the routes is picked for outgoing traffic. This leads to other routes being unutilized for sending outgoing traffic. You can enable multipath routing to load balance and utilize all the available routes.

Steps

1. Log in to the advanced privilege level:

   `set -privilege advanced`

2. Enable multipath routing:

   `network options multipath-routing modify -is-enabled true`

   Multipath routing is enabled for all nodes in the cluster.

```
network options multipath-routing modify -is-enabled true
```

Delete a static route

You can delete an unneeded static route from a storage virtual machine (SVM).

Step

Use the `network route delete` command to delete a static route.

For more information about this command, see the `network route` man page: ONTAP 9 commands.

The following example deletes a static route associated with SVM vs0 with a gateway of 10.63.0.1 and a destination IP address of 0.0.0.0/0:

```
network route delete -vserver vs0 -gateway 10.63.0.1 -destination
0.0.0.0/0
```

Display routing information

You can display information about the routing configuration for each SVM on your cluster. This can help you diagnose routing problems involving connectivity issues between client applications or services and a LIF on a node in the cluster.

Steps

1. Use the `network route show` command to display routes within one or more SVMs. The following example shows a route configured in the vs0 SVM:

```
network route show
  (network route show)
Vserver             Destination     Gateway         Metric
------------------- --------------- --------------- ------
vs0
                    0.0.0.0/0       172.17.178.1    20
```

2. Use the `network route show-lifs` command to display the association of routes and LIFs within one or more SVMs.

   The following example shows LIFs with routes owned by the vs0 SVM:

```
network route show-lifs
  (network route show-lifs)

Vserver: vs0
Destination             Gateway                 Logical Interfaces
----------------------  --------------          --------------------
0.0.0.0/0               172.17.178.1            cluster_mgmt,
                                                LIF-b-01_mgmt1,
                                                LIF-b-02_mgmt1
```

3. Use the `network route active-entry show` command to display installed routes on one or more nodes, SVMs, subnets, or routes with specified destinations.

   The following example shows all installed routes on a specific SVM:

```
network route active-entry show -vserver Data0

Vserver: Data0
Node: node-1
Subnet Group: 0.0.0.0/0
Destination             Gateway             Interface   Metric  Flags
----------------------  ------------------- ---------   ------  -----
127.0.0.1               127.0.0.1           lo              10  UHS
127.0.10.1              127.0.20.1          losk            10  UHS
127.0.20.1              127.0.20.1          losk            10  UHS

Vserver: Data0
Node: node-1
Subnet Group: fd20:8b1e:b255:814e::/64
Destination             Gateway             Interface   Metric  Flags
----------------------  ------------------- ---------   ------  -----
default                 fd20:8b1e:b255:814e::1
                                            e0d             20  UGS
fd20:8b1e:b255:814e::/64
                        link#4              e0d              0  UC

Vserver: Data0
Node: node-2
Subnet Group: 0.0.0.0/0
Destination             Gateway             Interface   Metric  Flags
----------------------  ------------------- ---------   ------  -----
127.0.0.1               127.0.0.1           lo              10  UHS

Vserver: Data0
Node: node-2
Subnet Group: 0.0.0.0/0
Destination             Gateway             Interface   Metric  Flags
----------------------  ------------------- ---------   ------  -----
127.0.10.1              127.0.20.1          losk            10  UHS
127.0.20.1              127.0.20.1          losk            10  UHS

Vserver: Data0
Node: node-2
Subnet Group: fd20:8b1e:b255:814e::/64
Destination             Gateway             Interface   Metric  Flags
----------------------  ------------------- ---------   ------  -----
default                 fd20:8b1e:b255:814e::1
                                            e0d             20  UGS
fd20:8b1e:b255:814e::/64
                        link#4              e0d              0  UC
fd20:8b1e:b255:814e::1  link#4              e0d              0  UHL
```

```
11 entries were displayed.
```

Remove dynamic routes from routing tables

When ICMP redirects are received for IPv4 and IPv6, dynamic routes are added to the routing table. By default, the dynamic routes are removed after 300 seconds. If you want to maintain dynamic routes for a different amount of time, you can change the time out value.

About this task

You can set the timeout value from 0 to 65,535 seconds. If you set the value to 0, the routes never expire. Removing dynamic routes prevents loss of connectivity caused by the persistence of invalid routes.

Steps

1. Display the current timeout value.
   - For IPv4:

     ```
     network tuning icmp show
     ```

   - For IPv6:

     ```
     network tuning icmp6 show
     ```

2. Modify the timeout value.
   - For IPv4:

     ```
     network tuning icmp modify -node node_name -redirect-timeout
     timeout_value
     ```

   - For IPv6:

     ```
     network tuning icmp6 modify -node node_name -redirect-v6-timeout
     timeout_value
     ```

3. Verify that the timeout value was modified correctly.
   - For IPv4:

     ```
     network tuning icmp show
     ```

   - For IPv6:

```
network tuning icmp6 show
```

ONTAP port usage on a storage system

Overview

A number of well-known ports are reserved for ONTAP communications with specific services. Port conflicts will occur if a port value in your storage network environment is the same as on ONTAP port.

The following table lists the TCP ports and UDP ports that are used by ONTAP.

Service	Port/Protocol	Description
ssh	22/TCP	Secure shell login
telnet	23/TCP	Remote login
DNS	53/TCP	Load Balanced DNS
http	80/TCP	Hyper Text Transfer Protocol
rpcbind	111/TCP	Remote procedure call
rpcbind	111/UDP	Remote procedure call
ntp	123/UDP	Network Time Protocol
msrpc	135/UDP	MSRPC
netbios-ssn	139/TCP	NetBIOS service session
snmp	161/UDP	Simple network management protocol
https	443/TCP	HTTP over TLS
microsoft-ds	445/TCP	Microsoft-ds
mount	635/TCP	NFS mount
mount	635/UDP	NFS Mount
named	953/UDP	Name daemon
nfs	2049/UDP	NFS Server daemon
nfs	2049/TCP	NFS Server daemon
nrv	2050/TCP	NetApp Remote Volume protocol
iscsi	3260/TCP	iSCSI target port
lockd	4045/TCP	NFS lock daemon
lockd	4045/UDP	NFS lock daemon
NFS	4046/TCP	Network Status Monitor
NSM	4046/UDP	Network Status Monitor

rquotad	4049/UDP	NFS rquotad protocol
krb524	4444/UDP	Kerberos 524
mdns	5353/UDP	Multicast DNS
HTTPS	5986/UDP	HTTPS Port - Listening binary protocol
https	8443/TCP	7MTT GUI Tool through https
ndmp	10000/TCP	Network Data Management Protocol
Cluster peering	11104/TCP	Cluster peering
Cluster peering	11105/TCP	Cluster peering
NDMP	18600 - 18699/TCP	NDMP
cifs witness port	40001/TCP	cifs witness port
tls	50000/TCP	Transport layer security
iscsi	65200/TCP	ISCSI port

ONTAP internal ports

The following table lists the TCP ports and UDP ports that are used internally by ONTAP. These ports are used to establish intracluster LIF communication:

Port/Protocol	Description
514	Syslog
900	NetApp Cluster RPC
902	NetApp Cluster RPC
904	NetApp Cluster RPC
905	NetApp Cluster RPC
910	NetApp Cluster RPC
911	NetApp Cluster RPC
913	NetApp Cluster RPC
914	NetApp Cluster RPC
915	NetApp Cluster RPC
918	NetApp Cluster RPC
920	NetApp Cluster RPC
921	NetApp Cluster RPC
924	NetApp Cluster RPC
925	NetApp Cluster RPC
927	NetApp Cluster RPC
928	NetApp Cluster RPC

929	NetApp Cluster RPC
931	NetApp Cluster RPC
932	NetApp Cluster RPC
933	NetApp Cluster RPC
934	NetApp Cluster RPC
935	NetApp Cluster RPC
936	NetApp Cluster RPC
937	NetApp Cluster RPC
939	NetApp Cluster RPC
940	NetApp Cluster RPC
951	NetApp Cluster RPC
954	NetApp Cluster RPC
955	NetApp Cluster RPC
956	NetApp Cluster RPC
958	NetApp Cluster RPC
961	NetApp Cluster RPC
963	NetApp Cluster RPC
964	NetApp Cluster RPC
966	NetApp Cluster RPC
967	NetApp Cluster RPC
5125	Alternate Control Port for disk
5133	Alternate Control Port for disk
5144	Alternate Control Port for disk
65502	Node scope SSH
65503	LIF Sharing
7810	NetApp Cluster RPC
7811	NetApp Cluster RPC
7812	NetApp Cluster RPC
7813	NetApp Cluster RPC
7814	NetApp Cluster RPC
7815	NetApp Cluster RPC
7816	NetApp Cluster RPC
7817	NetApp Cluster RPC
7818	NetApp Cluster RPC

7819	NetApp Cluster RPC
7820	NetApp Cluster RPC
7821	NetApp Cluster RPC
7822	NetApp Cluster RPC
7823	NetApp Cluster RPC
7824	NetApp Cluster RPC
8023	Node Scope TELNET
8514	Node Scope RSH
9877	KMIP Client Port (Internal Local Host Only)

View network information

Overview

You can view information related to ports, LIFs, routes, failover rules, failover groups, firewall rules, DNS, NIS, and connections.

This information can be useful in situations such as reconfiguring networking settings, or when troubleshooting the cluster.

If you are a cluster administrator, you can view all the available networking information. If you are an SVM administrator, you can view only the information related to your assigned SVMs.

Display network port information

You can display information about a specific port, or about all ports on all nodes in the cluster.

About this task

The following information is displayed:

- Node name
- Port name
- IPspace name
- Broadcast domain name
- Link status (up or down)
- MTU setting
- Port speed setting and operational status (1 gigabit or 10 gigabits per second)
- Auto-negotiation setting (true or false)
- Duplex mode and operational status (half or full)
- The port’s interface group, if applicable
- The port’s VLAN tag information, if applicable

- The port’s health status (health or degraded)
- Reasons for a port being marked as degraded

If data for a field is not available (for example, the operational duplex and speed for an inactive port would not be available), the field value is listed as `-`.

Step

Display network port information by using the `network port show` command.

You can display detailed information for each port by specifying the `-instance` parameter, or get specific information by specifying field names using the `-fields` parameter.

```
network port show
Node: node1

Ignore
                                                  Speed(Mbps) Health
Health
Port      IPspace      Broadcast Domain Link MTU  Admin/Oper  Status
Status
--------- ------------ ---------------- ---- ---- ----------- --------
------
e0a       Cluster      Cluster          up   9000  auto/1000  healthy
false
e0b       Cluster      Cluster          up   9000  auto/1000  healthy
false
e0c       Default      Default          up   1500  auto/1000  degraded
false
e0d       Default      Default          up   1500  auto/1000  degraded
true
Node: node2

Ignore
                                                  Speed(Mbps) Health
Health
Port      IPspace      Broadcast Domain Link MTU  Admin/Oper  Status
Status
--------- ------------ ---------------- ---- ---- ----------- --------
------
e0a       Cluster      Cluster          up   9000  auto/1000  healthy
false
e0b       Cluster      Cluster          up   9000  auto/1000  healthy
false
e0c       Default      Default          up   1500  auto/1000  healthy
false
e0d       Default      Default          up   1500  auto/1000  healthy
false
8 entries were displayed.
```

Display information about a VLAN (cluster administrators only)

You can display information about a specific VLAN or about all VLANs in the cluster.

About this task

You can display detailed information for each VLAN by specifying the `-instance` parameter. You can display specific information by specifying field names using the `-fields` parameter.

Step

Display information about VLANs by using the `network port vlan show` command. The following command displays information about all VLANs in the cluster:

```
network port vlan show
                 Network Network
Node   VLAN Name Port    VLAN ID  MAC Address
------ --------- ------- -------- -----------------
cluster-1-01
       a0a-10    a0a     10       02:a0:98:06:10:b2
       a0a-20    a0a     20       02:a0:98:06:10:b2
       a0a-30    a0a     30       02:a0:98:06:10:b2
       a0a-40    a0a     40       02:a0:98:06:10:b2
       a0a-50    a0a     50       02:a0:98:06:10:b2
cluster-1-02
       a0a-10    a0a     10       02:a0:98:06:10:ca
       a0a-20    a0a     20       02:a0:98:06:10:ca
       a0a-30    a0a     30       02:a0:98:06:10:ca
       a0a-40    a0a     40       02:a0:98:06:10:ca
       a0a-50    a0a     50       02:a0:98:06:10:ca
```

Display interface group information (cluster administrators only)

You can display information about an interface group to determine its configuration.

About this task

The following information is displayed:

- Node on which the interface group is located
- List of network ports that are included in the interface group
- Interface group’s name
- Distribution function (MAC, IP, port, or sequential)
- Interface group’s Media Access Control (MAC) address
- Port activity status; that is, whether all aggregated ports are active (full participation), whether some are active (partial participation), or whether none are active

Step

Display information about interface groups by using the `network port ifgrp show` command.

You can display detailed information for each node by specifying the `-instance` parameter. You can display specific information by specifying field names using the `-fields` parameter.

The following command displays information about all interface groups in the cluster:

```
network port ifgrp show
         Port     Distribution                    Active
Node     IfGrp    Function     MAC Address        Ports   Ports
-------- -------- ------------ -----------------  ------- --------
cluster-1-01
         a0a      ip           02:a0:98:06:10:b2  full    e7a, e7b
cluster-1-02
         a0a      sequential   02:a0:98:06:10:ca  full    e7a, e7b
cluster-1-03
         a0a      port         02:a0:98:08:5b:66  full    e7a, e7b
cluster-1-04
         a0a      mac          02:a0:98:08:61:4e  full    e7a, e7b
```

The following command displays detailed interface group information for a single node:

```
network port ifgrp show -instance -node cluster-1-01

                 Node: cluster-1-01
 Interface Group Name: a0a
Distribution Function: ip
        Create Policy: multimode
          MAC Address: 02:a0:98:06:10:b2
   Port Participation: full
        Network Ports: e7a, e7b
             Up Ports: e7a, e7b
           Down Ports: -
```

Display LIF information

You can view detailed information about a LIF to determine its configuration.

You might also want to view this information to diagnose basic LIF problems, such as checking for duplicate IP addresses or verifying whether the network port belongs to the correct subnet. storage virtual machine (SVM) administrators can view only the information about the LIFs associated with the SVM.

About this task

The following information is displayed:

- IP address associated with the LIF
- Administrative status of the LIF
- Operational status of the LIF

  The operational status of data LIFs is determined by the status of the SVM with which the data LIFs are associated. When the SVM is stopped, the operational status of the LIF changes to down. When the SVM is started again, the operational status changes to up

* Node and the port on which the LIF resides

If data for a field is not available (for example, if there is no extended status information), the field value is listed as −.

Step

Display LIF information by using the network interface show command.

You can view detailed information for each LIF by specifying the -instance parameter, or get specific information by specifying field names using the -fields parameter.

The following command displays general information about all LIFs in a cluster:

```
network interface show
           Logical    Status     Network          Current      Current Is
Vserver    Interface  Admin/Oper Address/Mask     Node         Port
Home
---------- ---------- ---------- ---------------- ------------ -------
----
example
           lif1         up/up    192.0.2.129/22   node-01
                                                               e0d
false
node
           cluster_mgmt up/up    192.0.2.3/20     node-02
                                                               e0c
false
node-01
           clus1        up/up    192.0.2.65/18    node-01
                                                               e0a
true
           clus2        up/up    192.0.2.66/18    node-01
                                                               e0b
true
           mgmt1        up/up    192.0.2.1/20     node-01
                                                               e0c
true
node-02
           clus1        up/up    192.0.2.67/18    node-02
                                                               e0a
true
           clus2        up/up    192.0.2.68/18    node-02
                                                               e0b
true
           mgmt2        up/up    192.0.2.2/20     node-02
                                                               e0d
true
vs1
           d1           up/up    192.0.2.130/21   node-01
                                                               e0d
false
           d2           up/up    192.0.2.131/21   node-01
                                                               e0d
true
           data3        up/up    192.0.2.132/20   node-02
                                                               e0c
true
```

The following command shows detailed information about a single LIF:

```
network interface show -lif data1 -instance

                    Vserver Name: vs1
          Logical Interface Name: data1
                            Role: data
                   Data Protocol: nfs,cifs
                       Home Node: node-01
                       Home Port: e0c
                    Current Node: node-03
                    Current Port: e0c
              Operational Status: up
                 Extended Status: -
                         Is Home: false
                 Network Address: 192.0.2.128
                         Netmask: 255.255.192.0
             Bits in the Netmask: 18
                 IPv4 Link Local: -
                     Subnet Name: -
           Administrative Status: up
                 Failover Policy: local-only
                 Firewall Policy: data
                     Auto Revert: false
   Fully Qualified DNS Zone Name: xxx.example.com
         DNS Query Listen Enable: false
             Failover Group Name: Default
                        FCP WWPN: -
                  Address family: ipv4
                         Comment: -
                  IPspace of LIF: Default
```

Display routing information

You can display information about routes within an SVM.

Step

Depending on the type of routing information that you want to view, enter the applicable command:

To view information about…	Enter…
Static routes, per SVM	`network route show`
LIFs on each route, per SVM	`network route show-lifs`

You can display detailed information for each route by specifying the `-instance` parameter. The following command displays the static routes within the SVMs in cluster- 1:

```
network route show
Vserver             Destination     Gateway         Metric
------------------- --------------- --------------- ------
Cluster
                    0.0.0.0/0       10.63.0.1       10
cluster-1
                    0.0.0.0/0       198.51.9.1      10
vs1
                    0.0.0.0/0       192.0.2.1       20
vs3
                    0.0.0.0/0       192.0.2.1       20
```

The following command displays the association of static routes and logical interfaces (LIFs) within all SVMs in cluster-1:

```
network route show-lifs
Vserver: Cluster
Destination             Gateway                 Logical Interfaces
----------------------  ----------------------  -------------------
0.0.0.0/0               10.63.0.1               -

Vserver: cluster-1
Destination             Gateway                 Logical Interfaces
----------------------  ----------------------  -------------------
0.0.0.0/0               198.51.9.1              cluster_mgmt,
                                                cluster-1_mgmt1,

Vserver: vs1
Destination             Gateway                 Logical Interfaces
----------------------  ----------------------  -------------------
0.0.0.0/0               192.0.2.1               data1_1, data1_2

Vserver: vs3
Destination             Gateway                 Logical Interfaces
----------------------  ----------------------  -------------------
0.0.0.0/0               192.0.2.1               data2_1, data2_2
```

Display DNS host table entries (cluster administrators only)

The DNS host table entries map host names to IP addresses. You can display the host names and alias names and the IP address that they map to for all SVMs in a cluster.

Step

Display the host name entries for all SVMs by using the vserver services name-service dns hosts show command.

The following example displays the host table entries:

```
vserver services name-service dns hosts show
Vserver    Address        Hostname        Aliases
---------- -------------- --------------- ---------------------
cluster-1
           10.72.219.36   lnx219-36       -
vs1
           10.72.219.37   lnx219-37       lnx219-37.example.com
```

You can use the `vserver services name-service dns` command to enable DNS on an SVM, and configure it to use DNS for host-name resolution. Host names are resolved using external DNS servers.

Display DNS domain configurations

You can display the DNS domain configuration of one or more storage virtual machines (SVMs) in your cluster to verify that it is configured properly.

Step

Viewing the DNS domain configurations by using the `vserver services name-service dns show` command.

The following command displays the DNS configurations for all SVMs in the cluster:

```
vserver services name-service dns show
                                                  Name
Vserver         State     Domains                 Servers
-------------- --------- ------------------------ -------------
cluster-1       enabled   xyz.company.com          192.56.0.129,
                                                  192.56.0.130
vs1            enabled   xyz.company.com          192.56.0.129,
                                                  192.56.0.130
vs2            enabled   xyz.company.com          192.56.0.129,
                                                  192.56.0.130
vs3            enabled   xyz.company.com          192.56.0.129,
                                                  192.56.0.130
```

The following command displays detailed DNS configuration information for SVM vs1:

```
vserver services name-service dns show -vserver vs1
               Vserver: vs1
               Domains: xyz.company.com
          Name Servers: 192.56.0.129, 192.56.0.130
    Enable/Disable DNS: enabled
        Timeout (secs): 2
      Maximum Attempts: 1
```

Display information about failover groups

You can view information about failover groups, including the list of nodes and ports in each failover group, whether failover is enabled or disabled, and the type of failover policy that is being applied to each LIF.

Steps

1. Display the target ports for each failover group by using the `network interface failover-groups show` command.

   The following command displays information about all failover groups on a two-node cluster:

   ```
   network interface failover-groups show
                                 Failover
   Vserver        Group          Targets
   -------------- -------------- ---------------------------------
   Cluster
                  Cluster
                                 cluster1-01:e0a, cluster1-01:e0b,
                                 cluster1-02:e0a, cluster1-02:e0b
   vs1
                  Default
                                 cluster1-01:e0c, cluster1-01:e0d,
                                 cluster1-01:e0e, cluster1-02:e0c,
                                 cluster1-02:e0d, cluster1-02:e0e
   ```

2. Display the target ports and broadcast domain for a specific failover group by using the `network interface failover-groups show` command.

   The following command displays detailed information about failover group data12 for SVM vs4:

```
network interface failover-groups show -vserver vs4 -failover-group
data12

       Vserver Name: vs4
Failover Group Name: data12
   Failover Targets: cluster1-01:e0f, cluster1-01:e0g, cluster1-02:e0f,
                     cluster1-02:e0g
   Broadcast Domain: Default
```

3. Display the failover settings used by all LIFs by using the `network interface show` command.

   The following command displays the failover policy and failover group that is being used by each LIF:

```
network interface show -vserver * -lif * -fields failover-
group,failover-policy
vserver   lif                  failover-policy        failover-group
--------  -------------------  ---------------------  --------------
Cluster   cluster1-01_clus_1  local-only             Cluster
Cluster   cluster1-01_clus_2  local-only             Cluster
Cluster   cluster1-02_clus_1  local-only             Cluster
Cluster   cluster1-02_clus_2  local-only             Cluster
cluster1  cluster_mgmt        broadcast-domain-wide  Default
cluster1  cluster1-01_mgmt1   local-only             Default
cluster1  cluster1-02_mgmt1   local-only             Default
vs1       data1               disabled               Default
vs3       data2               system-defined         group2
```

Display LIF failover targets

You might have to check whether the failover policies and the failover groups of a LIF are configured correctly. To prevent misconfiguration of the failover rules, you can display the failover targets for a single LIF or for all LIFs.

About this task

Displaying LIF failover targets enables you to check for the following:

- Whether the LIFs are configured with the correct failover group and failover policy
- Whether the resulting list of failover target ports is appropriate for each LIF
- Whether the failover target of a data LIF is not a management port (e0M)

Step

Display the failover targets of a LIF by using the `failover` option of the `network interface show` command.

The following command displays information about the failover targets for all LIFs in a two-node cluster. The

`Failover Targets` row shows the (prioritized) list of node-port combinations for a given LIF.

```
network interface show -failover
         Logical       Home                  Failover        Failover
Vserver  Interface     Node:Port             Policy          Group
-------- ------------- --------------------- --------------- ---------
Cluster
         node1_clus1   node1:e0a             local-only      Cluster
                       Failover Targets: node1:e0a,
                                         node1:e0b
         node1_clus2   node1:e0b             local-only      Cluster
                       Failover Targets: node1:e0b,
                                         node1:e0a
         node2_clus1   node2:e0a             local-only      Cluster
                       Failover Targets: node2:e0a,
                                         node2:e0b
         node2_clus2   node2:e0b             local-only      Cluster
                       Failover Targets: node2:e0b,
                                         node2:e0a
cluster1
         cluster_mgmt  node1:e0c             broadcast-domain-wide
                                                             Default
                       Failover Targets: node1:e0c,
                                         node1:e0d,
                                         node2:e0c,
                                         node2:e0d
         node1_mgmt1   node1:e0c             local-only      Default
                       Failover Targets: node1:e0c,
                                         node1:e0d
         node2_mgmt1   node2:e0c             local-only      Default
                       Failover Targets: node2:e0c,
                                         node2:e0d
vs1
         data1         node1:e0e             system-defined  bcast1
                       Failover Targets: node1:e0e,
                                         node1:e0f,
                                         node2:e0e,
                                         node2:e0f
```

Display LIFs in a load balancing zone

You can verify whether a load balancing zone is configured correctly by displaying all of the LIFs that belong to it. You can also view the load balancing zone of a particular LIF, or the load balancing zones for all LIFs.

Step

Display the LIFs and load balancing details that you want by using one of the following commands

To display…	Enter…
LIFs in a particular load balancing zone	`network interface show -dns-zone zone_name` `zone_name` specifies the name of the load balancing zone.
The load balancing zone of a particular LIF	`network interface show -lif lif_name -fields dns-zone`
The load balancing zones of all LIFs	`network interface show -fields dns-zone`

Examples of displaying load balancing zones for LIFs

The following command displays the details of all LIFs in the load balancing zone storage.company.com for SVM vs0:

```
net int show -vserver vs0 -dns-zone storage.company.com

         Logical    Status     Network           Current   Current Is
Vserver  Interface  Admin/Oper Address/Mask      Node      Port    Home
-------- ---------- ---------- ----------------- --------- ------- ----
vs0
         lif3         up/up    10.98.226.225/20  ndeux-11  e0c     true
         lif4         up/up    10.98.224.23/20   ndeux-21  e0c     true
         lif5         up/up    10.98.239.65/20   ndeux-11  e0c     true
         lif6         up/up    10.98.239.66/20   ndeux-11  e0c     true
         lif7         up/up    10.98.239.63/20   ndeux-21  e0c     true
         lif8         up/up    10.98.239.64/20   ndeux-21  e0c     true
```

The following command displays the DNS zone details of the LIF data3:

```
network interface show -lif data3 -fields dns-zone
Vserver  lif    dns-zone
-------  -----  --------
vs0      data3  storage.company.com
```

The following command displays the list of all LIFs in the cluster and their corresponding DNS zones:

```
network interface show -fields dns-zone
Vserver   lif          dns-zone
-------   ------------ --------
cluster   cluster_mgmt none
ndeux-21  clus1        none
ndeux-21  clus2        none
ndeux-21  mgmt1        none
vs0       data1        storage.company.com
vs0       data2        storage.company.com
```

Display cluster connections

You can display all the active connections in the cluster or a count of active connections on the node by client, logical interface, protocol, or service. You can also display all the listening connections in the cluster.

Display active connections by client (cluster administrators only)

You can view the active connections by client to verify the node that a specific client is using and to view possible imbalances between client counts per node.

About this task

The count of active connections by client is useful in the following scenarios:

- Finding a busy or overloaded node.
- Determining why a particular client's access to a volume is slow.

  You can view details about the node that the client is accessing and then compare it with the node on which the volume resides. If accessing the volume requires traversing the cluster network, clients might experience decreased performance because of the remote access to the volume on an oversubscribed remote node.

- Verifying that all nodes are being used equally for data access.
- Finding clients that have an unexpectedly high number of connections.
- Verifying whether certain clients have connections to a node.

Step

Display a count of the active connections by client on a node by using the `network connections active show-clients` command.

For more information about this command, see the man page: ONTAP 9 commands

```
network connections active show-clients
Node    Vserver Name    Client IP Address     Count
------  --------------  -----------------     ------
node0   vs0             192.0.2.253                1
        vs0             192.0.2.252                2
        Cluster         192.10.2.124               5
node1   vs0             192.0.2.250                1
        vs0             192.0.2.252                3
        Cluster         192.10.2.123               4
node2   vs1             customer.example.com       1
        vs1             192.0.2.245                3
        Cluster         192.10.2.122               4
node3   vs1             customer.example.org       1
        vs1             customer.example.net       3
        Cluster         192.10.2.121               4
```

Display active connections by protocol (cluster administrators only)

You can display a count of the active connections by protocol (TCP or UDP) on a node to compare the usage of protocols within the cluster.

About this task

The count of active connections by protocol is useful in the following scenarios:

- Finding the UDP clients that are losing their connection.

  If a node is near its connection limit, UDP clients are the first to be dropped.

- Verifying that no other protocols are being used.

Step

Display a count of the active connections by protocol on a node by using the `network connections active show-protocols` command.

For more information about this command, see the man page.

```
network connections active show-protocols
Node      Vserver Name  Protocol   Count
-------  ------------  ---------  ------
node0
          vs0           UDP            19
          Cluster       TCP            11
node1
          vs0           UDP            17
          Cluster       TCP             8
node2
          vs1           UDP            14
          Cluster       TCP            10
node3
          vs1           UDP            18
          Cluster       TCP             4
```

Display active connections by service (cluster administrators only)

You can display a count of the active connections by service type (for example, by NFS, SMB, mount, and so on) for each node in a cluster. This is useful to compare the usage of services within the cluster, which helps to determine the primary workload of a node.

About this task

The count of active connections by service is useful in the following scenarios:

- Verifying that all nodes are being used for the appropriate services and that the load balancing for that service is working.
- Verifying that no other services are being used. Display a count of the active connections by service on a node by using the `network connections active show-services` command.

For more information about this command, see the man page: ONTAP 9 commands

```
network connections active show-services
Node       Vserver Name    Service    Count
---------  --------------  ---------  ------
node0
           vs0             mount           3
           vs0             nfs            14
           vs0             nlm_v4          4
           vs0             cifs_srv        3
           vs0             port_map       18
           vs0             rclopcp        27
           Cluster         ctlopcp        60
node1
           vs0             cifs_srv        3
           vs0             rclopcp        16
           Cluster         ctlopcp        60
node2
           vs1             rclopcp        13
           Cluster         ctlopcp        60
node3
           vs1             cifs_srv        1
           vs1             rclopcp        17
           Cluster         ctlopcp        60
```

Display active connections by LIF on a node and SVM

You can display a count of active connections for each LIF, by node and storage virtual machine (SVM), to view connection imbalances between LIFs within the cluster.

About this task

The count of active connections by LIF is useful in the following scenarios:

- Finding an overloaded LIF by comparing the number of connections on each LIF.
- Verifying that DNS load balancing is working for all data LIFs.
- Comparing the number of connections to the various SVMs to find the SVMs that are used the most.

Step

Display a count of active connections for each LIF by SVM and node by using the `network connections active show-lifs` command.

For more information about this command, see the man page: ONTAP 9 commands

```
network connections active show-lifs
Node      Vserver Name  Interface Name  Count
--------  ------------  --------------- ------
node0
          vs0           datalif1             3
          Cluster       node0_clus_1         6
          Cluster       node0_clus_2         5
node1
          vs0           datalif2             3
          Cluster       node1_clus_1         3
          Cluster       node1_clus_2         5
node2
          vs1           datalif2             1
          Cluster       node2_clus_1         5
          Cluster       node2_clus_2         3
node3
          vs1           datalif1             1
          Cluster       node3_clus_1         2
          Cluster       node3_clus_2         2
```

Display active connections in a cluster

You can display information about the active connections in a cluster to view the LIF, port, remote host, service, storage virtual machines (SVMs), and protocol used by individual connections.

About this task

Viewing the active connections in a cluster is useful in the following scenarios:

- Verifying that individual clients are using the correct protocol and service on the correct node.
- If a client is having trouble accessing data using a certain combination of node, protocol, and service, you can use this command to find a similar client for configuration or packet trace comparison.

Step

Display the active connections in a cluster by using the `network connections active show` command.

For more information about this command, see the man page: ONTAP 9 commands

The following command shows the active connections on the node node1:

```
network connections active show -node node1
Vserver  Interface           Remote
Name     Name:Local Port     Host:Port           Protocol/Service
-------  ------------------  ------------------  ----------------
Node: node1
Cluster  node1_clus_1:50297  192.0.2.253:7700    TCP/ctlopcp
Cluster  node1_clus_1:13387  192.0.2.253:7700    TCP/ctlopcp
Cluster  node1_clus_1:8340   192.0.2.252:7700    TCP/ctlopcp
Cluster  node1_clus_1:42766  192.0.2.252:7700    TCP/ctlopcp
Cluster  node1_clus_1:36119  192.0.2.250:7700    TCP/ctlopcp
vs1      data1:111           host1.aa.com:10741  UDP/port-map
vs3      data2:111           host1.aa.com:10741  UDP/port-map
vs1      data1:111           host1.aa.com:12017  UDP/port-map
vs3      data2:111           host1.aa.com:12017  UDP/port-map
```

The following command shows the active connections on SVM vs1:

```
network connections active show -vserver vs1
Vserver  Interface           Remote
Name     Name:Local Port     Host:Port           Protocol/Service
-------  ------------------  ------------------  ----------------
Node: node1
vs1      data1:111           host1.aa.com:10741  UDP/port-map
vs1      data1:111           host1.aa.com:12017  UDP/port-map
```

Display listening connections in a cluster

You can display information about the listening connections in a cluster to view the LIFs and ports that are accepting connections for a given protocol and service.

About this task

Viewing the listening connections in a cluster is useful in the following scenarios:

- Verifying that the desired protocol or service is listening on a LIF if client connections to that LIF fail consistently.
- Verifying that a UDP/rclopcp listener is opened at each cluster LIF if remote data access to a volume on one node through a LIF on another node fails.
- Verifying that a UDP/rclopcp listener is opened at each cluster LIF if SnapMirror transfers between two nodes in the same cluster fail.
- Verifying that a TCP/ctlopcp listener is opened at each intercluster LIF if SnapMirror transfers between two nodes in different clusters fail.

Step

Display the listening connections per node by using the `network connections listening show` command.

```
network connections listening show
Vserver Name     Interface Name:Local Port        Protocol/Service
---------------- -------------------------------  ----------------
Node: node0
Cluster          node0_clus_1:7700                TCP/ctlopcp
vs1              data1:4049                       UDP/unknown
vs1              data1:111                        TCP/port-map
vs1              data1:111                        UDP/port-map
vs1              data1:4046                       TCP/sm
vs1              data1:4046                       UDP/sm
vs1              data1:4045                       TCP/nlm-v4
vs1              data1:4045                       UDP/nlm-v4
vs1              data1:2049                       TCP/nfs
vs1              data1:2049                       UDP/nfs
vs1              data1:635                        TCP/mount
vs1              data1:635                        UDP/mount
Cluster          node0_clus_2:7700                TCP/ctlopcp
```

Commands for diagnosing network problems

You can diagnose problems on your network by using commands such as `ping`, `traceroute`, `ndp`, and `tcpdump`. You can also use commands such as `ping6` and `traceroute6` to diagnose IPv6 problems.

If you want to…	Enter this command…
Test whether the node can reach other hosts on your network	`network ping`
Test whether the node can reach other hosts on your IPv6 network	`network ping6`
Trace the route that the IPv4 packets take to a network node	`network traceroute`
Trace the route that the IPv6 packets take to a network node	`network traceroute6`
Manage the Neighbor Discovery Protocol (NDP)	`network ndp`
Display statistics about packets that are received and sent on a specified network interface or on all network interfaces	`run -node` *`node_name`* `ifstat` **Note**: This command is available from the nodeshell.
Display information about neighboring devices that are discovered from each node and port in the cluster, including the remote device type and device platform	`network device-discovery show`
View the CDP neighbors of the node (ONTAP supports only CDPv1 advertisements)	`run -node` *`node_name`* `cdpd show-neighbors` **Note**: This command is available from the nodeshell.

Trace the packets that are sent and received in the network	`network tcpdump start -node` *`node-name`* `-port` *`port_name`* **Note**: This command is available from the nodeshell.
Measure latency and throughput between intercluster or intracluster nodes	`network test -path -source-node` *`source_nodename local`* `-destination -cluster` *`destination_clustername`* `-destination-node` *`destination_nodename`* `-session-type` *`Default, AsyncMirrorLocal, AsyncMirrorRemote, SyncMirrorRemote,`* `or` *`RemoteDataTransfer`* For more information, see the Performance management.

For more information about these commands, see the appropriate man pages: ONTAP 9 commands

Display network connectivity with neighbor discovery protocols

In a data center, you can use neighbor discovery protocols to view network connectivity between a pair of physical or virtual systems and their network interfaces. ONTAP supports two neighbor discovery protocols: Cisco Discovery Protocol (CDP) and Link Layer Discovery Protocol (LLDP).

About this task

Neighbor discovery protocols enable you to automatically discover and view information about directly connected protocol-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 protocol-enabled devices.

For two devices to become neighbors, each must have a protocol enabled and correctly configured. Discovery protocol functionality is limited to directly connected networks. Neighbors can include protocol-enabled devices such as switches, routers, bridges, and so on. ONTAP supports two neighbor discovery protocols, which can be used individually or together.

Cisco Discovery Protocol (CDP)

CDP is a proprietary link layer protocol developed by Cisco Systems. It is enabled by default in ONTAP for cluster ports, but must be enabled explicitly for data ports.

Link Layer Discovery Protocol (LLDP)

LLDP is a vendor-neutral protocol specified in the standards document IEEE 802.1AB. It must be enabled explicitly for all ports.

Use CDP to detect network connectivity

Using CDP to detect network connectivity consists of reviewing deployment considerations, enabling it on data ports, viewing neighbor devices, and adjusting CDP configuration values as needed. CDP is enabled by default on cluster ports.

CDP must also be enabled on any switches and routers before information about neighbor devices can be displayed.

ONTAP release	Description
9.10.1 and earlier	CDP is also used by the cluster switch health monitor to automatically discover your cluster and management network switches.
9.11.1 and later	CDP is also used by the cluster switch health monitor to automatically discover your cluster, storage, and management network switches.

Related information

System administration

Considerations for using CDP

By default, CDP-compliant devices send CDPv2 advertisements. CDP-compliant devices send CDPv1 advertisements only when they receive CDPv1 advertisements. ONTAP supports only CDPv1. Therefore, when an ONTAP node sends CDPv1 advertisements, CDP-compliant neighboring devices send back CDPv1 advertisements.

You should consider the following information before enabling CDP on a node:

- CDP is supported for all ports.
- CDP advertisements are sent and received by ports that are in the up state.
- CDP must be enabled on both the transmitting and receiving devices for sending and receiving CDP advertisements.
- CDP advertisements are sent at regular intervals, and you can configure the time interval.
- When IP addresses are changed for a LIF, the node sends the updated information in the next CDP advertisement.
- ONTAP 9.10.1 and earlier:
    - CDP is always enabled on cluster ports.
    - CDP is disabled, by default, on all non-cluster ports.
- ONTAP 9.11.1 and later:
    - CDP is always enabled on cluster and storage ports.
    - CDP is disabled, by default, on all non-cluster and non-storage ports.

> Sometimes when LIFs are changed on the node, the CDP information is not updated at the receiving device side (for example, a switch). If you encounter such a problem, you should configure the network interface of the node 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 of the LIFs configured on the VLANs on that port are advertised.
- For physical ports that are part of an interface group, all of the IP addresses configured on that interface group are advertised on each physical port.
- For an interface group that hosts VLANs, all of the LIFs configured on the interface group and the VLANs are advertised on each of the network ports.

- Due to CDP packets being restricted to no more than 1500 bytes, on ports configured with a large number of LIFs only a subset of these IP addresses may be reported on the adjacent switch.

Enable or disable CDP

To discover and send advertisements to CDP-compliant neighboring devices, CDP must be enabled on each node of the cluster.

By default in ONTAP 9.10.1 and earlier, CDP is enabled on all cluster ports of a node and disabled on all non-cluster ports of a node.

By default in ONTAP 9.11.1 and later, CDP is enabled on all cluster and storage ports of a node and disabled on all non-cluster and non-storage ports of a node.

About this task

The `cdpd.enable` option controls whether CDP is enabled or disabled on the ports of a node:

- For ONTAP 9.10.1 and earlier, on enables CDP on non-cluster ports.
- For ONTAP 9.11.1 and later, on enables CDP on non-cluster and non-storage ports.
- For ONTAP 9.10.1 and earlier, off disables CDP on non-cluster ports; you cannot disable CDP on cluster ports.
- For ONTAP 9.11.1 and later, off disables CDP on non-cluster and non-storage ports; you cannot disable CDP on cluster ports.

When CDP is disabled on a port that is connected to a CDP-compliant device, network traffic might not be optimized.

Steps

1. Display the current CDP setting for a node, or for all nodes in a cluster:

To view the CDP setting of…	Enter…
A node	`run - node <node_name> options cdpd.enable`
All nodes in a cluster	`options cdpd.enable`

2. Enable or disable CDP on all ports of a node, or on all ports of all nodes in a cluster:

To enable or disable CDP on…	Enter…
A node	`run -node node_name options cdpd.enable {on or off}`
All nodes in a cluster	`options cdpd.enable {on or off}`

View CDP neighbor information

You can view information about the neighboring devices that are connected to each port of the nodes of your cluster, provided that the port is connected to a CDP-compliant device. You can use the `network device-discovery show -protocol cdp` command to view neighbor information.

About this task

In ONTAP 9.10.1 and earlier, because CDP is always enabled for cluster ports, CDP neighbor information is always displayed for those ports. CDP must be enabled on non-cluster ports for neighbor information to appear for those ports.

In ONTAP 9.11.1 and later, because CDP is always enabled for cluster and storage ports, CDP neighbor information is always displayed for those ports. CDP must be enabled on non-cluster and non-storage ports for neighbor information to appear for those ports.

Step

Display information about all CDP-compliant devices that are connected to the ports on a node in the cluster:

```
network device-discovery show -node node -protocol cdp
```

The following command shows the neighbors that are connected to the ports on node sti2650-212:

```
network device-discovery show -node sti2650-212 -protocol cdp
Node/       Local  Discovered
Protocol    Port   Device (LLDP: ChassisID)  Interface         Platform
----------- ------ ------------------------- ----------------
----------------
sti2650-212/cdp
            e0M    RTP-LF810-510K37.gdl.eng.netapp.com(SAL1942R8JS)
                                             Ethernet1/14      N9K-
C93120TX
            e0a    CS:RTP-CS01-510K35        0/8               CN1610
            e0b    CS:RTP-CS01-510K36        0/8               CN1610
            e0c    RTP-LF350-510K34.gdl.eng.netapp.com(FDO21521S76)
                                             Ethernet1/21      N9K-
C93180YC-FX
            e0d    RTP-LF349-510K33.gdl.eng.netapp.com(FDO21521S4T)
                                             Ethernet1/22      N9K-
C93180YC-FX
            e0e    RTP-LF349-510K33.gdl.eng.netapp.com(FDO21521S4T)
                                             Ethernet1/23      N9K-
C93180YC-FX
            e0f    RTP-LF349-510K33.gdl.eng.netapp.com(FDO21521S4T)
                                             Ethernet1/24      N9K-
C93180YC-FX
```

The output lists the Cisco devices that are connected to each port of the specified node.

Configure the hold time for CDP messages

Hold time is the period of time for which CDP advertisements are stored in cache in neighboring CDP-compliant devices. Hold time is advertised in each CDPv1 packet and is updated whenever a CDPv1 packet is received by a node.

- The value of the `cdpd.holdtime` option should be set to the same value on both nodes of an HA pair.
- The default hold time value is 180 seconds, but you can enter values ranging from 10 seconds to 255 seconds.
- If an IP address is removed before the hold time expires, the CDP information is cached until the hold time expires.

Steps

1. Display the current CDP hold time for a node, or for all nodes in a cluster:

To view the hold time of…	Enter…
A node	`run -node node_name options cdpd.holdtime`
All nodes in a cluster	`options cdpd.holdtime`

2. Configure the CDP hold time on all ports of a node, or on all ports of all nodes in a cluster:

To set the hold time on…	Enter…
A node	`run -node node_name options cdpd.holdtime holdtime`
All nodes in a cluster	`options cdpd.holdtime holdtime`

Set the interval for sending CDP advertisements

CDP advertisements are sent to CDP neighbors at periodic intervals. You can increase or decrease the interval for sending CDP advertisements depending on network traffic and changes in the network topology.

- The value of the `cdpd.interval` option should be set to the same value on both nodes of an HA pair.
- The default interval is 60 seconds, but you can enter a value from 5 seconds to 900 seconds.

Steps

1. Display the current CDP advertisement time interval for a node, or for all nodes in a cluster:

To view the interval for…	Enter…
A node	`run -node node_name options cdpd.interval`
All nodes in a cluster	`options cdpd.interval`

2. Configure the interval for sending CDP advertisements for all ports of a node, or for all ports of all nodes in a cluster:

To set the interval for…	Enter…
A node	`run -node node_name options cdpd.interval interval`
All nodes in a cluster	`options cdpd.interval interval`

View or clear CDP statistics

You can view the CDP statistics for the cluster and non-cluster ports on each node to detect potential network connectivity issues. CDP statistics are cumulative from the time they were last cleared.

About this task

In ONTAP 9.10.1 and earlier, because CDP is always enabled for ports, CDP statistics are always displayed for traffic on those ports. CDP must be enabled on ports for statistics to appear for those ports.

In ONTAP 9.11.1 and later, because CDP is always enabled for cluster and storage ports, CDP statistics are always displayed for traffic on those ports. CDP must be enabled on non-cluster or non-storage ports for statistics to appear for those ports.

Step

Display or clear the current CDP statistics for all ports on a node:

If you want to…	Enter…
View the CDP statistics	`run -node node_name cdpd show-stats`
Clear the CDP statistics	`run -node node_name cdpd zero-stats`

Example of showing and clearing statistics

The following command shows the CDP statistics before they are cleared. The output displays the total number of packets that have been sent and received since the last time the statistics were cleared.

```
run -node node1 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

OTHER
 Init failures:      0
```

The following command clears the CDP statistics:

```
run -node node1 cdpd zero-stats
```

```
run -node node1 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, they begin to accumulate after the next CDP advertisement is sent or received.

Use LLDP to detect network connectivity

Using LLDP to detect network connectivity consists of reviewing deployment considerations, enabling it on all ports, viewing neighbor devices, and adjusting LLDP configuration values as needed.

LLDP must also be enabled on any switches and routers before information about neighbor devices can be displayed.

ONTAP currently reports the following type-length-value structures (TLVs):

- Chassis ID
- Port ID
- Time-To-Live (TTL)
- System name

  The system name TLV is not sent on CNA devices.

Certain converged network adapters (CNAs), such as the X1143 adapter and the UTA2 onboard ports, contain offload support for LLDP:

- LLDP offload is used for Data Center Bridging (DCB).
- Displayed information might differ between the cluster and the switch.

  The Chassis ID and Port ID data displayed by the switch might be different for CNA and non-CNA ports.

For example:

- For non-CNA ports:
  - Chassis ID is a fixed MAC address of one of the ports on the node
  - Port ID is the port name of the respective port on the node
- For CNA ports:
  - Chassis ID and Port ID are the MAC addresses of the respective ports on the node.

However, the data displayed by the cluster is consistent for these port types.

> The LLDP specification defines access to the collected information through an SNMP MIB. However, ONTAP does not currently support the LLDP MIB.

Enable or disable LLDP

To discover and send advertisements to LLDP-compliant neighboring devices, LLDP must be enabled on each node of the cluster. Beginning with ONTAP 9.7, LLDP is enabled on all ports of a node by default.

About this task

For ONTAP 9.10.1 and earlier, the `lldp.enable` option controls whether LLDP is enabled or disabled on the ports of a node:

- `on` enables LLDP on all ports.
- `off` disables LLDP on all ports.

For ONTAP 9.11.1 and later, the `lldp.enable` option controls whether LLDP is enabled or disabled on the non-cluster and non-storage ports of a node:

- `on` enables LLDP on all non-cluster and non-storage ports.
- `off` disables LLDP on all non-cluster and non-storage ports.

Steps

1. Display the current LLDP setting for a node, or for all nodes in a cluster:
   - Single node: `run -node node_name options lldp.enable`
   - All nodes: options `lldp.enable`
2. Enable or disable LLDP on all ports of a node, or on all ports of all nodes in a cluster:

To enable or disable LLDP on…	Enter…
A node	`run -node node_name options lldp.enable {on|off}`
All nodes in a cluster	`options lldp.enable {on|off}`

   - Single node:

```
run -node node_name options lldp.enable {on|off}
```

◦ All nodes:

```
options lldp.enable {on|off}
```

View LLDP neighbor information

You can view information about the neighboring devices that are connected to each port of the nodes of your cluster, provided that the port is connected to an LLDP-compliant device. You use the network device-discovery show command to view neighbor information.

Step

1. Display information about all LLDP-compliant devices that are connected to the ports on a node in the cluster:

```
network device-discovery show -node node -protocol lldp
```

The following command shows the neighbors that are connected to the ports on node cluster-1_01. The output lists the LLDP-enabled devices that are connected to each port of the specified node. If the `-protocol` option is omitted, the output also lists CDP-enabled devices.

```
network device-discovery show -node cluster-1_01 -protocol lldp
Node/       Local  Discovered
Protocol    Port   Device                    Interface         Platform
----------- ------ ------------------------- ----------------
----------------
cluster-1_01/lldp
            e2a    0013.c31e.5c60            GigabitEthernet1/36
            e2b    0013.c31e.5c60            GigabitEthernet1/35
            e2c    0013.c31e.5c60            GigabitEthernet1/34
            e2d    0013.c31e.5c60            GigabitEthernet1/33
```

Adjust the interval for transmitting LLDP advertisements

LLDP advertisements are sent to LLDP neighbors at periodic intervals. You can increase or decrease the interval for sending LLDP advertisements depending on network traffic and changes in the network topology.

About this task

The default interval recommended by IEEE is 30 seconds, but you can enter a value from 5 seconds to 300 seconds.

Steps

1. Display the current LLDP advertisement time interval for a node, or for all nodes in a cluster:

   ◦ Single node:

```
run -node <node_name> options lldp.xmit.interval
```

  ◦ All nodes:

```
options lldp.xmit.interval
```

2. Adjust the interval for sending LLDP advertisements for all ports of a node, or for all ports of all nodes in a cluster:
   ◦ Single node:

```
run -node <node_name> options lldp.xmit.interval <interval>
```

   ◦ All nodes:

```
options lldp.xmit.interval <interval>
```

Adjust the time-to-live value for LLDP advertisements

Time-To-Live (TTL) is the period of time for which LLDP advertisements are stored in cache in neighboring LLDP-compliant devices. TTL is advertised in each LLDP packet and is updated whenever an LLDP packet is received by a node. TTL can be modified in outgoing LLDP frames.

About this task

- TTL is a calculated value, the product of the transmit interval (`lldp.xmit.interval`) and the hold multiplier (`lldp.xmit.hold`) plus one.
- The default hold multiplier value is 4, but you can enter values ranging from 1 to 100.
- The default TTL is therefore 121 seconds, as recommended by IEEE, but by adjusting the transmit interval and hold multiplier values, you can specify a value for outgoing frames from 6 seconds to 30001 seconds.
- If an IP address is removed before the TTL expires, the LLDP information is cached until the TTL expires.

Steps

1. Display the current hold multiplier value for a node, or for all nodes in a cluster:
   ◦ Single node:

```
run -node <node_name> options lldp.xmit.hold
```

   ◦ All nodes:

```
options lldp.xmit.hold
```

2. Adjust the hold multiplier value on all ports of a node, or on all ports of all nodes in a cluster:
   - Single node:

     ```
     run -node <node_name> options lldp.xmit.hold <hold_value>
     ```

   - All nodes:

     ```
     options lldp.xmit.hold <hold_value>
     ```

View or clear LLDP statistics

You can view the LLDP statistics for the cluster and non-cluster ports on each node to detect potential network connectivity issues. LLDP statistics are cumulative from the time they were last cleared.

About this task

For ONTAP 9.10.1 and earlier, because LLDP is always enabled for cluster ports, LLDP statistics are always displayed for traffic on those ports. LLDP must be enabled on non-cluster ports for statistics to appear for those ports.

For ONTAP 9.11.1 and later, because LLDP is always enabled for cluster and storage ports, LLDP statistics are always displayed for traffic on those ports. LLDP must be enabled on non-cluster and non-storage ports for statistics to appear for those ports.

Step

Display or clear the current LLDP statistics for all ports on a node:

If you want to…	Enter…
View the LLDP statistics	`run -node node_name lldp stats`
Clear the LLDP statistics	`run -node node_name lldp stats -z`

Show and clear statistics example

The following command shows the LLDP statistics before they are cleared. The output displays the total number of packets that have been sent and received since the last time the statistics were cleared.

```
cluster-1::> run -node vsim1 lldp stats

RECEIVE
 Total frames:     190k  | Accepted frames:   190k | Total drops:
0
TRANSMIT
 Total frames:     5195  | Total failures:      0
OTHER
 Stored entries:      64
```

The following command clears the LLDP statistics.

```
cluster-1::> The following command clears the LLDP statistics:
run -node vsim1 lldp stats -z
run -node node1 lldp stats

RECEIVE
 Total frames:        0  | Accepted frames:     0  | Total drops:
0
TRANSMIT
 Total frames:        0  | Total failures:      0
OTHER
 Stored entries:      64
```

After the statistics are cleared, they begin to accumulate after the next LLDP advertisement is sent or received.