

NETAPP UNIVERSITY

# ONTAP Cluster Administration

Student Guide  
Content Version 1.0



NETAPP UNIVERSITY

## ONTAP Cluster Administration

### Student Guide

Course ID: STRSW-ILT-ONTAPADM  
Catalog Number: STRSW-ILT-ONTAPADM-SG

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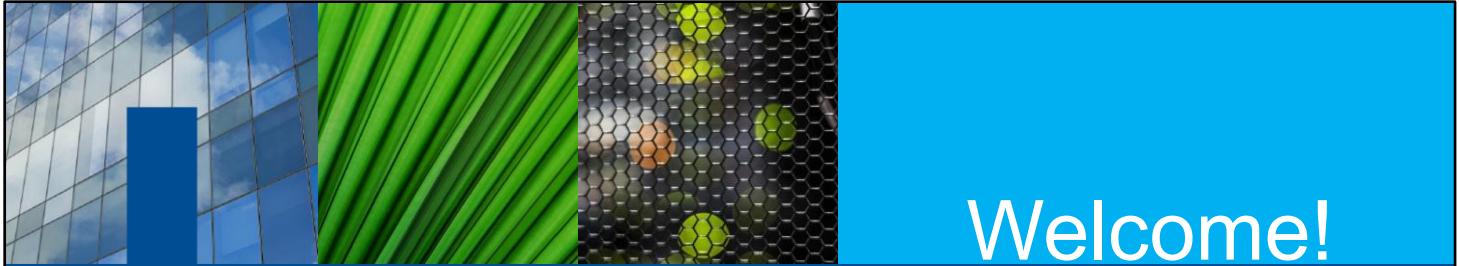
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# Welcome!

## ONTAP Cluster Administration

- Sign in (classroom sessions only).
- Be sure that you have your Student Guide and Exercise Guide.
- Test your headset and microphone (virtual sessions only).
- Provide yourself with two screens (virtual sessions only).
- Make yourself comfortable—class begins soon.



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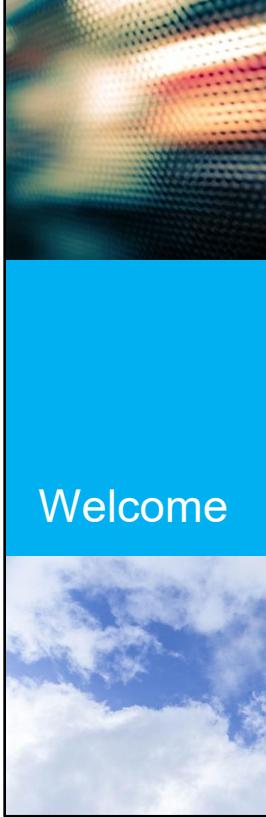
# ONTAP Cluster Administration

Course ID: STRSW-ILT-ONTAPADM



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## Welcome

# Classroom Logistics

## Getting Started

- Schedule (start, stop, breaks, breakout sessions)
- Activities and participation
- Materials
- Equipment check
- Support

## Classroom Sessions

- Sign-in sheet
- Refreshments
- Phones
- Alarm signal
- Evacuation procedure
- Electrical safety

## Virtual Sessions

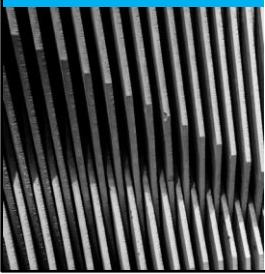
- Collaboration tools
- Ground rules
- Phones and headsets

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## Introductions



### Virtual Sessions



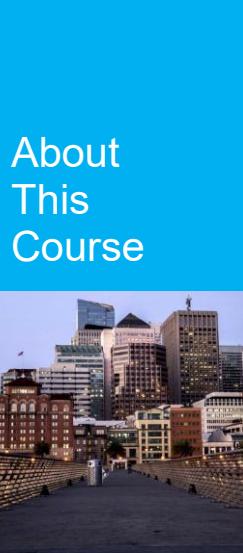
### Classroom Sessions



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Take time to get to know one another. If you are participating in a NetApp Virtual Live class, your instructor will ask you to use the chat window or a conference connection to speak. If you are using a conference connection, unmute your line to speak and be sure to mute again after you speak.



## About This Course

This course focuses on enabling you to do the following:

- Describe how NetApp ONTAP software fits into the NetApp vision for NetApp's Cloud and Data Fabric strategy
- Identify supported ONTAP platforms
- Describe a Storage Virtual Machine's (SVM's) role in NetApp's storage architecture
- Define ONTAP cluster components
- Create a cluster
- Manage ONTAP administrators

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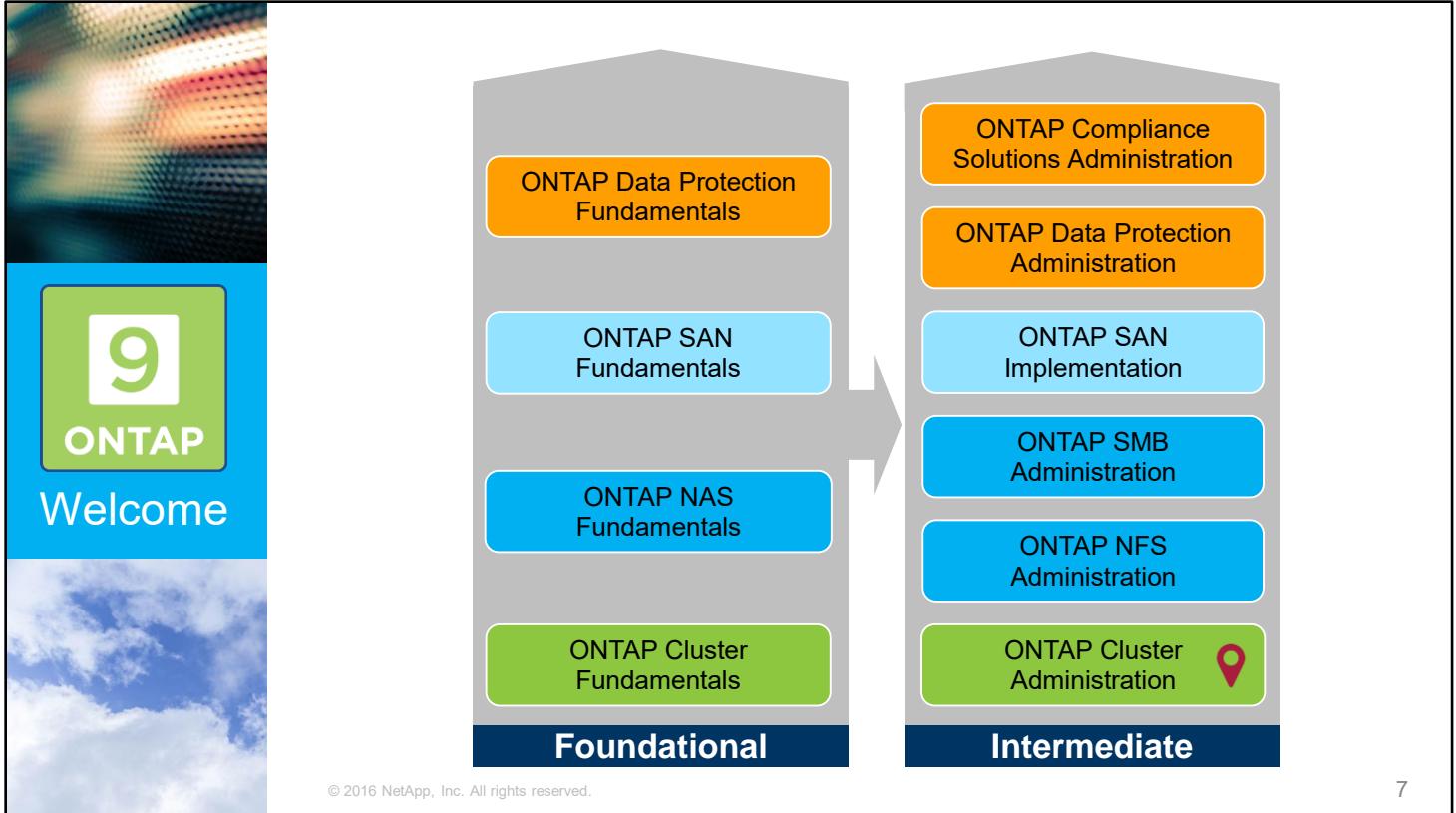


This course focuses on enabling you to do the following (cont.):

- Configure and manage networking resources
- Configure and manage storage resources
- Create and configure an SVM
- Create and manage FlexVols
- Implement storage efficiency features
- Create protocol servers within an SVM
- Upgrade and revert ONTAP patches and releases
- Describe the levels on which ONTAP protects data

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The ONTAP 9 Data Management Software learning path consists of multiple courses that focus on particular topics. Fundamental courses build knowledge as you progress up the foundational column and should therefore be taken in the order shown. Likewise, administration courses also build knowledge as you progress up the intermediate column, but they require the prerequisite foundational knowledge.

You can navigate the learning path in one of three ways:

- Complete all of the fundamental courses and then progress through the administration courses. This navigation is the recommended progression.
- Take a fundamental course and then take its complementary administration course. The courses are color-coded to make complementary courses easier to identify (green=cluster topics, blue=protocol topics, and orange=data protection topics).
- Take the course or courses that best fit your particular needs. For example, if you manage only SMB file shares, you can take ONTAP NAS Fundamentals and then take ONTAP SMB Administration. Most courses require some prerequisite knowledge. For this example, the prerequisites are ONTAP Cluster Fundamentals and ONTAP Cluster Administration.

The “you are here” indicator shows where this course appears in the ONTAP learning path. You should take ONTAP Cluster Fundamentals in preparation for this course.



## Course Agenda: Day 1

### Morning

- Module 1: ONTAP Overview
- Module 2: Cluster Setup

### Afternoon

- Module 3: Management
- Module 4: Network Management

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## Course Agenda: Day 2

### Morning

- Module 5: Physical Storage
- Module 6: Logical Storage

### Afternoon

- Module 7: Storage Efficiency
- Module 8: NAS Protocols

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## Course Agenda: Day 3

### Morning

- Module 9: SAN Protocols
- Module 10: Cluster Maintenance

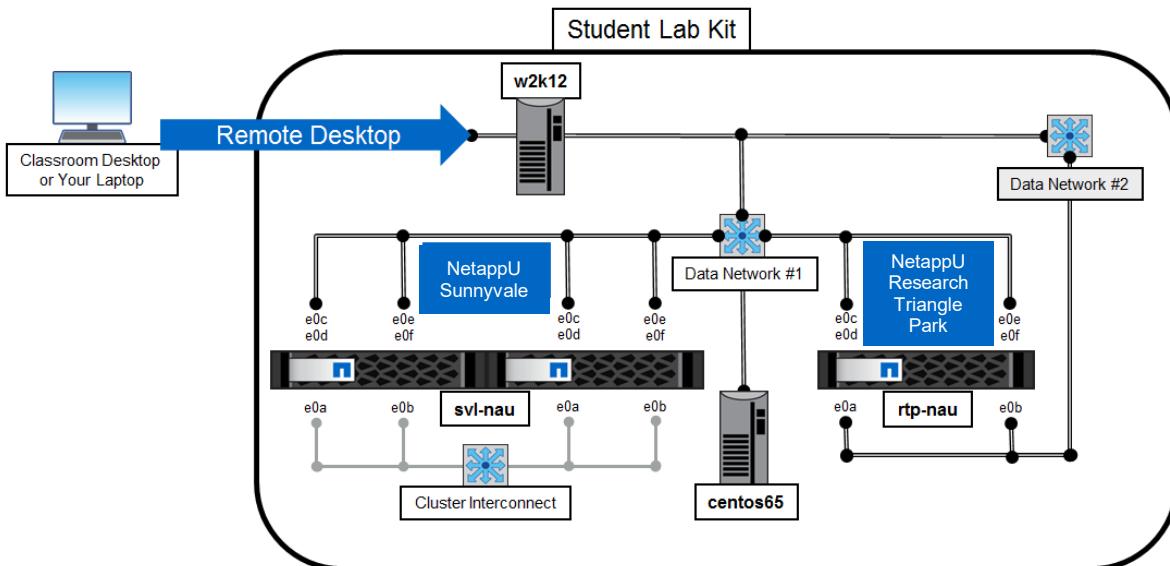
### Afternoon

- Module 11: Data Protection Features

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# Class Equipment: Basic Architecture



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Launch your exercise equipment kit from your laptop or from the classroom desktop. To connect to your exercise equipment, use Remote Desktop Connection or the NetApp University portal.

The Windows 2012 Server is your Windows domain controller for the LEARN windows domain. The Windows Server hosts the domain DNS server.

Your exercise equipment consists of several servers:

- A two-node NetApp ONTAP cluster
- A one-node ONTAP cluster
- A CentOS Linux server

# ACTION: Complete an Exercise

Module 0: Checking the Lab Setup



Duration: 15 minutes

## Access your lab equipment.

- Use the login credentials that your instructor provided to you.

## Complete the specified exercises.

- Go to the exercise for Module 0.
- Start with Exercise 1.
- Stop at the end of Exercise 1.

## Participate in the review session.

- Share your results.
- Report issues.

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Please refer to your exercise guide.

## ACTION: Share Your Experiences

Roundtable questions for the equipment-based exercises



- Do you have questions about your equipment kit?
- Do you have an issue to report?



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If you encounter an issue, notify your instructor immediately so that it can be resolved promptly.

# Your Learning Journey

Bookmark these pages

## NetApp University

### ▪ [NetApp University Overview](#)

- Find the training that you need
- Explore certification
- Follow your learning map

### ▪ [NetApp University Community](#)

Join the discussion

### ▪ [NetApp University Support](#)

Contact the support team

## NetApp

### ▪ [New to NetApp Support Webcast](#)

Encourage a successful support experience

### ▪ [NetApp Support](#)

Access downloads, tools, documentation

### ▪ [Customer Success Community](#)

Engage with experts

### ▪ [NetApp Knowledgebase](#)

Access a wealth of knowledge

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The *NetApp University Overview* page is your front door to learning. Find training that fits your learning map and your learning style, learn how to become certified, link to blogs and discussions, and subscribe to the NetApp newsletter *Tech OnTap*.

<http://www.netapp.com/us/services-support/university/index.aspx>

The *NetApp University Community* page is a public forum for NetApp employees, partners, and customers. NetApp University welcomes your questions and comments.

[https://communities.netapp.com/community/netapp\\_university](https://communities.netapp.com/community/netapp_university)

The *NetApp University Support* page is a self-help tool that enables you to search for answers to your questions and to contact the NetApp University support team. <http://netappusupport.custhelp.com>

Are you new to NetApp? If so, register for the *New to NetApp Support Webcast* to acquaint yourself with facts and tips that can help you have a successful support experience.

[http://www.netapp.com/us/forms/supportwebcastseries.aspx?REF\\_SOURCE=new2ntapwl-netappu](http://www.netapp.com/us/forms/supportwebcastseries.aspx?REF_SOURCE=new2ntapwl-netappu)

The *NetApp Support* page is your introduction to all products and solutions support: <http://mysupport.netapp.com>. Use the *Getting Started* link (<http://mysupport.netapp.com/info/web/ECMP1150550.html>) to establish your support account and hear from the NetApp CEO. Search for products, downloads, tools, and documentation or link to the *NetApp Support Community* (<http://community.netapp.com/t5/Products-and-Solutions/ct-p/products-and-solutions>).

Join the *Customer Success Community* to ask support-related questions, share tips, and engage with other users and experts.

<https://forums.netapp.com/>

Search the *NetApp Knowledgebase* to harness the accumulated knowledge of NetApp users and product experts.

<https://kb.netapp.com/support/index?page=home>



# Module 1

## ONTAP Review

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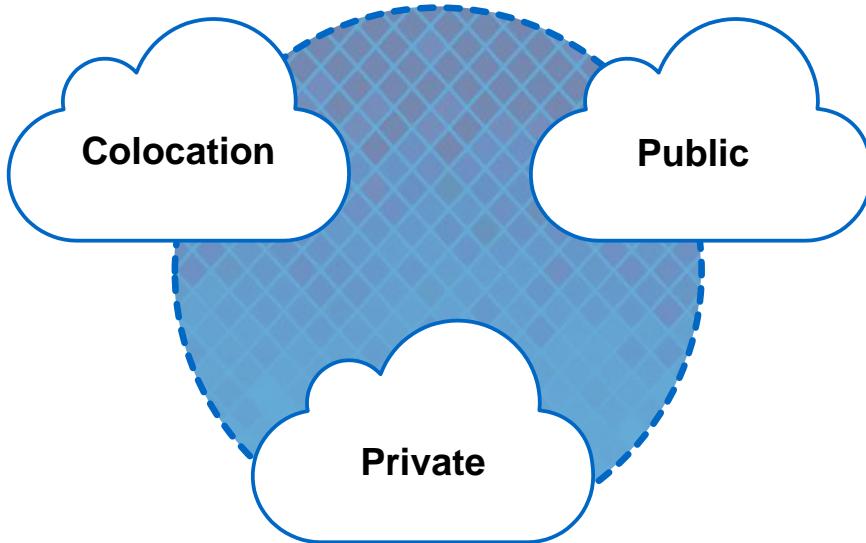
1

## About This Module

This module focuses on enabling you to do the following:

- Describe how NetApp ONTAP software fits into the NetApp vision for the cloud and Data Fabric
- Define ONTAP cluster components
- Describe the role of a storage virtual machine (SVM) in the NetApp storage architecture
- Identify ONTAP configurations

# The Data Fabric Powered by NetApp



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Managing data in hybrid cloud architectures can be a challenge. Sometimes the hybrid architecture becomes a collection of separate, incompatible repositories for data, known as “data silos.” As a solution, the Data Fabric powered by NetApp connects cloud resources. When clouds are connected by the Data Fabric strategy, IT can draw from the resources of each cloud. IT can also move data and applications to new cloud services and place every workload on the most appropriate platform.

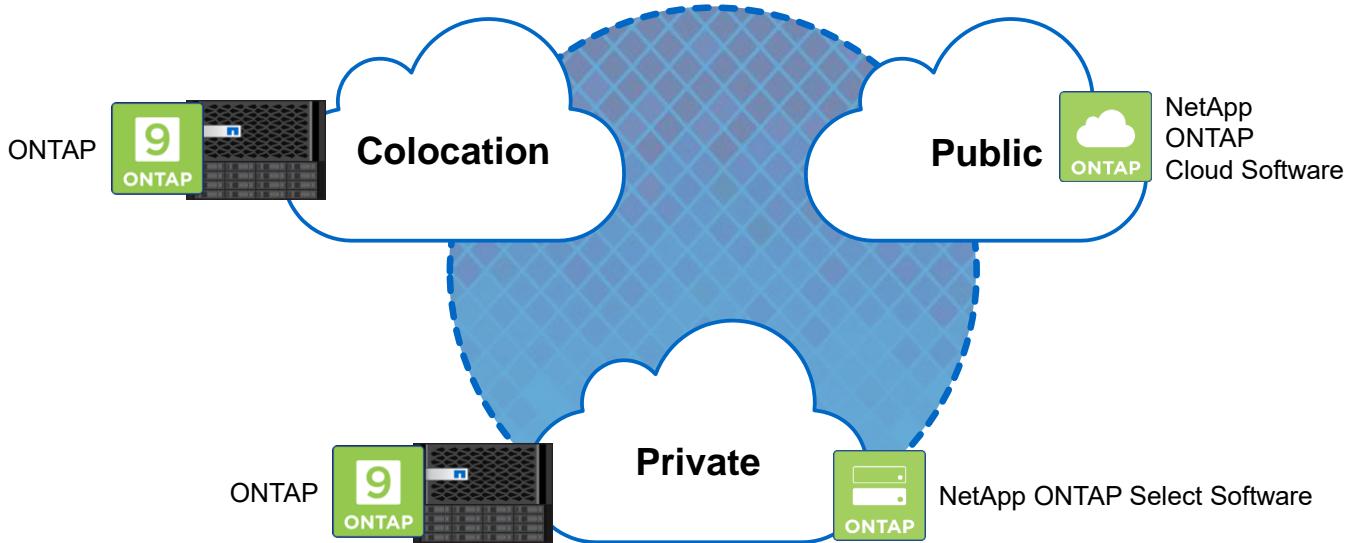
Data Fabric is the NetApp vision for the future of data management. Data Fabric is the NetApp architecture for the hybrid cloud.

Data Fabric seamlessly connects multiple data-management environments across disparate clouds into a cohesive, integrated whole. Organizations control the management, security, protection, and access of data across the hybrid cloud, no matter where the data is located. IT has the flexibility to select the right set of resources and the freedom to change the resources whenever necessary.

For more information about Data Fabric, see the Welcome to Data Fabric video:

<http://www.netapp.com/us/campaigns/data-fabric/index.aspx>.

# ONTAP Software



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NetApp ONTAP software is known primarily as the storage software that runs on FAS and All Flash FAS controllers. ONTAP software is the foundation of Data Fabric, the NetApp vision for the future of data management.

As part of the Data Fabric vision, ONTAP software can also run in the cloud as a software storage system; for example, NetApp ONTAP Cloud for Amazon Web Services (ONTAP Cloud for AWS).

For remote offices that lack space and resources, NetApp ONTAP Select software can be run as a virtual machine on the VMware vSphere platform. This virtualization enables the distribution of data center management and end-to-end data protection for the remote office environment.

Although this course focuses on ONTAP clusters, the knowledge is also applicable to ONTAP Cloud and ONTAP Select software.

# Data Fabric Layers

	Services Unify management across all environments and through all layers
	Ecosystem Integration Integrate storage systems and data management with application software frameworks
	Data Management Deliver a set of capabilities that enable management of and access to data
	Storage Management Increase the performance, availability, durability, scalability, and supportability of system hardware components
	Transport Connect all platforms via a shared data transport
	Platform Provide purpose-built and software-defined storage systems

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Creators of a data fabric system must take a data-centric view of IT infrastructure in every layer of the environment: platform, transport, storage management, data management, ecosystem integration, and services. The architecture contains the products and solutions that unbind data from underlying systems so that the data can be accessed across the fabric. With Data Fabric powered by NetApp, IT architects have many building blocks to choose from at each layer. These building blocks adhere to the principles of a true Data Fabric strategy.

Data Fabric starts at the platform layer. The platform layer includes the storage systems that are the building blocks for the endpoints of the Data Fabric strategy. The course focuses on ONTAP software, running on FAS or All Flash FAS systems, as the endpoint. The course also discusses the features that the other Data Fabric layers contain.



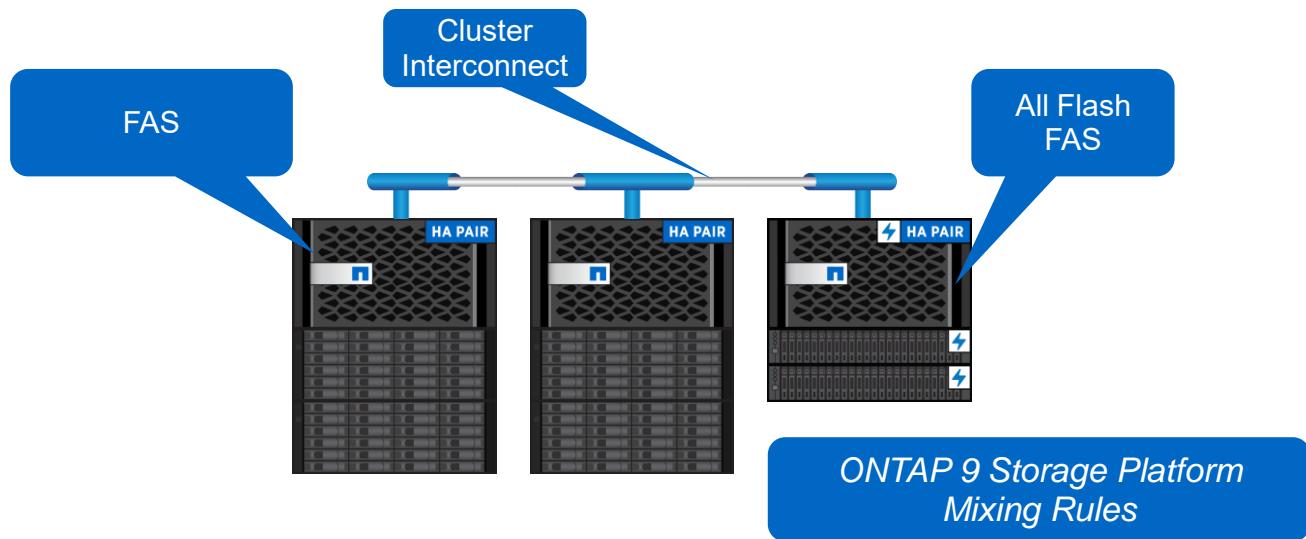
# Lesson 1

## The Cluster

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# The Cluster



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You might wonder, “What *is* a cluster?” The course examines cluster components individually, but first, consider a high-level view.

A cluster is one or more FAS or All Flash FAS controllers that run the ONTAP software. In ONTAP terminology, a controller is called a *node*. In clusters with more than one node, a cluster interconnect is required so that the nodes appear as one cluster.

A cluster can be a mix of various FAS and All Flash FAS models, depending on the workload requirements. Nodes can be added to or removed from a cluster as workload requirements change. For more information about the number and types of nodes, see the *ONTAP 9 Storage Platform Mixing Rules* in the NetApp Library.

# Nodes

A node consists of the following:



- A FAS or All Flash FAS controller that runs ONTAP software:
  - Network ports
  - Expansion slots
  - NVRAM or NVMEM
- Disk shelves

For product specifications, see the Hardware Universe:  
[hwu.netapp.com](http://hwu.netapp.com)

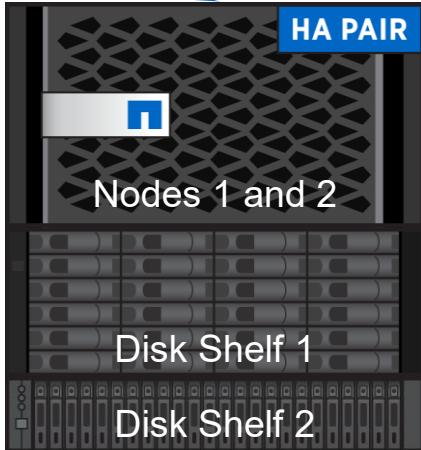
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For information about specific controller models, see the product documentation on the NetApp Support site, or see the Hardware Universe at <http://hwu.netapp.com/>.

# High-Availability Pairs

FAS8060 with an Internal Interconnect



- Characteristics of high-availability (HA) pairs:

- Two connected nodes form a partnership.
- Both nodes connect to the same disk shelves.
- Each node owns the disks on its primary cabling path (by default).
- The surviving node takes control of the failed partner's disks.

- Components of HA pair connections:

- HA interconnect
- Multipath HA shelf connectivity
- Cluster interconnect connectivity

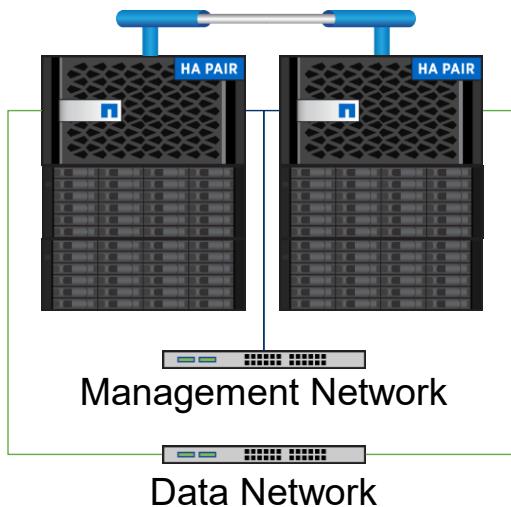
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In multinode clusters, high-availability (HA) pairs are used.

The controllers in the nodes of an HA pair connect either through an HA interconnect, which consists of adapters and cables, or through an internal interconnect. In the example here, the FAS8060 model uses an internal interconnect. The nodes must use redundant paths to connect to the same shelves. The nodes also need to be connected to a cluster interconnect, even if the cluster is composed of only one HA pair.

# Networks



- Cluster interconnect:
  - Connection of nodes
  - Private network
- Management network:
  - For cluster administration
  - Potential for management and data to be on a shared Ethernet network
- Data network:
  - One or more networks that are used for data access from clients or hosts
  - Ethernet, FC, or converged network

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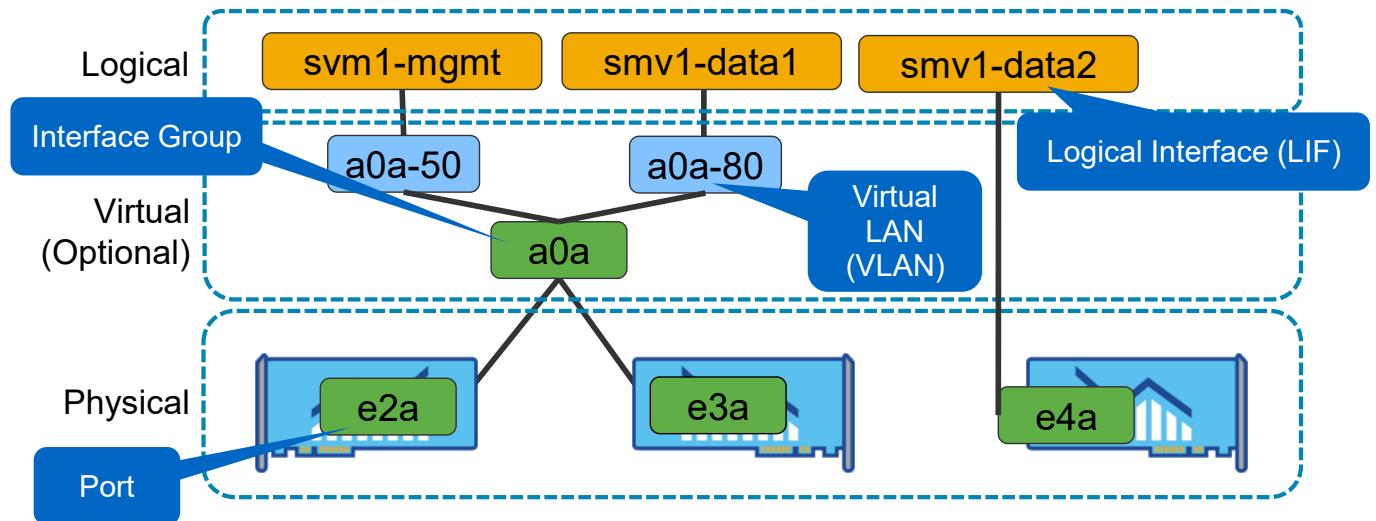
Clusters require one or more networks, depending on the environment.

In multinode clusters, nodes need to communicate with each other over a cluster interconnect. In a two-node cluster, the interconnect can be switchless. Clusters with more than two nodes require a private cluster interconnect that uses switches.

The management network is used for cluster administration. Redundant connections to the management ports on each node and management ports on each cluster switch should be provided to the management network. In smaller environments, the management and data networks might be on a shared Ethernet network.

For clients and hosts to access data, a data network is also required. The data network can be composed of one or more networks that are primarily used for data access by clients or hosts. Depending on the environment, there might be an Ethernet, FC, or converged network. Data networks can consist of one or more switches or even redundant networks.

# Ports and Logical Interfaces



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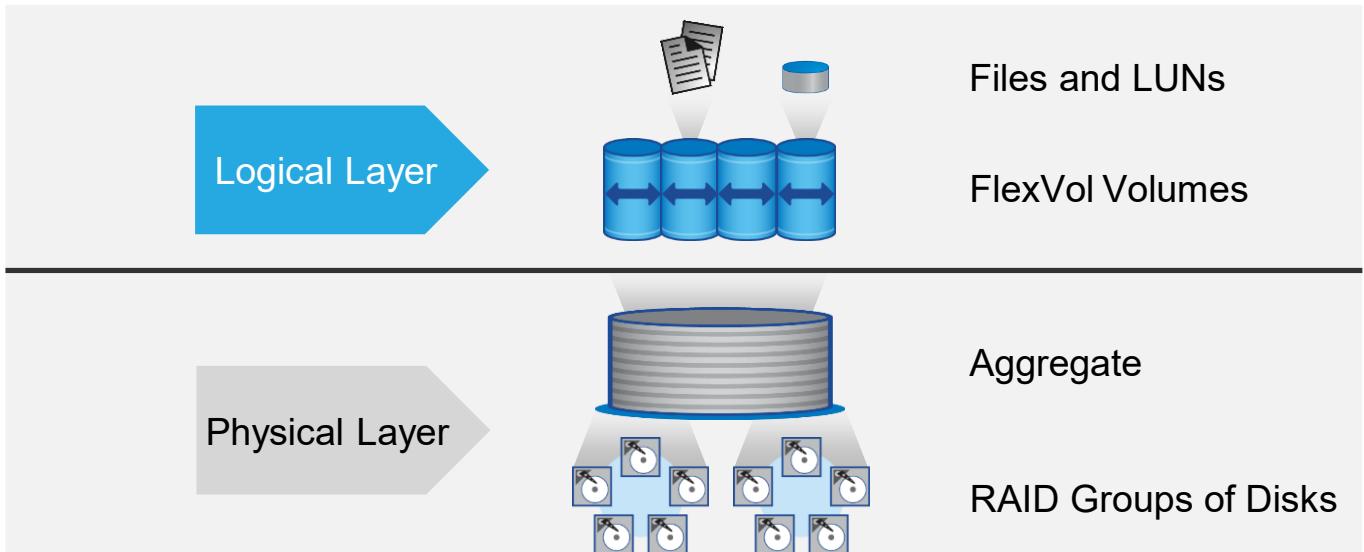
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Nodes have various physical ports that are available for cluster, management, and data traffic. The ports need to be configured appropriately for the environment.

Ethernet ports can be used directly or can be aggregated by using interface groups. Also, physical Ethernet ports and interface groups can be segmented by using virtual LANs (VLANs). Interface groups and VLANs are called *virtual ports*, which are treated like physical ports.

A logical interface (LIF) represents a network access point to a node in the cluster. A LIF can be associated with a physical port, an interface group, or a VLAN to interface with the management or data network.

# ONTAP Storage Architecture



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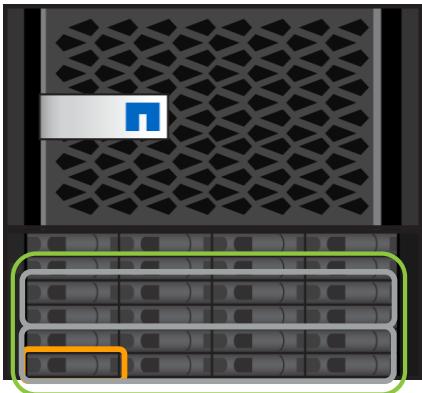
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The ONTAP storage architecture dynamically maps physical storage resources to logical containers.

In ONTAP software, disks are grouped into RAID groups. An aggregate is a collection of physical disk space that contains one or more RAID groups. Each aggregate has a RAID configuration and a set of assigned disks. The disks, RAID groups, and aggregates make up the physical storage layer.

Within each aggregate, you can create one or more FlexVol volumes. A FlexVol volume is an allocation of disk space that is a portion of the available space in the aggregate. A FlexVol volume can contain files or LUNs. The FlexVol volumes, files, and LUNs make up the logical storage layer.

# Physical Storage



- **Disk:**

- Disk ownership can be assigned to one controller.
- A disk can be used as a spare or added to a RAID group.

- **RAID group:**

- A RAID group is a collection of disks.
- RAID groups protect data in the aggregate.

- **Aggregate:**

- One or more RAID groups can be used to form an aggregate.
- Data is written across all groups.
- One controller owns an aggregate.

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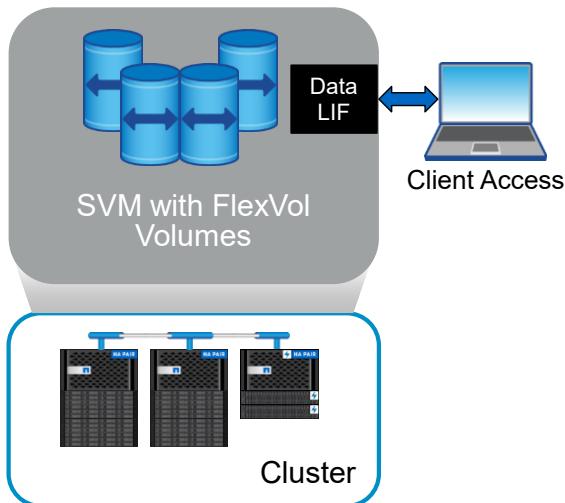
Three parts make up the physical storage on a node.

When a disk enters the system, the disk is unowned. Ownership is automatically or manually assigned to one controller. After ownership is assigned, a disk is marked as spare until the disk is used to create an aggregate or is added to an existing aggregate.

A RAID group is a collection of disks across which client data is striped and stored.

To support differing performance and data-sharing needs, you can group the physical data storage resources into one or more aggregates. Aggregates can contain one or more RAID groups, depending on the desired level of performance and redundancy. Although only one controller can own aggregates, aggregates can be relocated to the HA partner for service or performance reasons.

# SVM Components



- **SVM:**
  - Container for data volumes
  - Access of client data through a LIF
- **Volume:**
  - Logical data container for files or LUNs
  - One or more FlexVol volumes on an SVM or one scalable infinite volume on an SVM
- **LIF:**
  - Representation of the network address that is associated with a port
  - Access to client data

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A storage virtual machine (SVM) contains data volumes and LIFs. The data volumes store client data, which is accessed through a LIF.

A volume is a logical data container that might contain files or LUNs. SVMs might have one or more FlexVol volumes or a single, scalable infinite volume.

A LIF represents the IP address or worldwide port name (WWPN) that is associated with a port. Data LIFs are used to access client data.

# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes

## Instructor begins polling session

- Questions appear in the polling panel.
- Answer each question.
- When finished, click **Submit**.

## Instructor ends polling session

- Correct answers have a green check mark.
- Compare your answers to the correct answers.

## Instructor leads debrief discussion

Raise your hand to ask a question or make a comment.



## Poll Question

Check your understanding

Which set of networks are part of a cluster?

- a. data network, management network, and cluster interconnect
- b. data network, HA interconnect, and cluster interconnect
- c. HA interconnect, cluster interconnect, and backup network
- d. data network, cluster interconnect, and backup network



## Lesson 2

### Storage Virtual Machines

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# SVM Types

## Data SVMs:

- Client access to user data
- Components:
  - Data volumes
  - LIFs
  - Protocols and access control
- Use cases:
  - Secure multitenancy
  - Separation of resources and workloads
  - Delegation of management

## Administrative SVM:

- One per cluster
- Owns cluster-scoped resources
- Is also known as the cluster-management server (Cserver)

## Node SVM:

- One per node in the cluster
- Owns node-scoped resources

svl-nau::> vserver show							
Vserver	Type	Subtype	Admin		Operational		Root
			State	State	Volume	Aggregate	
svl-nau	admin	-	-	-	-	-	-
svl-nau-01	node	-	-	-	-	-	-
svl-nau-02	node	-	-	-	-	-	-
svm_red	data	default	running	running	svm_red_root	svl01_fcsl_001	
svm_yellow	data	default	running	running	svm_yellow_root	svl01_fcsl_001	

4 entries were displayed.

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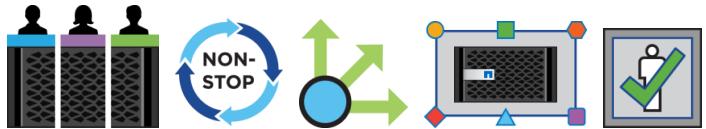
18

A data SVM contains data volumes and LIFs that serve data to clients. Unless otherwise specified, the term SVM refers to data SVM. In the CLI, SVMs are displayed as “Vservers.” SVMs might have one or more FlexVol volumes or one scalable infinite volume that can be used as a content repository.

# SVM Benefits

- Unified storage—SVMs with FlexVol volumes:
  - NAS protocols: CIFS and NFS
  - SAN protocols: iSCSI and FC (FCoE included)
- Nondisruptive operations (NDO) and nondisruptive upgrades (NDU):
  - Resource migration
  - Resource availability during hardware and software upgrades
- Scalability:
  - Adding and removing SVMs as needed
  - Modifying SVMs for data throughput and storage requirements on demand

- Secure multitenancy:
  - Partitioning of a storage system
  - Isolation of data and management
  - No data flow among SVMs in the cluster
- Delegation of management:
  - User authentication and administrator authentication
  - Access assigned by the cluster administrator



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SVMs provide many benefits.

The first benefit is unified storage. SVMs can serve data concurrently through multiple data access protocols. SVMs with FlexVol volumes provide file-level data access through NAS protocols, such as CIFS and NFS, and provide block-level data access through SAN protocols, such as iSCSI, FC, or FCoE. SVMs with FlexVol volumes can serve data to SAN and NAS clients independently at the same time.

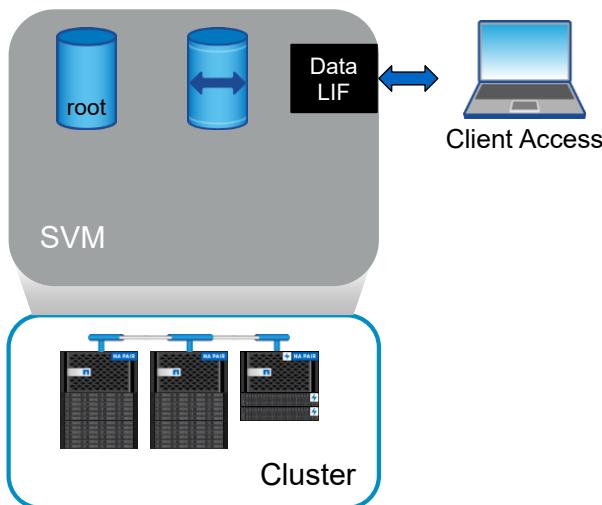
Another benefit is nondisruptive operations (NDO). SVMs can operate continuously and nondisruptively. By enabling resources such as volumes and LIFs to move to other nodes, SVMs help clusters to operate continuously. Continuous operations are advantageous during software and hardware upgrades, the addition and removal of nodes, and all administrative operations.

A third benefit of SVMs is scalability. SVMs can be added, removed, or given more resources as the underlying physical storage grows. SVMs can be modified to meet on-demand data throughput and the other storage requirements.

SVMs are the fundamental unit of secure multitenancy. SVMs enable partitioning of the storage infrastructure so that it appears as multiple independent storage systems. These partitions isolate data and management. Each SVM appears as a single independent server, which enables multiple SVMs to coexist in a cluster and prevents data from flowing among SVMs.

Finally, SVMs support delegation of management. Each SVM can have its own user authentication and administrator authentication. SVM administrators can manage the SVMs that they are authorized to access. However, cluster administrators assign privileges to SVM administrators.

## SVM Root Volume

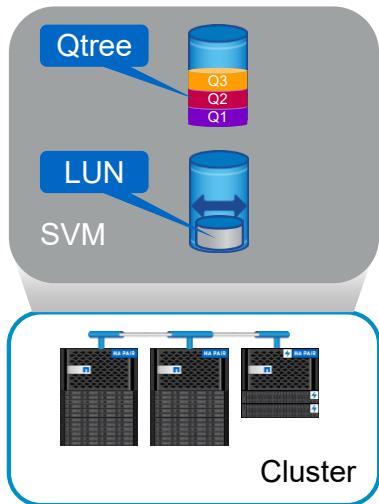


Characteristics of root volume:

- Is created when the SVM is created
- Serves as the NAS client entry point to the namespace that an SVM provides
- Should not be used to store user data

When the SVM is created, a root volume is also created, which serves as the NAS client entry point to the namespace that an SVM provides. NAS client data access depends on the health of the root volume in the namespace. SAN client data access is independent of the root volume health in the namespace.

# SVM with FlexVol Volumes



- **FlexVol volume:**
  - Representation of the file system in a NAS environment
  - Container for LUNs in a SAN environment
- **LUN:** Logical unit that represents a SCSI disk
- **Qtree:**
  - Partitioning of FlexVol volumes into smaller segments
  - Management of quotas, security style, and CIFS opportunistic lock (oplock) settings

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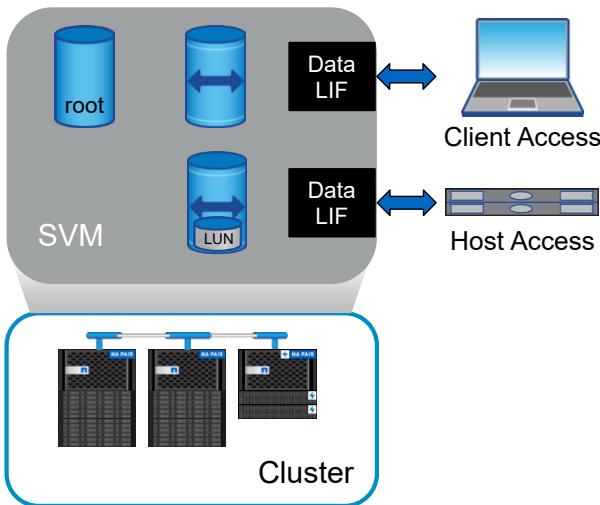
21

An SVM can contain one or more FlexVol volumes. In a NAS environment, volumes represent the file system where clients store data. In a SAN environment, a LUN is created in the volumes for a host to access.

In a SAN environment, the host operating system controls the reads and writes for the file system.

Qtrees can be created to partition a FlexVol volume into smaller segments, much like directories. Qtrees can also be used to manage quotas, security styles, and CIFS opportunistic lock (oplock) settings.

# Data LIFs



## NAS data LIFs:

- Multiprotocol (NFS, CIFS, or both)
- Manually or automatically assigned IP addresses
- Failover or migration to any node in the cluster

## SAN data LIFs:

- Single protocol (FC or iSCSI):
  - FC LIF is assigned a worldwide port name (WWPN) when created.
  - iSCSI LIF IP addresses can be assigned manually or automatically.
- No failover
- Restrictions on migration

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Data LIFs that are assigned a NAS protocol follow slightly different rules than LIFs that are assigned a SAN protocol.

NAS LIFs are created so that clients can access data from a specific SVM. NAS LIFs are multiprotocol and can be assigned an NFS, CIFS, or both. When the LIF is created, you can manually assign an IP address or specify a subnet so that the address is assigned automatically. NAS LIFs can fail over or migrate to any node in the cluster.

SAN LIFs are created so that a host can access LUNs from a specific SVM. SAN LIFs are single-protocol and can be assigned either the FC or iSCSI protocol. When a LIF is assigned the FC protocol, a WWPN is automatically assigned. When a LIF is assigned the iSCSI protocol, you can either manually assign an IP address or specify a subnet so that the address is assigned automatically. Although SAN Data LIFs do not fail over, they can be migrated. However, restrictions exist on migration.

For more information about migrating SAN LIFs, see the *ONTAP 9 SAN Administration Guide*.

# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes

## Instructor begins polling session

- Questions appear in the polling panel.
- Answer each question.
- When finished, click **Submit**.

## Instructor ends polling session

- Correct answers have a green check mark.
- Compare your answers to the correct answers.

## Instructor leads debrief discussion

Raise your hand to ask a question or make a comment.



## Poll Question

Check your understanding

Which set of components are a major part of data SVMs?

- a. aggregates and network ports
- b. disks and nodes
- c. data LIFs and aggregates
- d. volumes and data LIFs



## Lesson 3

# ONTAP Deployment Options

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# Consolidate Across Environments with ONTAP

Simply Anywhere



## ONTAP Common Data Services

Engineered



All Flash FAS+  
FAS

Converged



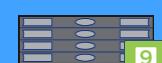
FlexPod  
Solutions

Third-Party



FlexArray  
Software

Software-  
Defined Storage



ONTAP Select

Near Cloud



NetApp Private  
Storage (NPS)

Cloud



ONTAP Cloud

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ONTAP 9 has many deployment options and can be used in different environments. Simply put, “It’s just ONTAP!” After being deployed—whether on an engineered system, commodity hardware, or the cloud—all ONTAP software is managed the same way.

## Supported Platforms

- **FAS22x0:** FAS2220, FAS2240
- **FAS25xx:** FAS2520, FAS2552, FAS2554
- **FAS/V32x0:** FAS3220, FAS3250, FAS3270
- **FAS/V62x0:** FAS6210, FAS6220, FAS6240, FAS6250, FAS6280, FAS6290
- **FAS80x0:** FAS8020, FAS8040, FAS8060, FAS8080
- **AFF80x0:** AFF8020, AFF8040, AFF8060, AFF8080



**NOTE:** See the Hardware Universe for details.

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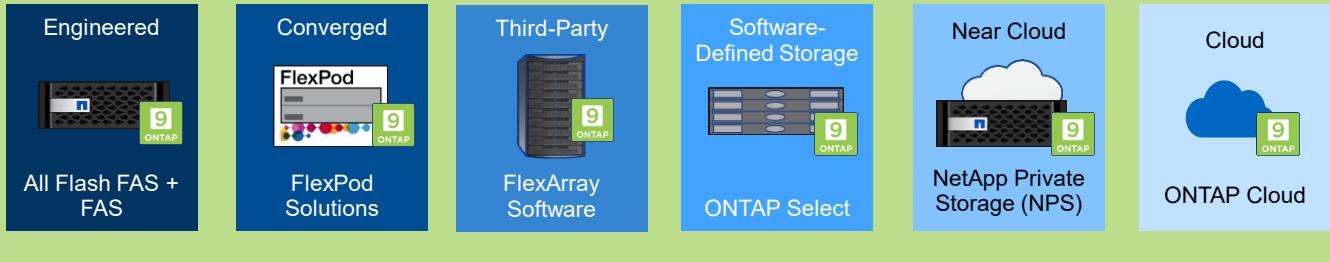
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For more details about the supported engineered platform for ONTAP 9, see the Hardware Universe at <http://hwu.netapp.com/>.

# ONTAP 9

Simply Anywhere

## ONTAP Common Data Services



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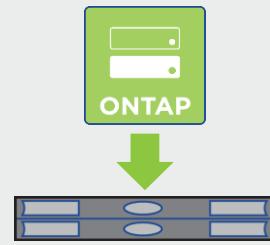
The current section focuses on software-defined storage or third-party servers that run ONTAP Select software.

# ONTAP Select

A new choice

## ONTAP Select

- Software-defined storage on third-party servers
- Deployed in data center or remote office
- Flexible, capacity-based license

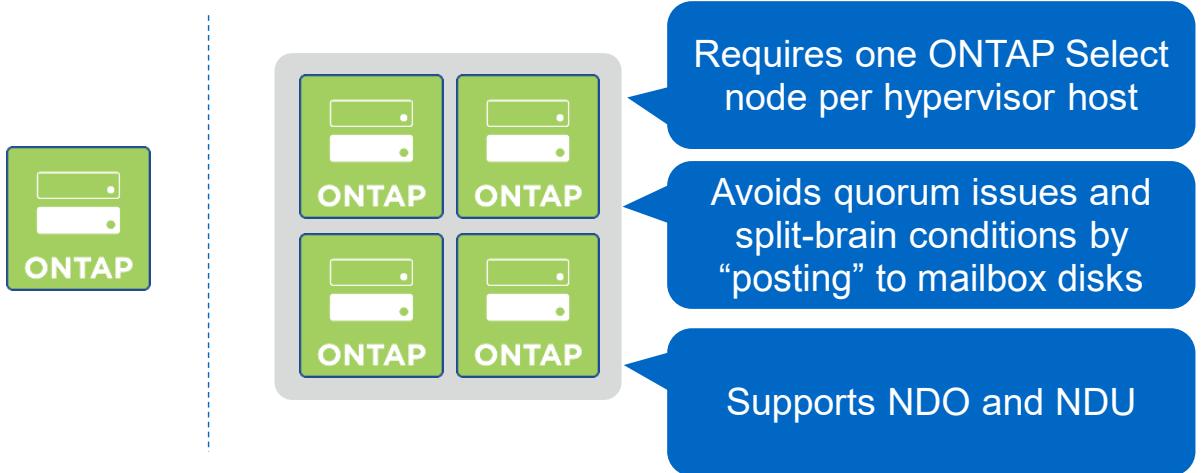


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# ONTAP Select

Single-node versus four-node configuration



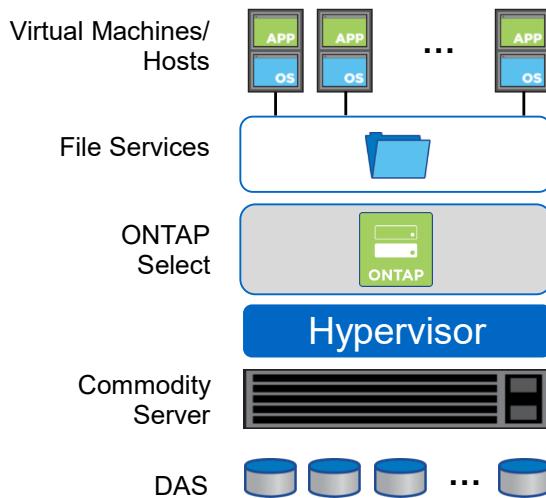
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ONTAP Select software supports single-node and four-node configurations.

The four-node configuration requires one ONTAP Select node per physical controller, so there are four separate VMware ESX hosts.

# ONTAP Select



- A software-only platform for the private cloud:
  - ONTAP on commodity server hardware
  - Storage provided by local direct-attached storage (DAS)
  - Data center and remote office solution
- Customer problems that are addressed:
  - Business agility
  - Enterprise availability
  - Efficient and effective protection
- Support for VMware vSphere and KVM

# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes

## Instructor begins polling session

- Questions appear in the polling panel.
- Answer each question.
- When finished, click **Submit**.

## Instructor ends polling session

- Correct answers have a green check mark.
- Compare your answers to the correct answers.

## Instructor leads debrief discussion

Raise your hand to ask a question or make a comment.



## Poll Question

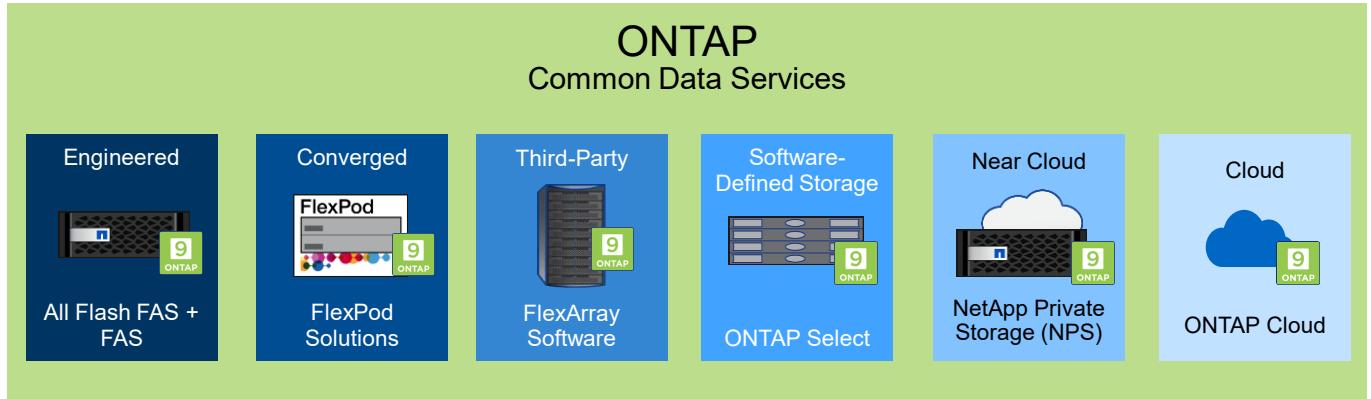
Check your understanding

Which two configurations does ONTAP Select software support? (Choose two.)

- a. single-node
- b. two-node switchless
- c. four-node
- d. MetroCluster software

# ONTAP 9

Simply Anywhere



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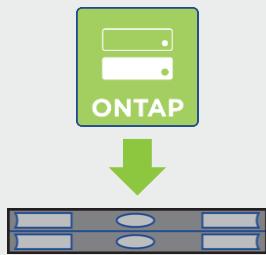
The current section focuses on cloud storage as provided by ONTAP Cloud for AWS.

# Options for ONTAP

Two choices

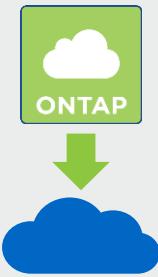
## ONTAP Select

- Software-defined storage on third-party servers
- Deployed in data center or remote office
- Flexible, capacity-based license



## ONTAP Cloud

- Software-defined storage on Amazon Web Services (AWS)
- Pay only for what you use, when you use it
- New high availability and higher performance

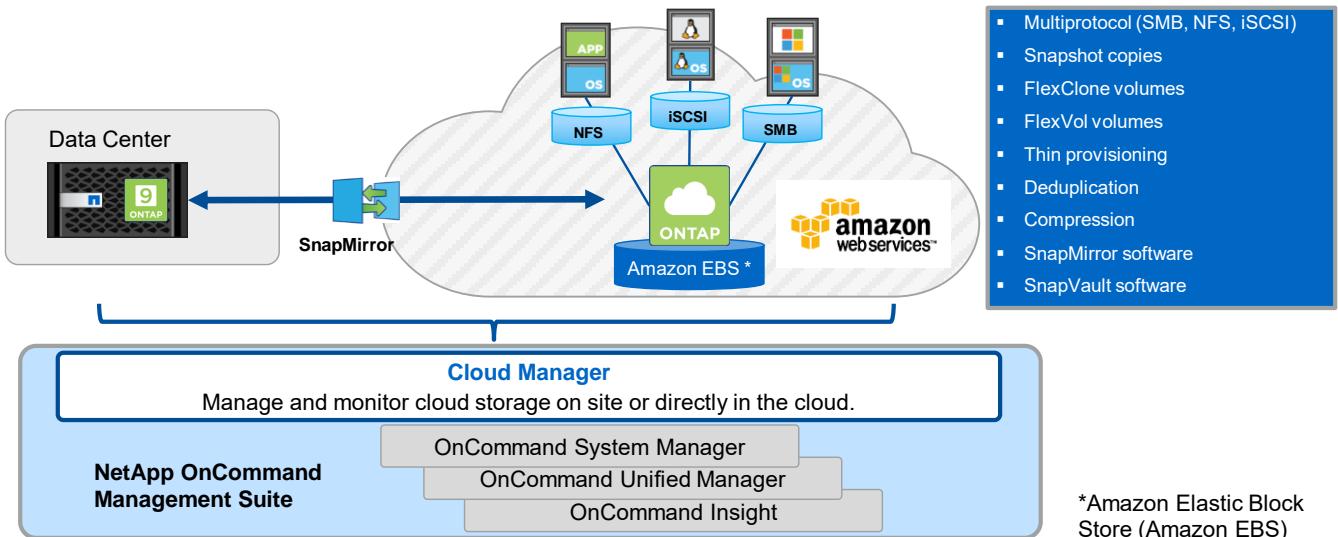


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# ONTAP Cloud

Expand your storage options in the cloud



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ONTAP Cloud software deploys ONTAP 9 as software in the cloud. ONTAP Cloud software further enables a common set of data services in the cloud. You can choose to own, lease, or rent on demand. You can explore and test the full power of ONTAP 9 in the cloud with little risk. NetApp OnCommand Cloud Manager and OnCommand Insight simplify monitoring, provisioning, and data movement of all ONTAP 9 instances across clouds.

**NOTE:** Amazon Elastic Block Store (Amazon EBS) provides persistent block-level storage volumes for use with Amazon Elastic Compute Cloud (Amazon EC2) instances in the AWS cloud. You can find more information about Amazon EC2 and Amazon EBS at <http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/AmazonEBS.html>.

# ONTAP Cloud

## Licensing choices

- Pay as you go: Rapidly deploy by the hour off the Amazon Marketplace.
- Bring your own license (BYOL): Buy a six-month subscription from NetApp.

	Pay as You Go (AWS Marketplace)		BYOL (NetApp)
	ONTAP Cloud Explore Hourly	ONTAP Cloud Standard Hourly	ONTAP Cloud Standard BYOL
ONTAP Functionality	Multiprotocol	✓	✓
	FlexClone	✓	✓
	Premium Data Protection Bundle	✓	✓
	EC2* Instances	M3.XL	M3.XL, M3.2XL R3.XL, R3.2XL
	EBS Types	SSD** (GP2)	SSD (GP2)
	EBS Capacity Limits	2TB	10TB
	Support Offer	Software Support Plan	Software Support Plan

\*Amazon Elastic Compute Cloud (EC2)

\*\*solid-state drive (SSD)

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ONTAP Cloud software has two licensing models:

- The pay as you go model is purchased and deployed through the Amazon Marketplace.
- The bring your own license (BYOL) model is purchased in six-month subscriptions directly through NetApp.

**NOTE:** ONTAP Cloud software resides on Amazon Marketplace, but deployments are managed by OnCommand Cloud Manager.

For information about the Amazon EC2 instance types, see the <https://aws.amazon.com/ec2/instance-types/>.

# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes

## Instructor begins polling session

- Questions appear in the polling panel.
- Answer each question.
- When finished, click **Submit**.

## Instructor ends polling session

- Correct answers have a green check mark.
- Compare your answers to the correct answers.

## Instructor leads debrief discussion

Raise your hand to ask a question or make a comment.



## Poll Question

Check your understanding

Which two options are licensing choices for ONTAP Cloud software?

(Choose two.)

- a. node-locked
- b. clusterwide
- c. pay as you go
- d. BYOL

## Module Review

This module focuses on enabling you to do the following:

- Describe how NetApp ONTAP software fits into the NetApp vision for the cloud and Data Fabric
- Define ONTAP cluster components
- Describe the role of a storage virtual machine (SVM) in the NetApp storage architecture
- Identify ONTAP configurations



## Module 2

## Cluster Setup

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## About This Module

This module focuses on enabling you to do the following:

- Define the NetApp ONTAP software terminology
- Identify supported cluster configurations
- Manage cluster nodes at the hardware level



## Lesson 1

### Terminology Review

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# Terminology Review



Cluster	Provides seamless scalability
Node	Controls a set of physical storage and network resources
High-availability (HA) pair	Provides availability of partner physical resources during a node failover
Aggregate	Is a collection of RAID groups
Storage virtual machine (SVM)	Owns a set of logical storage and network resources

# Terminology Review

[More terms](#)



SVM root volume	Serves as the NAS-client entry point to the namespace
Node root volume	Contains cluster configuration data and network resources
FlexVol volume	Contains user data
Data logical interface (LIF)	Provides a network access point for clients or hosts to access data in an SVM
Cluster-management LIF	Provides a network access point to manage an SVM



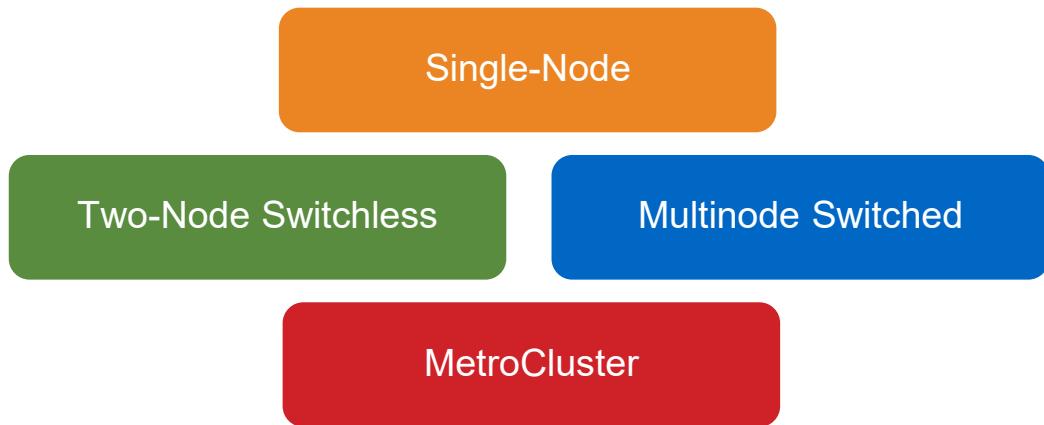
## Lesson 2

### Supported FAS Configurations

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# Supported Cluster Configurations

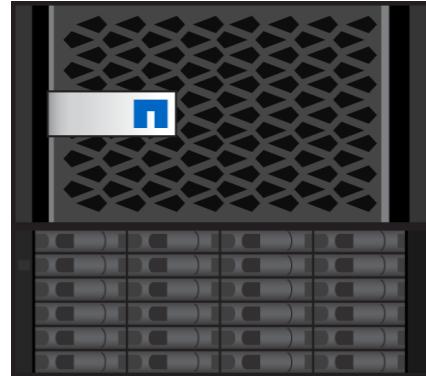


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# Single-Node Cluster

- Single-node cluster:
  - Special implementation of a cluster that runs on a standalone node
  - Appropriate when your workload requires only one node and does not need nondisruptive operations (NDO)
  - Use case: data protection for a remote office
- Unsupported features and operations:
  - Storage failover (SFO) and cluster high availability
  - Multinode operations
  - Infinite Volume



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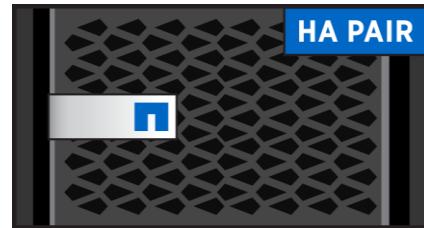
8

Some features and operations are not supported for single-node clusters. Because single-node clusters operate in a standalone mode, storage failover (SFO) and cluster high availability are unavailable. If the node goes offline, clients cannot access data that is stored in the cluster. Also, any operation that requires more than one node cannot be performed. For example, you cannot move volumes, perform most copy operations, or back up cluster configurations to other nodes. Lastly, an infinite volume must contain aggregates from at least two nodes. Therefore, Infinite Volume is not supported on single-node clusters.

## HA Pairs

HA pairs provide hardware redundancy to support the following tasks:

- Perform NDO and nondisruptive upgrades (NDU)
- Provide fault tolerance
- Enable a node to take over and give back partner storage
- Eliminate most hardware components and cables as single points of failure
- Improve data availability



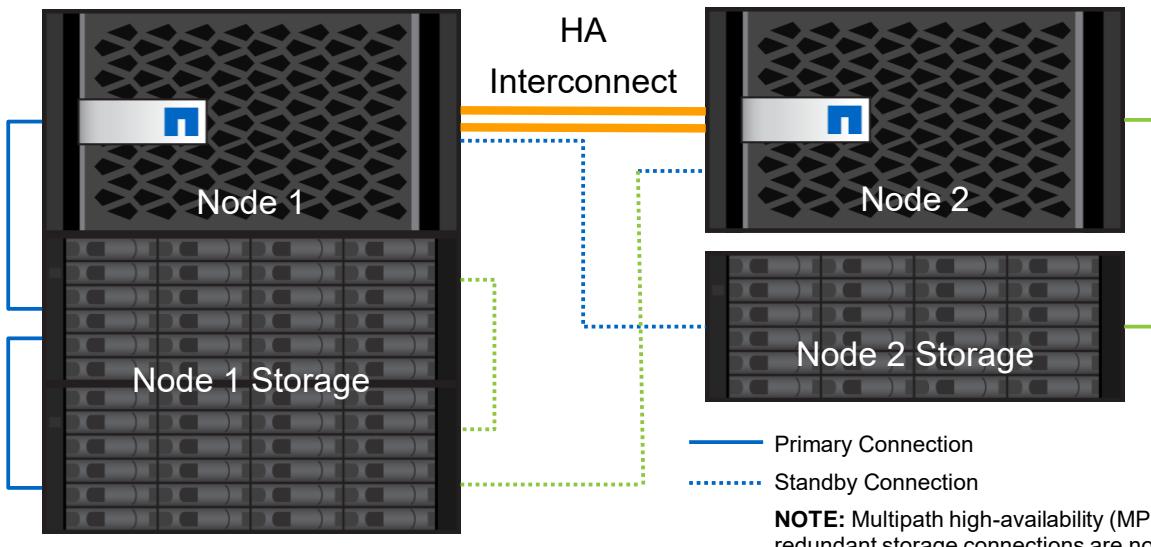
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9

HA pairs provide hardware redundancy that is required for nondisruptive operations (NDO) and fault tolerance. The hardware redundancy gives each node in the pair the software functionality to take over and return partner storage. The features also provide the fault tolerance required to perform NDO during hardware and software upgrades or maintenance.

A storage system has various single points of failure, such as certain cables or hardware components. A high-availability (HA) pair greatly reduces the number of single points of failure. If a failure occurs, the partner can take over and continue serving data until the failure is fixed. The controller failover function provides continuous data availability and preserves data integrity for client applications and users.

## HA Interconnect



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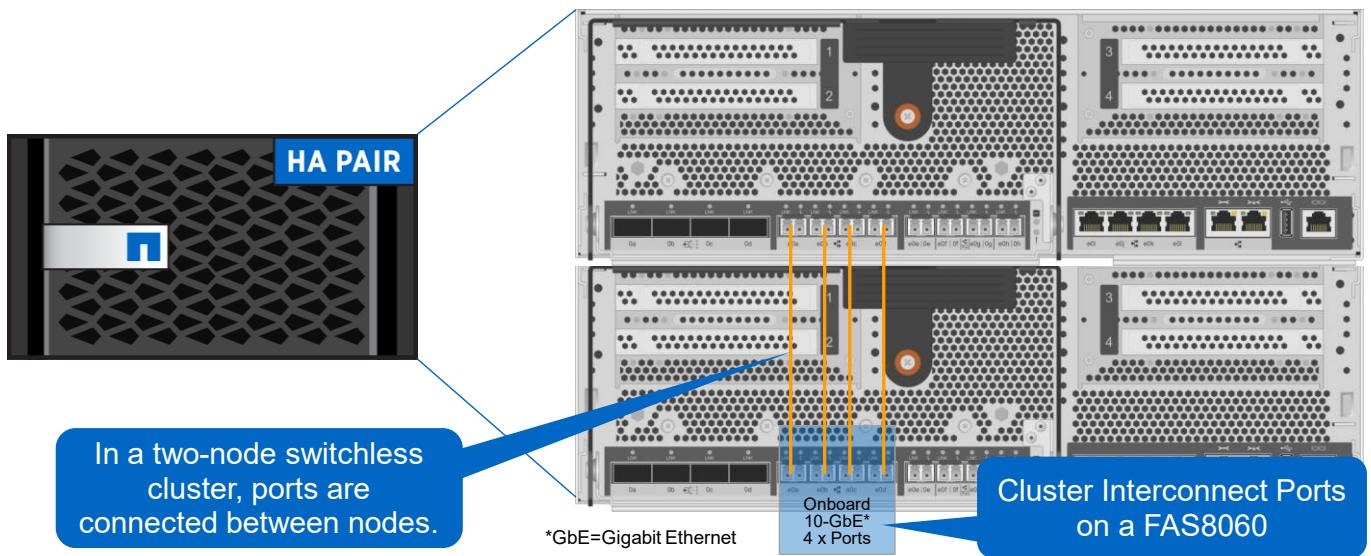
10

Each node in an HA pair requires an HA interconnect between the controllers and connections to both the node's disk shelves and the partner node's shelves.

The example here uses a standard FAS8080 EX HA pair with native DS4246 disk shelves. The controllers in the HA pair are connected through an HA interconnect that consists of adapters and cables. When the two controllers are in the same chassis, adapters and cabling are not required because connections are made through an internal interconnection. To validate an HA configuration, use the Hardware Universe.

For multipath high-availability (MPHA) support, redundant primary and secondary connections are also required. For simplicity, the connections are not shown on the slide. MPHA is required on all HA pairs except some FAS2500 series system configurations, which use a single-path high HA configuration and lack redundant standby connections.

## Two-Node Switchless Cluster



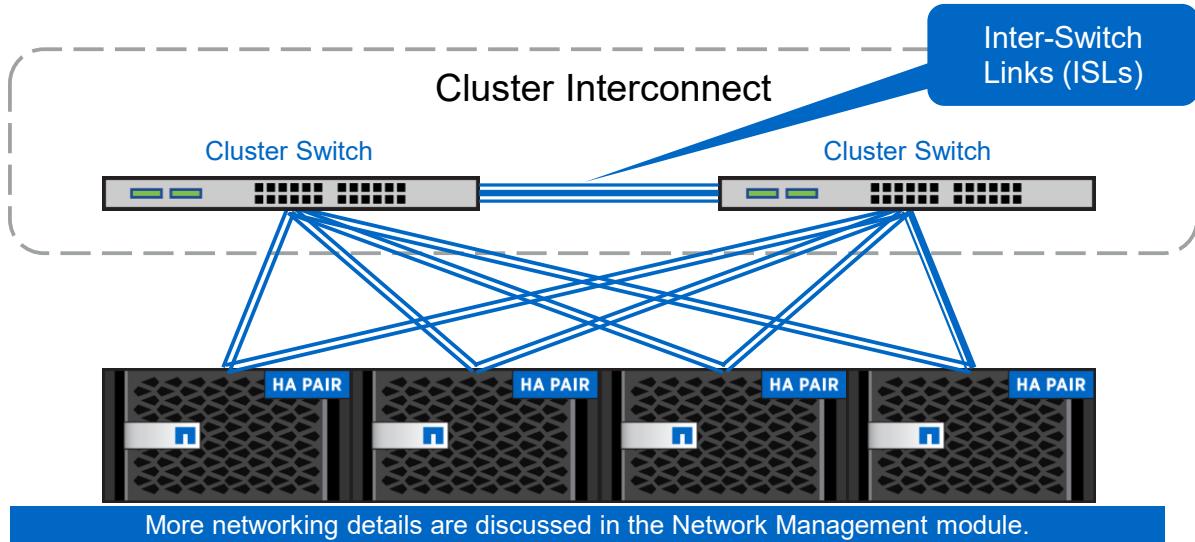
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In clusters that have more than one node, a cluster interconnect is required. The example here shows a FAS8060 system that has two controllers installed in the chassis. Each controller has a set of four onboard 10-Gigabit Ethernet (10-GbE) ports that can be used to connect to the cluster interconnect.

In a two-node switchless cluster, a redundant pair of ports is cabled together as shown on the slide.

## Switched Clusters



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If your workload requires more than two nodes, the cluster interconnect requires switches. The cluster interconnect requires two dedicated switches for redundancy and load balancing. Inter-Switch Links (ISLs) are required between the two switches. There should always be at least two cluster connections, one to each switch, from each node. The required connections vary, depending on the controller model.

After the cluster interconnect is established, you can add more nodes as your workload requires.

For more information about the maximum number and models of controllers supported, see the *ONTAP Storage Platform Mixing Rules* in the NetApp Library.

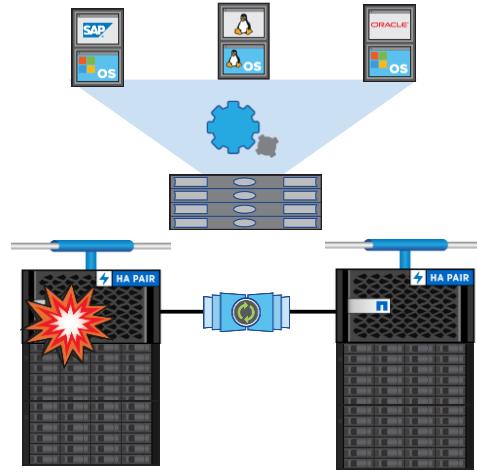
For more information about the cluster interconnect and connections, see the *ONTAP Network Management Guide*.

# MetroCluster Software

Benefits of MetroCluster software:

- Zero data loss
- Failover protection
- NDU

Learn more about the MetroCluster software in *ONTAP Data Protection Administration* and *ONTAP MetroCluster Installation*.



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The MetroCluster continuous-availability and disaster recovery software uses mirroring to protect the data in a cluster.

The MetroCluster software provides disaster recovery through one MetroCluster command. The command activates the mirrored data on the survivor site.

# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes

## Instructor begins polling session

- Questions appear in the polling panel.
- Answer each question.
- When finished, click “Submit.”

## Instructor ends polling session

- Correct answers have a green check mark.
- Compare your answers to the correct answers.

## Instructor leads debrief discussion

Raise your hand to ask a question or make a comment.



## Poll Question

Check your understanding

Which cluster configuration provides a cost-effective, nondisruptively scalable solution?

- a. single-node
- b. two-node switchless
- c. multinode switched
- d. MetroCluster



## Lesson 3

### Setting up a Cluster

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# Basic Steps to Set up a Cluster

1. Connect controllers, disks, and cables.
2. Set up and configure nodes.
3. Install software onto nodes.  
(Software is preinstalled on most systems.)
4. Initialize disks (not necessary on new clusters).
5. Set up cluster.
6. Create data aggregates.
7. Create a data SVM.
8. Create data volumes and configure protocols.

 This Module

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You must connect the controller, disks, and cables first. Powering on should start with the networking, then disk shelves, and finally the controllers.

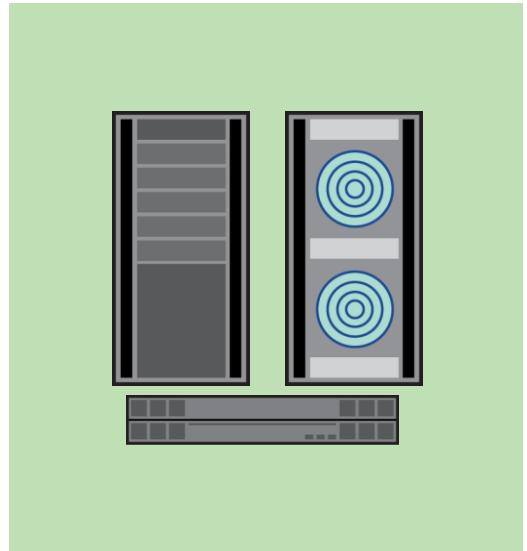
- If the system is new and does not require a software upgrade (or downgrade), simply start the setup process.
- If the system requires an upgrade or downgrade, install the software first. After the software installation is complete, initialize the disks. Initialization takes some time.

When the system boots completely, run a setup procedure to set up and configure the system or cluster. After the configuration is complete, you can create storage resources.

# Hardware Setup

Connect:

- HA interconnect
- Controllers to disk shelves
- Controllers to networks
- Any tape devices
- Controllers and disk shelves to power



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Connect controllers to disk shelves. Verify that shelf IDs are set properly.

If required for your controller type, connect NVRAM HA cable between partners. The connections can be through the chassis, 10-GbE, or InfiniBand, depending on your storage controllers.

Connect controllers to networks. If present, connect any tape devices. (You can connect tape devices later.)

Connect controllers and disk shelves to power.

## HA Interconnect Links

- Can be either:
  - External cables (dedicated 10-GbE or InfiniBand)
  - Internal interconnect (over the backplane in the chassis)
- Are used primarily to mirror NVRAM
- Provide a channel for certain types of communication traffic between the nodes in a pair:
  - Failover
  - Disk firmware
  - Heartbeats
  - Version information

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HA interconnects connect the two nodes of each HA pair for all controllers. The connections are internally provided over the backplane in the chassis of a dual-controller configuration. For chassis with single controllers, a dedicated InfiniBand or 10-GbE link is required, depending on the model and enclosure. Visit the NetApp Support site to see the appropriate hardware configuration guide for your model storage controller.

The following types of traffic flow over the HA interconnect links:

- **Failover:** The directives are related to performing SFO between the two nodes, regardless of whether the failover is:
  - Negotiated (planned and in response to an administrator request)
  - Not negotiated (unplanned and in response to an improper system shutdown or booting)
- **Disk firmware:** Nodes in an HA pair coordinate the update of disk firmware. While one node updates the firmware, the other node must not perform any I/O to that disk.
- **Heartbeats:** Regular messages demonstrate availability.
- **Version information:** The two nodes in an HA pair must be kept at the same major and minor revision levels for all software components.

## ACTION: Topics for Discussion



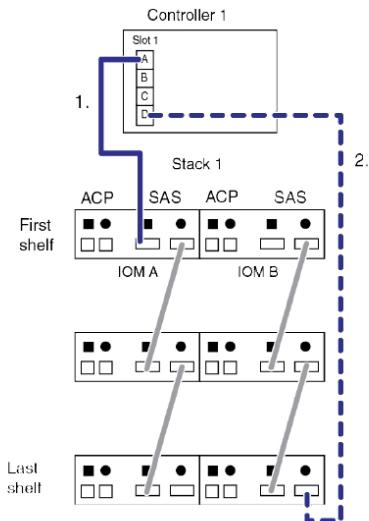
- What are the advantages of using MPHA cabling instead of single-path cabling?
- Why do I need an alternate control path (ACP)? The FC-connected shelves did not need an ACP.



# Disk-Shelf Best Practices

## Single-controller configuration

- Single-controller configuration must use a dual path.
- FAS22xx systems with external storage must use a dual path.
- Dual path is recommended for greater resiliency.



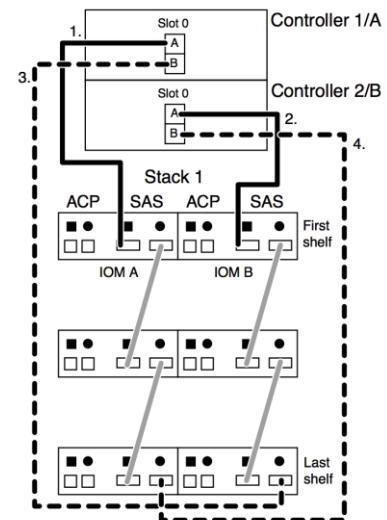
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# Disk-Shelf Best Practices

## MPHA configuration

- HA pair configuration must use MPHA.
- FAS22xx systems with external drives must use MPHA.



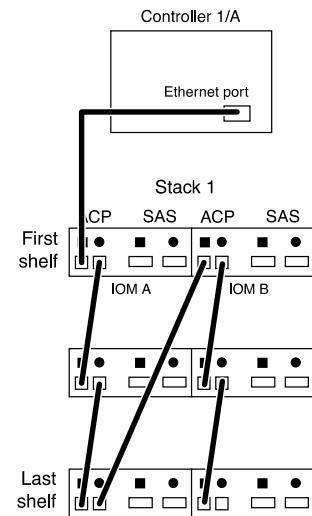
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# Disk-Shelf Best Practices

## ACP configuration

- ACP enables ONTAP to manage and control the disk-shelf management system.
- CAT-6 Ethernet cables and RJ-45 connectors must be used.
- One Ethernet port per controller is required.
- Cable the configuration by using connections within a series.



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## Powering on a System



1. Power on network switches.
2. Power on disk shelves.
3. Power on tape devices (if present).
4. Power on storage controllers.

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The order that is shown is recommended for powering on the hardware devices in a cluster.

## Firmware

- Use LOADER firmware.
- Two boot device images exist: flash0a and flash0b.
- Use `printenv` to show the firmware environment variables.
- Use `setenv` to set the firmware environment variables; for example,  
`setenv AUTOBOOT true`.

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1. Use LOADER firmware.
2. From the console, early in the booting process, press any key to enter the firmware.
3. Use `version` to show the firmware version.
4. Two boot device images exist (depending on the platform): flash0a and flash0b.
  - CompactFlash
  - USB flash
5. Use `printenv` to show the firmware environment variables.
6. Use `setenv` to set the firmware environment variables; for example, `setenv AUTOBOOT true`.

To copy flash0a to flash0b, run `flash flash0a flash0b`.

To put (or “flash”) a new image onto the primary flash, you must first configure the management interface. The `auto` option of `ifconfig` can be used if the management network has a Dynamic Host Configuration Protocol (DHCP) or BOOTP server. Otherwise, you must run `ifconfig <interface> addr=<ip> mask=<netmask> -gw=<gateway>`.

After the network is configured, verify that you can ping the IP address of the TFTP server that contains the new flash image. Then, to flash the new image, run `flash tftp://<tftp_server>/<path_to_image> flash0a`.

## Console on Boot

```
setenv comconsole_speed 115200
LOADER> setenv SYS_SERIAL_NUM 4082368-50-7
LOADER> setenv bootarg.nvram.sysid 4082368507
LOADER> boot
x86_64/freebsd/image1/kernel data=0x9a17d0+0x479ab8
x86_64/freebsd/image1/platform.ko text=0x1e5add data=0x485a0+0x42bd0
NetApp ONTAP 9.0
Copyright (C) 1992-2016 NetApp.
All rights reserved.
*****
*          *
* Press Ctrl-C for Boot Menu. *
*          *
*****
```

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## Boot Menu

```
^C
```

```
Boot Menu will be available.
```

```
Please choose one of the following:
```

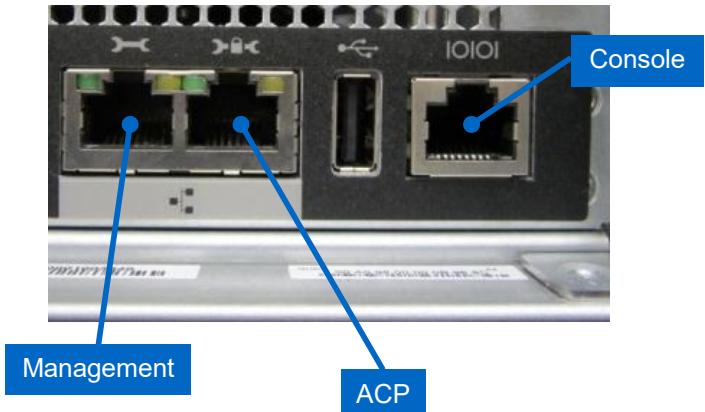
- (1) Normal Boot.
- (2) Boot without /etc/rc.
- (3) Change password.
- (4) Clean configuration and initialize all disks.
- (5) Maintenance mode boot.
- (6) Update flash from backup config.
- (7) Install new software first.
- (8) Reboot node.

```
Selection (1-8) ? 1
```

The boot menu appears only if you press Ctrl+C.

## Communication Connections

- Console connection (using ANSI-9600-8N1)
- Remote management device connection (dependent on model): Service Processor (SP)
- Management network connections
- Cluster interconnect connections
- Data network connections



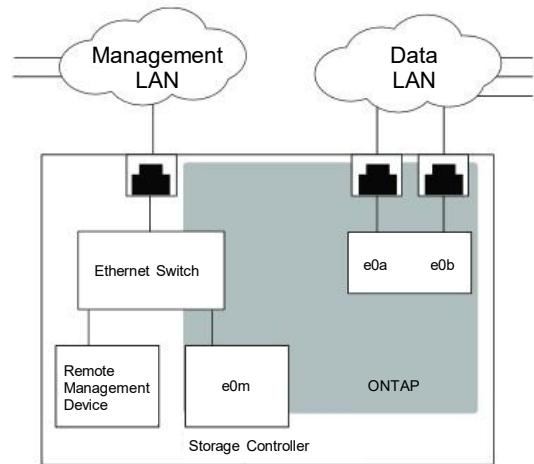
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Each controller should have a console connection, which is required to get to the firmware and the boot menu; for example, for the setup, installation, and initialization options. A remote management device connection, although not required, is helpful if you cannot get to the UI or console. Remote management enables remote booting, the forcing of core dumps, and other actions.

# Management Interfaces

- e0M interface:
  - Is dedicated for management traffic
  - Is used for ONTAP administrative tasks
- SP interface:
  - Is used to manage and provide remote management capabilities for the storage system
  - Provides remote access to console and provides monitoring, troubleshooting, logging, and alerting features
  - Remains operational
  - Uses the following setup command:  
`system node service-processor`



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

To set up a storage system that has the e0M interface, remember the following information:

- The Ethernet port that is indicated by a wrench icon on the rear of the chassis connects to an internal Ethernet switch.
- Follow the ONTAP setup script.
- To manage LAN in environments where dedicated LANs isolate management traffic from data traffic, e0M is the preferred interface.
- Configure e0M separately from the Remote LAN Module (RLM) or SP configuration.
- Both configurations require unique IP and MAC addresses to enable the Ethernet switch to direct traffic to either the management interfaces or the RLM or SP.

For more information on configuring remote support, refer to the *ONTAP System Administration Guide* and *ONTAP Remote Support Agent Configuration Guide*.

# Service Processor Commands

- To access the SP:

- ssh admin@xxx.xxx.xxx.xxx
  - Use system node service-processor to assign IP address.
  - Default port is 5000.
- From a console session, enter ^g

- SP commands:

- system sensors
- System console
- system power status
- system power on
- system power cycle
- system battery show
- system fru list

Sensor Name	Current	Unit	Status
CPU0_Temp_Margin	-55.000	degrees C	ok
CPU1_Temp_Margin	-56.000	degrees C	ok
In_Flow_Temp	32.000	degrees C	ok
Out_Flow_Temp	38.000	degrees C	ok
CPU1_Error	0x0	discrete	0x0180
CPU1_Therm_Trip	0x0	discrete	0x0180
CPU1_Hot	0x0	discrete	0x0180
IO_Midl_Temp	30.000	degrees C	ok
IO_Mid2_Temp	30.000	degrees C	ok
CPU_VTT	1.106	Volts	ok
CPU0_VCC	1.154	Volts	ok
3.3V	3.323	Volts	ok
5V	5.002	Volts	ok
STBY_1.8V	1.794	Volts	ok

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Find more information about the service processor in the *ONTAP System Administrator Reference*.

## ACTION: Topic for Discussion



What is the difference between console access and SP access?



# Installing and Initializing a Node

- You need the following:
  - Access to an FTP, Trivial File Transfer Protocol (TFTP), or HTTP server
  - The software image file on the server
- From the boot menu, complete the following:
  1. Select Option 7.
  2. When prompted, enter the URL of an ONTAP .tgz image.
  3. Wait for the system to boot.
- From the boot menu, select Option 4:
  - Deletes all data on the disks that the controller owns
  - Creates a new root aggregate and root volume for configuration

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After you boot the system, if the node stops at the firmware prompt (which happens if the firmware environment variable AUTOBOOT is set to false), type `boot_primary` to enable the node to continue to the boot menu. If AUTOBOOT is set to true, the node goes straight to the boot menu.

If you use TFTP, beware of older TFTP servers that have limited capabilities and might cause installation failures.

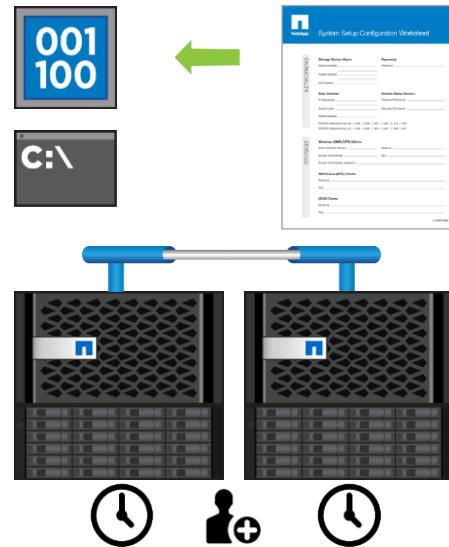
Because all disks are initialized parallel to one another, the time that is required to initialize the disks is based on the size of the largest disk that is attached to the node, not on the sum capacity of the disks. After the disks are initialized, the node's first aggregate and its vol0 volume are created automatically.

## Typical Boot Sequence

1. Loads the kernel into memory from the boot device
2. Mounts the “/” root image from rootfs.img on the boot device
3. Loads Init and runs startup scripts
4. Loads NVRAM kernel modules
5. Creates /var partition on NVRAM (restored from boot device if a backup copy exists)
6. Starts management processes
7. Loads the data and network modules
8. Mounts vol0 root volume
9. Is ready for use

# Creating a Cluster

- Tools for creating clusters:
  - System Setup software
  - Cluster setup wizard with the CLI
- Using the CLI to create a cluster:
  - 1.Create the cluster on the first node.
  - 2.Join the remaining nodes to the cluster.
  - 3.Synchronize the system time across the cluster.
  - 4.Configure event notification.
  - 5.Configure the AutoSupport support tool.



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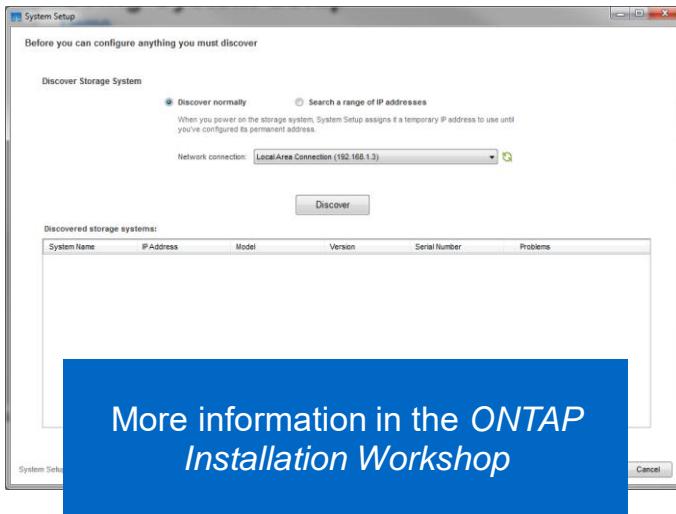
After installing the hardware, you should use System Setup whenever possible to set up the cluster. However, if System Setup does not support your configuration, you can use the CLI to run the cluster setup wizard.

Before setting up a cluster, you should use a cluster setup worksheet and record the values that you need during the setup process. Worksheets are available on the NetApp Support website. If you use the System Setup software, enter the information that you collected on the worksheet as the software prompts you.

If you use the CLI and the cluster setup wizard to create the cluster, you create the cluster on a single node in the cluster. The wizard helps you to configure the cluster interconnect, create the cluster admin, add feature license keys, and create the node management interface for the first node. After creating the cluster, you use the node setup wizard to join nodes to the cluster, one at a time. The node setup wizard helps you to configure each node's node management interface.

After using the CLI to add all nodes, you also need to manually configure a few items. Synchronizing the time ensures that every node in the cluster has the same time and prevents CIFS and Kerberos failures. You need to decide where to send event notifications: to an email address, a syslog server, or an SNMP traphost. NetApp also recommends that you configure the AutoSupport support tool.

# Using System Setup



System Setup automates cluster creation by using the following features:

- Automatic node discovery that uses Dynamic Host Configuration Protocol (DHCP) or a specific range of IP addresses
- Automatic identification of HA pairs
- Automatic configuration of multiple nodes in a cluster (no joining nodes)
- Options to configure networking
- Options to configure aggregates
- Options to create a data SVM and configure NFS, CIFS, and iSCSI protocols
- Options to enable AutoSupport and critical alerts

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You should use System Setup whenever possible to set up the cluster, because System Setup automates much of the cluster creation.

The software first automatically discovers nodes by using DHCP or a specific range of IP addresses. During the discovery, the software also identifies the HA pairs for proper failover configuration. The software automatically configures multiple nodes in a cluster. Unlike with the CLI, with the System Setup software you do not need to create the cluster on the first node and join the other nodes. No joining is required.

Optionally, you can also configure networking and aggregates, create a data SVM, and configure NFS, CIFS, and iSCSI protocols. Lastly, you can enable AutoSupport and critical alerts.

For more information about setting up a cluster, see the *ONTAP 9 Software Setup Guide*.

# Review

Basic steps for setting up a system

1. Connect controllers, disks, and cables.
2. Set up and configure nodes.
3. Install software onto nodes.  
(Software is preinstalled on most systems.)
4. Initialize disks.
5. Create a cluster on the first node, then join additional nodes to the cluster.
6. Create data aggregates.
7. Create an SVM.
8. Create data volumes and protocol configuration.

 This Module

## Additional Training

- ONTAP Installation Workshop
- System Installation and Configuration for ONTAP web-based course
- ONTAP Cabling web-based course





## Lesson 4

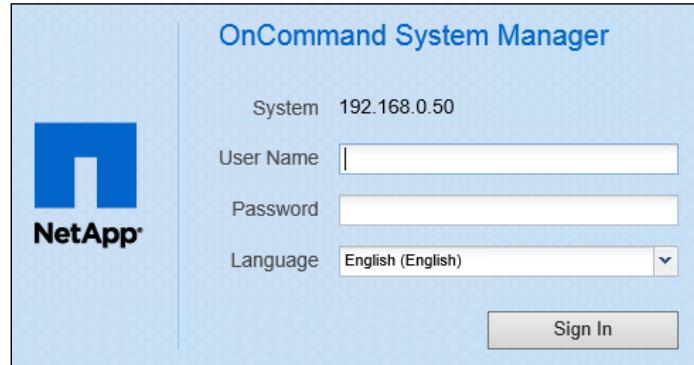
### User Interfaces

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# Cluster Administrators

- Manage the entire cluster:
  - All cluster resources
  - SVM creation and management
  - Access control and roles
  - Resource delegation
- Use login credentials:
  - The default user name is **admin**.
  - Use the password that was created during cluster setup.



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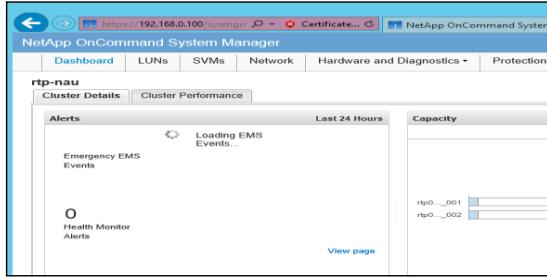
39

After you use System Setup to create the cluster, a link is provided to launch OnCommand System Manager. Log in as cluster administrator to manage the entire cluster. You manage all cluster resources, the creation and management of SVMs, access control and roles, and resource delegation.

To log in to the cluster, use the default user name **admin** and the password that you configured during cluster creation.

# Managing Resources in a Cluster

- NetApp OnCommand System Manager:
  - Visual representation of the available resources
  - Wizard-based resource creation
  - Best practice configurations
  - Limited advanced operations
- The CLI:
  - Manual or scripted commands
  - Manual resource creation that might require many steps
  - Ability to focus and switch quickly among specific objects

A screenshot of the NetApp OnCommand System Manager web interface. The top navigation bar includes links for Dashboard, LUNs, SVMs, Network, Hardware and Diagnostics, and Protection. The main content area shows 'Cluster Details' with sections for Alerts (Emergency EMS Events, Health Monitor Alerts), Last 24 Hours (Loading EMS Events), and Capacity (a chart showing two nodes, rpo\_001 and rpo\_002, with their respective capacities). A 'View page' link is at the bottom right.

```
login as: admin
Using keyboard-interactive authentication.
Password: *****
svl-nau::> cluster show
Node          Health   Eligibility
-----
svl-nau-01    true     true
svl-nau-02    true     true
```

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You can use many tools to create and manage cluster resources. Each tool has advantages and disadvantages.

OnCommand System Manager is a web-based UI that provides a visual representation of the available resources. Resource creation is wizard-based and adheres to best practices. However, not all operations are available. Some advanced operations might need to be performed by using commands in the CLI.

You can use the CLI to create and configure resources. Enter commands manually or through scripts. Instead of the wizards that System Manager uses, the CLI might require many manual commands to create and configure a resource. Although manual commands give the administrator more control, manual commands are also more prone to mistakes that can cause issues. One advantage of using the CLI is that the administrator can quickly switch focus without needing to move through System Manager pages to find different objects.

## Clustershell

The default CLI, or shell, in ONTAP is called the clustershell and features the following:

- Inline help
- Online manual pages
- Command history
- Ability to reissue a command
- Keyboard shortcuts
- Queries and UNIX-style patterns
- Wildcards

```
login as: admin
Using keyboard-interactive authentication.
Password: *****
svl-nau::> cluster show
Node          Health  Eligibility
-----
svl-nau-01    true    true
svl-nau-02    true    true

svl-nau::>
```

The cluster has different CLIs or shells for different purposes. This course focuses on the clustershell, which starts automatically when you log in to the cluster.

Clustershell features include inline help, an online manual, history and redo commands, and keyboard shortcuts. The clustershell also supports queries and UNIX-style patterns. Wildcards enable you to match multiple values in command-parameter arguments.

# Clustershell

Command scope

```
svl-nau::> storage aggregate
```

```
svl-nau::storage aggregate> modify
```

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Typing the first two levels of the command directory puts you in the command directory. You can then type a command from that level or type a fully qualified command from a different command directory.

# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes

## Instructor begins polling session

- Questions appear in the polling panel.
- Answer each question.
- When finished, click “Submit.”

## Instructor ends polling session

- Correct answers have a green check mark.
- Compare your answers to the correct answers.

## Instructor leads debrief discussion

Raise your hand to ask a question or make a comment.



## Poll Question

Check your understanding

Which prompt belongs to the clustershell?

- a. `cluster>`
- b. `x::storage aggregate*>`
- c. `cluster#`
- d. `::cluster999>`

# Clustershell

## Use of the question mark

```
svl-nau::> storage aggregate
svl-nau::> storage aggregate> modify ?
[-aggregate] <aggregate name>                                Aggregate
[ -disktype|-T {ATA | BSAS | FCAL | FSAS | LUN | MSATA | SAS | SATA | SSD | VMDISK} ]
                                                               Disk Type
[ -free-space-realloc {on|off|no_redirect} ]   Free Space Reallocation
[ -ha-policy {sfo|cfo} ]                           HA Policy
[ -percent-snapshot-space <percent> ]           Space Reserved for Snapshot Copies
[ -space-nearly-full-threshold-percent <percent> ]
                                                               Aggregate Nearly Full Threshold Percent
[ -space-full-threshold-percent <percent> ]        Aggregate Full Threshold Percent
[ -hybrid-enabled {true|false} ]                   Hybrid Enabled
[ -force-hybrid-enabled|-f [true] ]                Force Marking of Aggregate as Hybrid Enabled
[ -maxraidsize|-s <integer> ]                    Max RAID Size
...
svl-nau::storage aggregate> modify
```

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At the command line, press the question mark (?) key to show the command directories and commands that are available at that command level.

## ACTION: Try This Task



1. In your lab kit, log in to svl-nau.
2. Enter: ?  
Is a show command available?
3. Enter: **cluster show**
  - How many nodes does the cluster have?
  - What is the status of the nodes?
4. Enter: **cluster**  
What command scope are you in?
5. Enter: ?
  - Is a show command available?
  - How do you exit to the root command scope?

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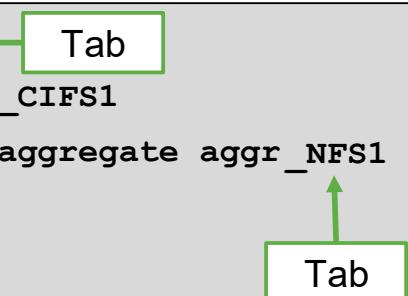
### Answers:

2. There is not a show command at this level.
- 3a. The cluster has two nodes.
- 3b. Both nodes should be healthy and eligible.
4. You are in the cluster command scope
- 5a. A show command is available.
- 5b. `top` or `..` will return you to the root of the command directory.

# Clustershell

Tab completion

```
svl-nau::storage aggregate> modify ← Tab  
aggr0_c_01 aggr0_c_02 aggr_NFS1 aggr_CIFS1  
svl-nau::storage aggregate> modify -aggregate aggr_NFS1  
-state online  
svl-nau::storage aggregate>
```



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Press the Tab key to show available directories, commands, and parameters or to automatically complete a command (or a portion of a command). You can also use the Tab key to complete nonambiguous substrings of commands, parameters, and values.

# Administrative Interfaces

## Privilege levels

```
svl-nau::> set -privilege advanced
Warning: These advanced commands are potentially dangerous;
use them only when directed to do so by NetApp personnel.
Do you want to continue? {y|n}: y
svl-nau::*> set admin
svl-nau::>
```

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The clustershell features privilege levels that force administrators to be mindful of commands that can harm the health of the storage system. The admin privilege level is used for most tasks. Advanced and diagnostic levels are reserved for more risky functions.

ONTAP provides multiple sets of commands that are based on privilege level. ONTAP offers administrative, advanced, and diagnostic levels. Use the `priv` command to set the privilege level.

The administrative level provides access to commands that are sufficient for managing your storage system. The advanced and diag levels provide access to the same administrative commands, plus additional troubleshooting and diagnostic commands.

Advanced and diag-level commands should be used only with the guidance of NetApp technical support.

# Clustershell

Scope return

```
svl-nau::storage disk option> ..
```

```
svl-nau::storage disk> top
```

```
svl-nau::>
```

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Use the `..` command to move up one level in the command hierarchy. Use the `top` command to move to the top level of the command hierarchy.

# Clustershell

## Additional features

- The search path enables you to run commands out of context:

```
sv1-nau:::system node> disk show = storage disk show
```

- Abbreviation is permitted (shortest unambiguous sequences of characters):

```
sv1-nau:::> storage aggregate create = sto a c or aggr create  
sv1-nau:::> network interface show = n i show
```

- You can run queries with patterns and wildcards:

```
sv1-nau:::> storage disk show -physical-size >500gb
```

- Use the up arrow key to review command history.

You can abbreviate commands and parameters in the clustershell if the abbreviation is unambiguous in the current context. You can also run commands out of context if the command is not available in any other context.

# OnCommand System Manager 9.0

The screenshot shows the NetApp OnCommand System Manager 9.0 interface. The top navigation bar includes links for Dashboard, LUNs, SVMs, Network, Hardware and Diagnostics, Protection, Configurations, Help, Administration, and Sign Out. The main content area is divided into several sections:

- Alerts:** Shows 0 Emergency EMS Events and 0 Health Monitor Alerts.
- Capacity:** Displays two aggregates: rpo...\_001 (7.48%) and rpo...\_002 (7.01%).
- Network Details:** Shows 2 Subnets, 3 Broadcast Domains, and 3 IP Spaces.
- Cluster:** Cluster name is rtp-nau, running NetApp Release 9.0RC1 (Wed Jun 15 12:34:39 UTC 2016). It has 1 Node and no entitlement risk.
- Disk Details:** 42 Total Disks, assigned to 28 disks (109.94 GB total). Breakdown: Spares (3.93 GB), Aggregates (78.53 GB), Root (27.48 GB).
- Selected Activities:** 0 Volume Move Operations, with a note: "No alerts for Volume Move".

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System Manager is a graphical management interface that enables you to manage storage systems and storage objects (such as disks, volumes, and aggregates) and perform management tasks that relate to storage systems. As a cluster administrator, you can use System Manager to administer the entire cluster and its resources.

System Manager is no longer available as an executable file and is now included with ONTAP as a web service, enabled by default. System Manager is accessible through a web browser. System Manager for ONTAP 9 has a slightly different layout than older versions.

System Manager enables you to perform many tasks:

- Configure and manage storage objects, such as disks, aggregates, volumes, qtrees, and quotas.
- Configure protocols, such as CIFS and NFS, and provision file sharing.
- Configure protocols such as FC, FCoE, and iSCSI, for block access.
- Create and configure network components such as subnets, broadcast domains, data and management interfaces, and interface groups.
- Set up and manage mirroring and vaulting relationships.
- Manage clusters, storage nodes, and SVMs.
- Create and configure SVMs, manage storage objects that are associated with SVMs, and manage SVM services.
- Monitor and manage HA configurations in a cluster.
- Configure SPs to remotely log in, manage, monitor, and administer the node, regardless of the state of the node.

# OnCommand System Manager 9.0

## Navigation

The screenshot shows the OnCommand System Manager 9.0 interface. At the top, there is a blue header bar with the title "NetApp OnCommand System Manager". Below the header is a navigation bar with tabs: "Dashboard" (highlighted in orange), "LUNs", "SVMs", "Network", and "Hardware and Diagnostics". To the right of the navigation bar is a vertical sidebar menu with options: "Help", "Administration", "admin", "Sign Out", "Search" (with a dropdown set to "All"), and a "Quick Resource Allocation" button. A plus sign icon is also present. The main content area is titled "cluster1" and contains sections for "Cluster Details" (selected), "Cluster Performance", "Alerts" (with a "Last 24 Hours" button), and "Capacity".

Tabs are ordered based on frequency of use by administrators.

Quick Resource Allocation

Tabs are dynamic, depending on protocols.

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System Manager has most of the same features as previous versions, with a new layout:

- The tabs are relocated from the left side to a row on the top. You do not need to navigate the Cluster, SVM, and Nodes tabs.
- Tabs are ordered by frequency of use.
- Tabs are dynamic, depending on licensed features; for example the LUN tab has been added because iSCSI was licensed.
- Quickly allocate resources by clicking the plus sign in the upper-right corner.



## References

- *ONTAP Storage Platform Mixing Rules*
- NetApp Hardware Universe: <http://hwu.netapp.com>

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# ACTION: Complete an Exercise

Module 2: Exploring ONTAP Management UIs



Duration: 30 minutes

## Access your lab equipment.

Use the login credentials that your instructor provided to you.

## Complete the specified exercises.

- Go to the exercise for the module.
- Start with Exercise 1.
- Stop at the end of Exercise 1.

## Participate in the review session.

- Share your results.
- Report issues.

## ACTION: Share Your Experiences

Roundtable questions for the equipment-based exercises



OnCommand System Manager versus clustershell:

- Which method do you prefer to use for configuring volumes?
- Which method do you prefer to use for configuring LUNs?



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Have a roundtable discussion with the class to answer these questions. You should also add any comments about experiences or “lessons learned” during the exercises that others may find helpful.

If you encounter an issue, notify your instructor immediately so that it can be resolved promptly.

## Module Review

This module focuses on enabling you to do the following:

- Define the NetApp ONTAP software terminology
- Identify supported cluster configurations
- Manage cluster nodes at the hardware level



## Module 3 Management

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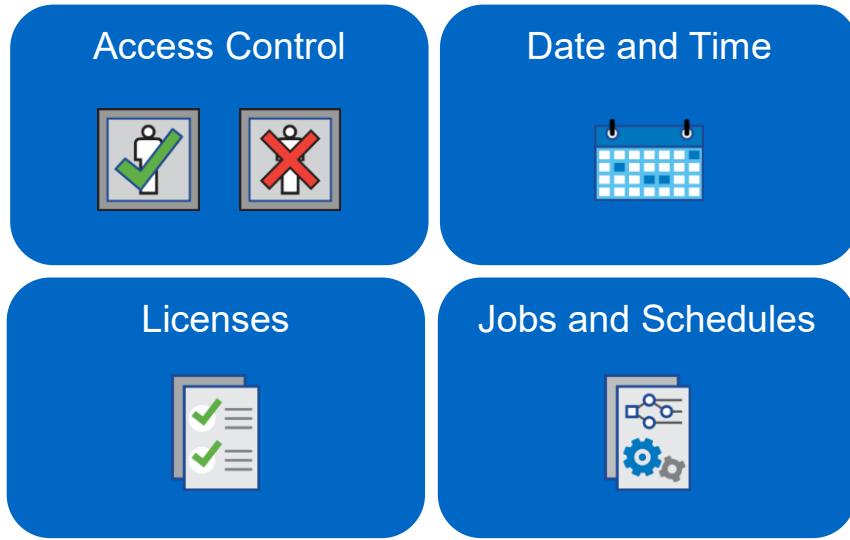
In this module, you learn how to configure key features of NetApp ONTAP software, such as role-based access control (RBAC), feature licensing, Network Time Protocol (NTP), and the AutoSupport tool. You also learn about policies and job schedules, which are used throughout this course.

## About This Module

This module focuses on enabling you to do the following:

- Manage NetApp ONTAP software administrators
- Implement cluster-level ONTAP features

# Managing Clusters



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The cluster might require initial configuration, depending on the environment. This module discusses access control, date and time, licenses, jobs, and schedules. Some of the items might already be configured if the cluster was created by using the System Setup software.



## Lesson 1

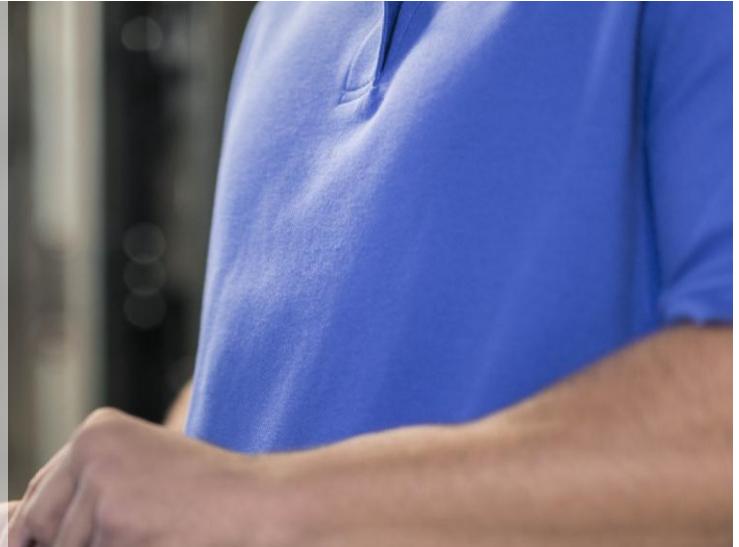
### Access Control

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# Administrators

- Tasks of cluster administrators:
  - Administer the entire cluster
  - Administer the cluster storage virtual machines (SVMs)
  - Create and delegate aggregates for SVM admin use
  - Can set up data SVMs and delegate SVM administration to SVM administrators
- Tasks of SVM administrators:
  - Administer only their own data SVMs
  - Can set up storage and network resources, such as volumes, protocols, logical interfaces (LIFs), and services



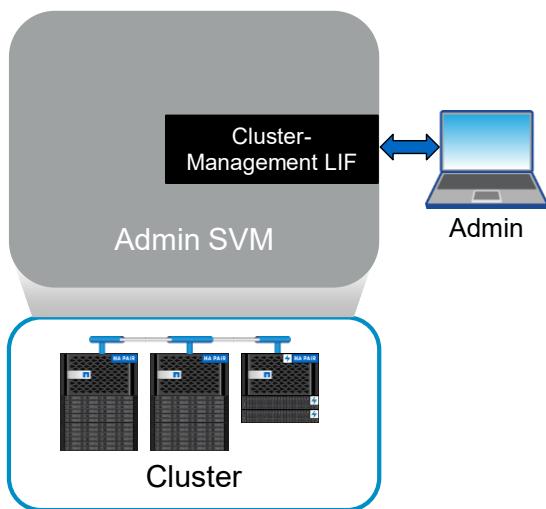
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This module focuses on cluster administration. Two types of administrators can manage a cluster.

What an SVM administrator can configure is based on how the cluster administrator has configured the SVM administrator's user account.

# Admin SVM



- Admin SVM (Cserver):
  - Automatic creation during cluster creation process
  - Representation of the cluster
  - Primary access point for administration of nodes, resources, and data SVMs
  - Not a server of data

A cluster must have at least one data SVM to serve data to its clients.

The cluster management LIF is configured to fail over to any node in the cluster.

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The admin storage virtual machine (SVM) is used to manage the cluster.

There is only one admin SVM, which represents the cluster. Through the cluster management logical interface (LIF), you can manage any node, resource, or data SVM.

Unless otherwise specified, as with the admin SVM, the term *SVM* typically refers to a data-serving SVM, which applies to both SVMs with FlexVol volumes and SVMs with Infinite Volume. Also, in the CLI, SVMs are displayed as Vservers.

## Administrative Access

- Admin: Pre-defined cluster administrator
  - Uses the CLI or NetApp OnCommand System Manager
  - Is associated with cluster or data SVMs

Administrator accounts are created with role-based access control (RBAC):  
sv1-nau::> security login



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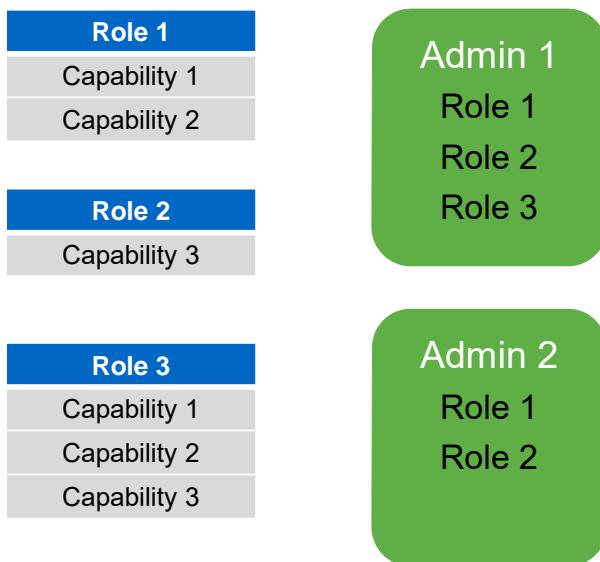
You can use the default system administration account to manage a storage system, or you can create additional administrator user accounts to manage administrative access to the storage system.

You might want to create an administrator account for the following reasons:

- You can specify administrators and groups of administrators with differing degrees of administrative access to your storage systems.
- You can limit an administrator's access to specific storage systems by providing an administrative account on only those systems.
- Creating different administrative users enables you to display information about who is performing which commands on the storage system.

# RBAC

Users, roles, and capabilities



- **Capability:**
  - Includes a command
  - Includes an access level
    - all
    - readonly
    - none
- **Role:**
  - A named set of capabilities and commands
  - Defined for cluster or SVM administration
- **User:**
  - Authenticated by the cluster
  - Authenticated for administration, not for data access
  - Created as cluster or SVM administrators

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You assign users to roles based on their responsibilities.

Each role is granted a set of rules that enable a set of capabilities, and are defined as cluster- or SVM-scoped. You can use built-in roles and create customer roles. The capabilities of the predefined roles cannot be changed.

Capabilities are a combination of a command and an access level. A command is a specific instruction or a an entire command tree. Available access levels are all, readonly, and none.

Administrators are assigned roles, and roles are assigned capabilities.

# RBAC

Predefined roles in ONTAP software

Cluster-scoped roles (Cserver):

- admin
- readonly
- None
- backup
- autosupport

```
svl-nau::> security login role show -vserver svl-nau
```

Data SVM-scoped roles:

- vsadmin
- vsadmin-volume
- vsadmin-protocol
- vsadmin-backup
- vsadmin\_READONLY

```
svl-nau::> security login role show -vserver svm_red
```

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ONTAP software includes administrative access-control roles that can be used to subdivide administration duties for SVM administration tasks.

The vsadmin role is the superuser role for an SVM. The admin role is the superuser for a cluster.

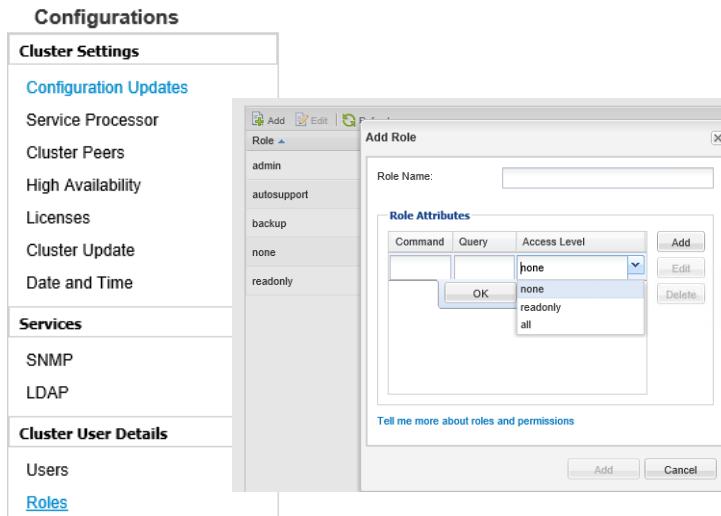
The vsadmin role grants the data SVM administrator full administrative privileges for the SVM. Additional roles include the vsadmin-protocol role, the vsadmin\_READONLY role, and the vsadmin-volume role. Each role provides a unique SVM administration privilege.

A cluster administrator with the readonly role can grant read-only capabilities. A cluster administrator with the none role cannot grant capabilities.

# RBAC

## Custom roles

- Role name
- Command directory
- Query



```
svl-nau::> security login role create...
```

```
svl-nau::> security login modify -vserver svm_red -user  
ken -role svmlvols
```

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Cluster administrators can create access-control roles to apply to cluster or SVM administrators. The roles can grant or limit authority to perform certain administrative tasks. An access-control role consists of a role name and a command or a command directory to which the role has access. The role can include an access level (none, readonly, or all) and a query that applies to the specified command or command directory. The example on the slide creates a role that is named svmlvols and that grants access to the volume commands but limits access to aggregates that start with the string “aggr7”. The role is assigned to a user who is named Ken.

After the role is created, you can apply the role to individual administrators:

```
c1::> security login modify -vserver svm1 -user ken -role svmlvols
```

```
c1::> security login role create -vserver svm1 -role svmlvols -cmddirname volume  
-query "-aggr aggr7*" -access all
```

## Active Directory Authentication for Administrators

- Fully supported Active Directory authentication functionality
- No CIFS license required

```
svl-nau::> security login create -vserver svl-nau  
-username learn\Administrator -application ssh  
-authmethod domain
```

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Active Directory authentication for cluster and SVM administrators provides a dedicated, CIFS-licensed SVM that serves as a communication tunnel to the administration server. The enhancement satisfies customers who want to use Active Directory to authenticate their storage and SVM administrators but do not need CIFS data access.

You must also create cluster user accounts for the domain users.

## Administrative Security

- Use the security login command to configure role-based administrative access to the cluster.
- Configure by application: console, HTTP, SNMP, Secure Shell (SSH), and the ONTAPI interface library.
- To enable and disable security audit logging, use the following command:

```
sv1-nau::> security audit modify -cliset on -httpset on  
-cliget on -httpget on
```

- Audited commands go to the management log.
- Nodes track local SSH and console commands in the command history log.

**NOTE:** System log access is covered later in the course.

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cliset: Permit the user to create or modify settings by using the clustershell.

cliget: Permit the user to view settings by using the clustershell.

httpset: Permit the user to create or modify settings with management tools that use HTTP.

httpget: Permit the user to view settings with management tools that use HTTP.

# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes

## Instructor begins polling session

- Questions appear in the polling panel.
- Answer each question.
- When finished, click “Submit.”

## Instructor ends polling session

- Correct answers have a green check mark.
- Compare your answers to the correct answers.

## Instructor leads debrief discussion

Raise your hand to ask a question or make a comment.



## Poll Question

Check your understanding

The admin SVM is created to manage the cluster and serve data to the cluster administrators.

- a. True
- b. False

## ACTION: Topic for Discussion



How might multitenancy affect the way that you use RBAC?





## Lesson 2

### Date and Time

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# Date and Time

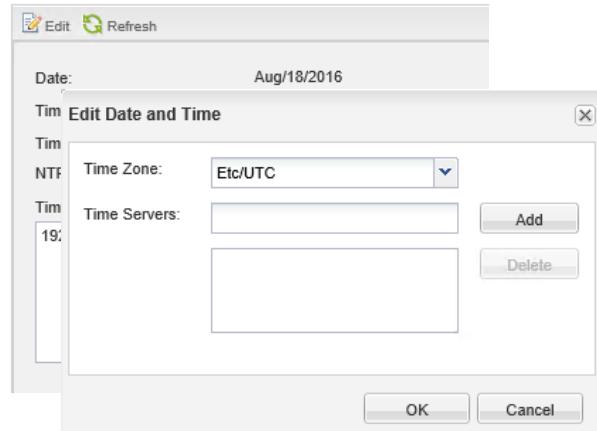
Ways to configure date and time:

- Manually: using CLI
- Automatically: using Network Time Protocol (NTP) servers

After you add an NTP server, the nodes require time to synchronize.

Configurations

<b>Cluster Settings</b>
Configuration Updates
Service Processor
Cluster Peers
High Availability
Licenses
Cluster Update
<b>Date and Time</b>
<b>Services</b>
SNMP
LDAP



```
svl-nau::> cluster time-service ntp server create -server xx.xx.xx.xx  
svl-nau::> date
```

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Problems can occur when the cluster time is inaccurate. ONTAP software enables you to manually set the time zone, date, and time on the cluster. However, you should configure the NTP servers to synchronize the cluster time.

To configure the date and time, in NetApp OnCommand System Manager, on the cluster's system tools Configurations tab, click the **Date and Time** link. Click **Edit**, select the time zone from the Time Zone list, enter the NTP address in the Time Servers field, and then click **Add**.

Adding the NTP server automatically configures all the nodes in the cluster, but each node needs to synchronize individually. The synchronization for all the nodes in the cluster might require a few minutes.

# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes

## Instructor begins polling session

- Questions appear in the polling panel.
- Answer each question.
- When finished, click “Submit.”

## Instructor ends polling session

- Correct answers have a green check mark.
- Compare your answers to the correct answers.

## Instructor leads debrief discussion

Raise your hand to ask a question or make a comment.



## Poll Question

Check your understanding

Which function or functions rely on NTP?

- a. log file review
- b. troubleshooting
- c. setting up SMB
- d. all of the above



## Lesson 3

### Licenses

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## NetApp Licensing Model

- Proof of sale is recorded as a license entitlement record.
- Standard licenses are linked to the controller serial number in Data ONTAP 8.2 and later.
- Features are licensed on every node.
- License keys are 28 characters long.



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A license is a record of one or more software entitlements. License keys, also known as license codes, enable you to use certain features or services on your cluster. Each cluster requires a cluster base license key, which you can install either during or after the cluster setup. Some features require additional licenses. ONTAP feature licenses are issued as packages, each of which contains one or more features. A package requires a license key, and installing the key enables you to access all features in the package. ONTAP prevents you from installing a feature license before a cluster base license key is installed.

## License Types

- Standard license:
  - Locked to a node
  - Feature functions with one licensed node if a licensed node is running
- Site license:
  - Single license that enables the feature on the entire cluster
  - Not carried with nodes that are removed from the cluster
- Evaluation license:
  - Also known as a demo license
  - Temporary license with an expiration date
  - Clusterwide and not locked to a node



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- **Standard license:** A standard license is issued for a node with a specific system serial number and is valid only for the node that has the matching serial number. Installing a standard, node-locked license entitles a node, but not the entire cluster, to the licensed functionality. For the cluster to be enabled, though not entitled, to use the licensed functionality, at least one node must be licensed for the functionality. However, if only one node in a cluster is licensed for a feature, and that node fails, then the feature no longer functions on the rest of the cluster until the licensed node is restarted.
- **Site license:** A site license is not tied to a specific system serial number. When you install a site license, all nodes in the cluster are entitled to the licensed functionality. The `system license show` command displays site licenses under the cluster serial number. If your cluster has a site license and you remove a node from the cluster, the node does not carry the site license with it, and that node is no longer entitled to the licensed functionality. If you add a node to a cluster that has a site license, the node is automatically entitled to the functionality that the site license grants.
- **Evaluation license:** An evaluation license enables you to try certain software functionality without purchasing an entitlement. If your cluster has an evaluation license for a package and you remove a node from the cluster, the node does not carry the evaluation license.

# License Commands

The screenshot shows the ONTAP Cluster Administration interface. On the left, there's a sidebar with 'Configurations' and 'Cluster Settings' sections. The 'Licenses' section is highlighted. In the center, there's a 'Packages' tab showing a list of licenses: Cluster Base License, NFS License, CIFS License, iSCSI License, and SnapRestore License. A modal window titled 'Add License Packages' is open, containing a text input field and a note: 'For more than one license keys use comma(,) as delimiter.' Below the interface, a command-line help output for 'license ?' is shown:

```
rtp-nau::> license ?
  (system license)
  add                         Add one or more licenses
  capacity>                  The capacity directory
  clean-up                     Remove unnecessary licenses
  delete                       Delete a license
  entitlement-risk>          The entitlement-risk directory
  show                         Display licenses
  status>                     Display license status
```

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ONTAP enables you to manage feature licenses in the following ways:

- Add one or more license keys.
- Display information about installed licenses.
- Display the packages that require licenses and the current license status of the packages on the cluster.
- Delete a license from a cluster or from a node whose serial number you specify.  
**NOTE:** The cluster base license is required for the cluster to operate. ONTAP does not enable you to delete the license.
- Display or remove expired or unused licenses.

# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes

## Instructor begins polling session

- Questions appear in the polling panel.
- Answer each question.
- When finished, click “Submit.”

## Instructor ends polling session

- Correct answers have a green check mark.
- Compare your answers to the correct answers.

## Instructor leads debrief discussion

Raise your hand to ask a question or make a comment.



## Poll Question

Check your understanding

Which two statements about standard license keys are true? (Choose two.)

- a. They are node-locked.
- b. They are 28 characters long.
- c. They require only one license code per cluster per feature.
- d. They must be refreshed monthly.



## Lesson 4

### Policies, Jobs, and Schedules

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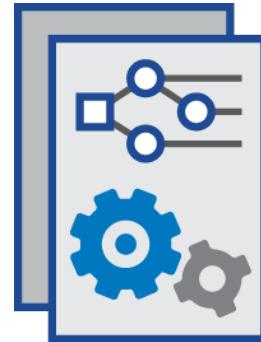
# Policy-Based Storage Services

Policy:

- A collection of rules that the cluster or SVM administrator creates and manages
- Predefined or created to manage data access

Policy examples:

- Firewall and security
- Export, quota, file, and data
- Snapshot and SnapMirror
- Quality of service (QoS)



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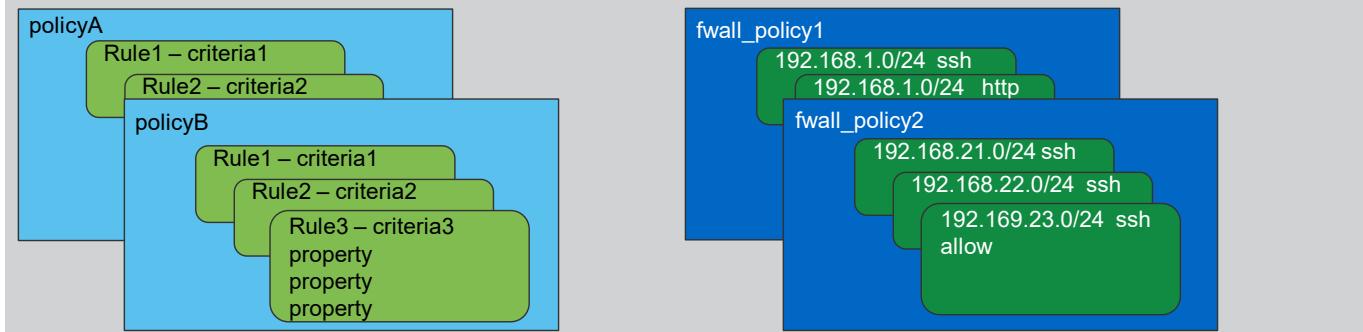
27

The following services are policy-based:

- Firewall
- System health
- SnapMirror
- Volume efficiency
- Volume FlexCache
- Volume quota
- Volume Snapshot
- SVM CIFS group
- SVM data
- SVM export
- SVM FPolicy
- SVM security file directory
- Quality of service (QoS) policy group
- Failover

# Policy-Based Management

- Assign a policy to a service or resource.
- A rule criteria in the policy matches the service or resource.
- The matching rule properties apply to the service or resource.
- The example is a firewall to permit or deny access to a protocol for specific IP address ranges.



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SVMs use policy-based management for many resources. A policy is a collection of rules or properties that the cluster administrator or SVM administrator create and manage. Policies are predefined as defaults or created to manage various resources. By default, a policy applies to the current resources and to newly created resources, unless otherwise specified.

For example, Snapshot policies can be used to schedule automatic controller-based Snapshot copies. The policy includes such things as the schedule or schedules to use and how many copies to retain. When a volume is created for the SVM, the policy is applied automatically but can be modified later.

The efficiency policy is used to schedule postprocess deduplication operations. The policy might include when and how long deduplication runs.

The examples are only two of the policies that you encounter in ONTAP. The advantage of policy-based management is that when you create a policy you can apply the policy to any appropriate resource, either automatically or manually. Without policy-based management, you would need to enter the settings separately for each individual resource.

## Jobs

- Asynchronous tasks
- Managed by the Job Manager
- Long-running operations
- In a job queue

The screenshot shows the 'Job' page in the NetApp OnCommand System Manager. The top navigation bar includes 'Dashboard', 'LUNs', 'SVMs', 'Network', 'Hardware and Diagnostics', and 'Protection'. The 'Hardware and Diagnostics' tab is selected. Below the navigation is a 'Job' section with tabs for 'Current Jobs' and 'Job History'. A 'Refresh' button is available. A table lists six jobs:

Job ID	Start Time	Job Name	Node	Status
1	10/20/2015 23:54:57	SnapMirror Servic...	cluster1-01	Dormant
4	11/04/2015 00:00:00	Certificate Expiry...		Queued
5	11/03/2015 18:15:04	CLUSTER BACK...		Queued
6	11/03/2015 00:10:05	CLUSTER BACK...		Queued

```
rtp-nau::> job show
          Owning
Job ID Name           Vserver   Node      State
----- -----
2     Vol Reaper       rtp-nau   -        Queued
      Description: Vol Reaper Job
6     SnapMirror Service Job rtp-nau   rtp-nau-01  Dormant
      Description: SnapMirror Service Job
```

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A job is any asynchronous task that Job Manager manages. Jobs are typically long-running volume operations such as copy, move, and mirror. Jobs are placed in a job queue. Jobs run in the background when resources are available. If a job consumes too many cluster resources, you can stop or pause the job until there is less demand on the cluster. You can also monitor, view the history of, and restart jobs.

# Schedules

## Schedules for tasks:

- Time-based schedules, which run at specific times (similar to UNIX cron schedules)
- Interval-based schedules, which run at intervals

```
rtp-nau::> job schedule show

Name          Type        Description
-----
5min         cron        @:00,:05,:10,:15,:20,:25,:30,:35
8hour        cron        @2:15,10:15,18:15
Auto Balance Aggregate Scheduler  interval Every 1h
RepositoryBalanceMonitorJobSchedule  interval Every 10m
daily         cron        @0:10
hourly        cron        @:05
weekly        cron        Sun@0:15
```

The screenshot shows the 'Schedules' page in System Manager. At the top, there are buttons for Create, Edit, Delete, and Refresh. Below is a table with columns for Name and Type. The table lists several scheduled tasks:

Name	Type
5min	Time based
8hour	Time based
Auto Balance Aggregate Scheduler	Interval based
daily	Time based
hourly	Time based
RepositoryBalanceMonitorJobSchedule	Interval based
weekly	Time based

Below the table is a 'Details:' section with the following settings:

- Runs at: Every hour
- Hours: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50 and 55th minute

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Many tasks, such as volume Snapshot copies, can be configured to run on specified schedules. Schedules that run at specific times are called cron schedules. The schedules are similar to UNIX cron schedules. Schedules that run at intervals are called interval schedules.

To manage schedules in System Manager, on the cluster Configuration tab, click the **Schedules** link. You can create, edit, or delete schedules.

## References

- *ONTAP System Administration Guide for Cluster Administrators*
- *ONTAP Software Setup Guide*
- TR4368: Role-Based Access Control for ONTAP



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# ACTION: Complete an Exercise

Module 3: Managing ONTAP Clusters and Administrators



Duration: 30 minutes

## Access your lab equipment.

Use the login credentials that your instructor provided to you.

## Complete the specified exercises.

- Go to the exercise for the module.
- Start with Exercise 1.
- Stop at the end of Exercise 1.

## Participate in the review session.

- Share your results.
- Report issues.

## ACTION: Share Your Experiences

Roundtable questions for the equipment-based exercises



- How did the cluster behave after you specified the NTP server?
- Did the time synchronize immediately?



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Have a roundtable discussion with the class to answer these questions. You should also add any comments about experiences or “lessons learned” during the exercises that others may find helpful.

If you encounter an issue, notify your instructor immediately so that it can be resolved promptly.

## Module Review

This module focused on enabling you to do the following:

- Manage NetApp ONTAP software administrators
- Implement cluster-level ONTAP features



## Module 4

# Network Management

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## About This Module

This module focuses on enabling you to do the following:

- Describe the interaction between physical and virtual network resources in a cluster
- Configure and manage physical and virtual networking resources



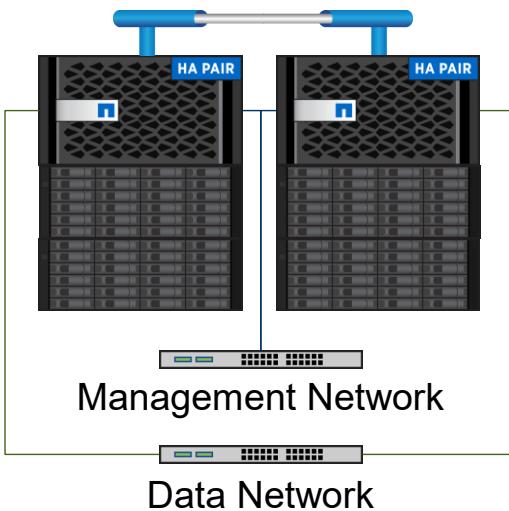
## Lesson 1

### NetApp ONTAP Network Review

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# ONTAP Network Types



- Cluster interconnect:
  - Connection of nodes
  - Private network
- Management network:
  - Cluster administration
  - Management and data may be on a shared Ethernet network
- Data network:
  - One or more networks that are used for data access from clients or hosts
  - Ethernet, FC, or converged network

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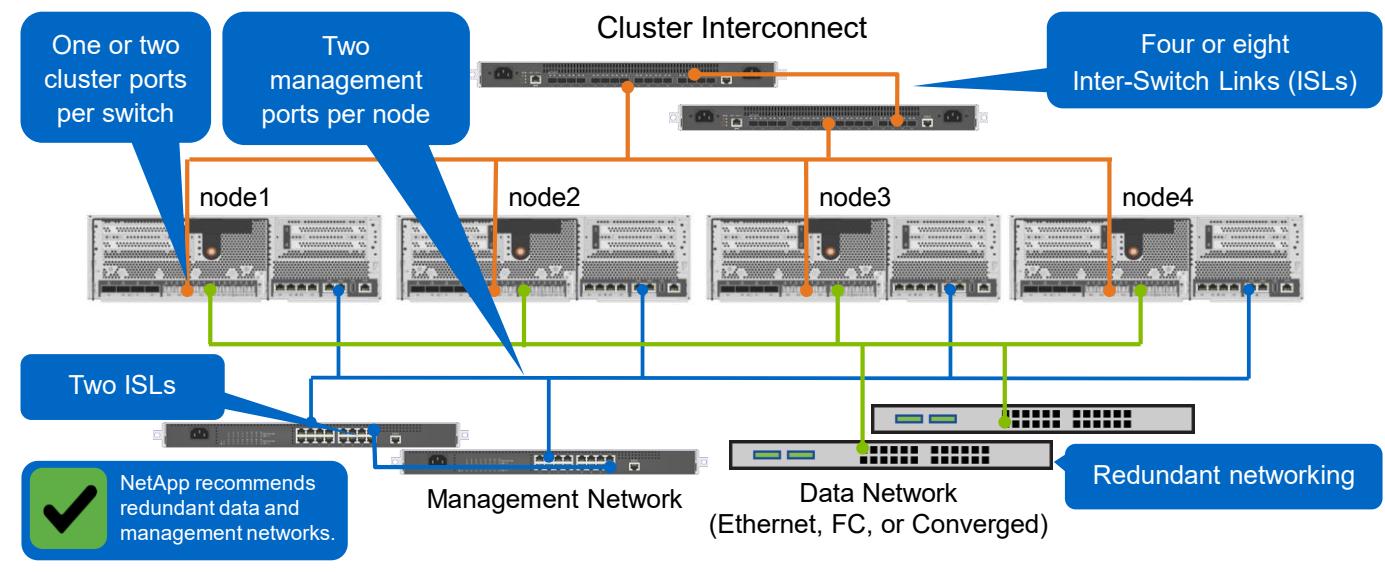
4

In multinode clusters, nodes need to communicate with each other over a cluster interconnect. In a two-node cluster, the interconnect can be switchless. When you add more than two nodes to a cluster, a private cluster interconnect using switches is required.

The management network is used for cluster administration. Redundant connections to the management ports on each node and management ports on each cluster switch should be provided to the management network. In smaller environments, the management and data networks may be on a shared Ethernet network.

For clients and host to access data, a data network is also required. The data network can be composed of one or more networks. Depending on the environment, the network might be an Ethernet, FC, or converged network. Data networks can consist of one or more switches or redundant networks.

# Networks



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A NetApp ONTAP software cluster is essentially a cluster of high-availability (HA) pairs. Therefore, you need a cluster network, or cluster interconnect, for all the nodes to communicate with one another. Keep the following principle in mind: If a node cannot see the cluster interconnect, then the node is not part of the cluster. Therefore, the cluster interconnect requires adequate bandwidth and resiliency.

The figure shows a four-node cluster and three distinct networks. ONTAP software requires both data and management connectivity, which can coexist on the same data network.

In multinode configurations, ONTAP software also requires a cluster interconnect for cluster traffic. In a two-node configuration, the cluster interconnect can be as simple as cabling the two nodes or using switches if expansion is desired. In clusters of more than two nodes, switches are required. Single-node clusters do not require a cluster interconnect if the environment does not require high availability and nondisruptive operations (NDO).



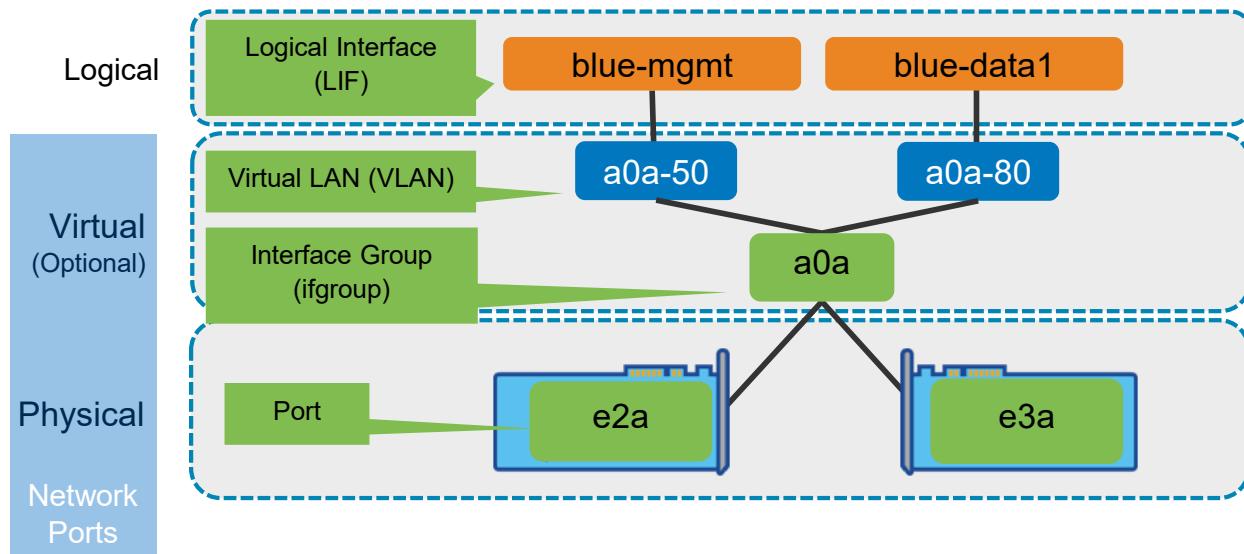
## Lesson 2

### Network Ports

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# ONTAP Networking



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Nodes have physical ports that are available for cluster traffic, management traffic, and data traffic. The ports need to be configured appropriately for the environment. The example shows Ethernet ports. Physical ports also include FC ports and Unified Target Adapter (UTA) ports.

Physical Ethernet ports can be used directly or combined by using interface groups (ifgroups). Also, physical Ethernet ports and ifgroups can be segmented by using virtual LANs (VLANs). VLANs and ifgroups are considered virtual ports but are treated like physical ports.

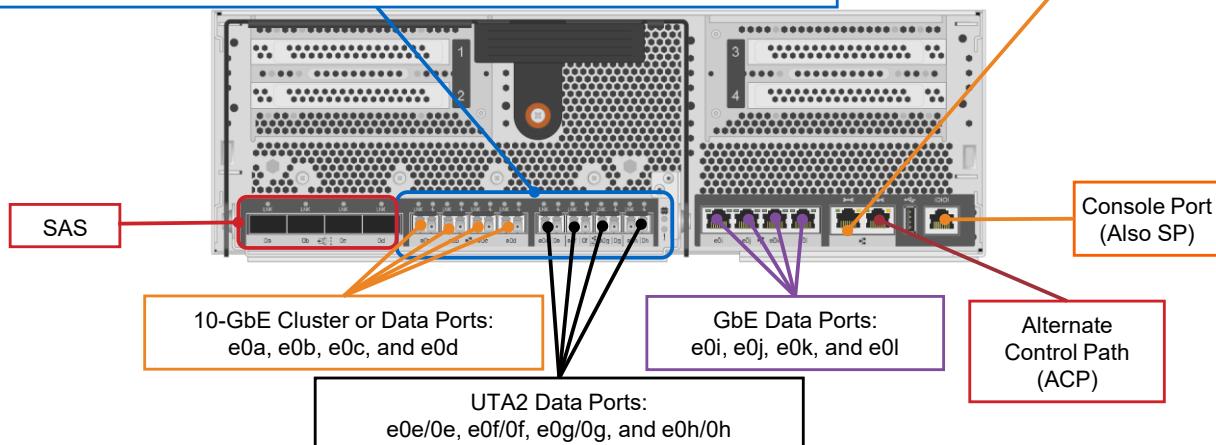
Unless specified, the term *network port* includes physical ports, ifgroups, and VLANs.

# Physical Ports Example

FAS8040 and FAS8060

10-Gigabit Ethernet (10-GbE) and Unified Target Adapter 2 (UTA2) ports use either Twinax copper (Cu) or optical (LC) cables, depending on the personality and type of small form-factor pluggable (SFP) module.

Management Port:  
e0M or Service Processor (SP)



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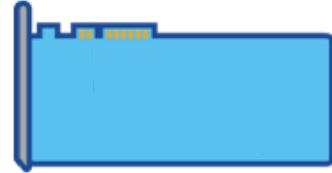
8

FAS8040 and FAS8060 systems contain the following network ports:

- 4 x 10-GbE ports for cluster interconnects
  - Supported: Two cluster interconnects (e0a and e0c) and two data (e0b and e0d) ports
  - Recommended: Four cluster interconnects (switched clusters only)
- 4x Unified Target Adapter 2 (UTA2) ports that can be configured as either 10-GbE or 16-Gbps FC for data
  - Can be used only for data (not cluster interconnects)
  - Port pairs must be set the same:
    - e0e/0e and e0f/0f, and e0g/0g and e0h/0h, are port pairs.
    - Choose from FC enhanced small-form factor pluggable (SFP+), 10-GbE SFP+, or Twinax Ethernet.
    - Set port mode command is ucadmin.
    - 4x GbE ports for data
- 1x management port (default for node-management network)
  - e0M runs at GbE.
  - SP runs at 10/100.
- 1x private management port that is used as an alternate control path (ACP) for SAS shelves
- 1x console port that can be configured for Service Processor (SP)
  - To toggle from serial console into SP, press **Ctrl+G**.
  - To toggle back, press **Ctrl+D**.

# Physical Port Identification

- Ethernet ports are named e<location><letter>:
  - e0a is the first port on the controller motherboard.
  - e3a is a port on a card in slot 3.
- FC ports are named <location><letter>:
  - 0a is the first port on the controller motherboard.
  - 3a is a port on a card in slot 3.
- UTA ports have both an Ethernet name and an FC name, e<location><letter>/<location><letter>:
  - e0e/0e is the first port on the controller motherboard.
  - e3a/3a is a port on a card in slot 3.
- Use of show commands returns only FC label names (even in Ethernet mode).



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Port names consist of two or three characters that describe the port type and location. You must be aware of certain port-naming conventions on the network interfaces.

**Ethernet ports:** The first character describes the port type and is always `e` to represent Ethernet. The second character is a numeral that identifies the slot in which the port adapter is located; the numeral 0 (zero) indicates that the port is on the node's motherboard. The third character indicates the port position on a multiport adapter. For example, the port name `e0b` indicates the second Ethernet port on the motherboard, and the port name `e3a` indicates the first Ethernet port on an adapter in slot 3.

**FC ports:** The name consists of two characters (dropping the `e`) but otherwise follows the same naming convention as Ethernet ports. For example, the port name `0b` indicates the second FC port on the motherboard, and the port name `3a` indicates the first FC port on an adapter in slot 3.

**UTA ports:** A UTA port is physically one port but can pass either Ethernet traffic or FC traffic. Therefore, UTA ports are labeled with both the Ethernet name and the FC name. For example, the port name `e0b/0b` indicates the second UTA port on the motherboard, and the port name `e3a/3a` indicates the first UTA port on an adapter in slot 3.

**NOTE:** UTA adapter ports are listed by the only FC label name when you use the `ucadmin` command, even when the personality is configured as 10-GbE.

## ACTION: Try This Task



Using cluster svl-nau on your lab kit, use the `net port show` command.

1. Which ports do you see?
2. In which slots are the adapters attached?

1. e0a, e0b, e0c, e0d, e0e, and e0f.
2. According to the naming convention for Ethernet ports, they are all in slot 0 which means they are internal ports.

# Modifying Network Port Attributes

Set UTA2 port personality

First remove any LIFs and take the port offline.

```
rtp-nau::> system node hardware unified-connect modify  
      -node rtp-nau-01 -adaptor 0e  
      -mode fc|cna  
rtp-nau::> system node reboot -node rtp-nau-01
```



Insert the proper optical module before changing modes.

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UTA ports are managed in a similar way and require a reboot to take effect. The adapter must also be offline before any changes can be made.

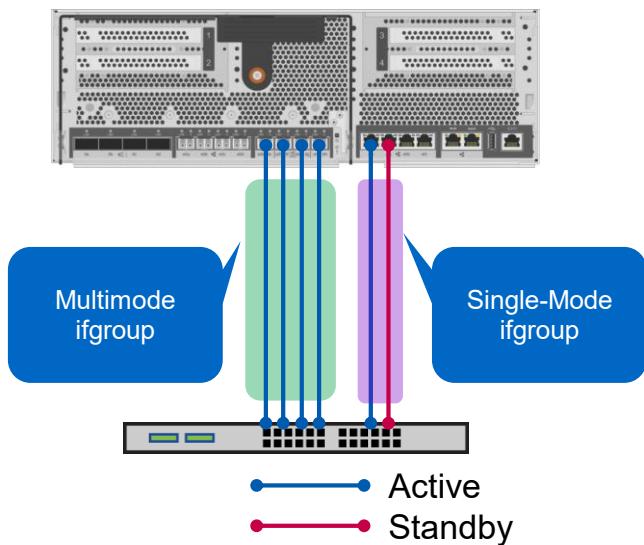
- When the adapter type is initiator, use the `run local storage disable adapter` command to bring the adapter offline.
- When the adapter type is target, use the `network fcp adapter modify` command to bring the adapter offline.

For more information about configuring FC ports, refer to the *ONTAP SAN Administration Guide* for your release, or attend the NetApp University SAN Implementation course.

# ifgroups

- Combine one or more Ethernet interfaces
- Three ifgroup modes:
  - Single-mode (active-standby)
  - Static multimode (active-active)
  - Dynamic multimode using Link Aggregation Control Protocol (LACP)
- Naming syntax: a<number><letter> (for example, a0a)

**NOTE:** Vendors might use other terms for combining Ethernet interfaces.



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An ifgroup combines one or more Ethernet interfaces, which can be implemented in one of three ways.

In single-mode, one interface is active and the other interfaces are inactive until the active link goes down. The standby paths are used only during a link failover.

In static multimode, all links are active. Therefore, static multimode provides link failover and load-balancing features. Static multimode complies with the IEEE 802.3ad (static) standard and works with any switch that supports the combination of Ethernet interfaces. However, static multimode does not have control packet exchange.

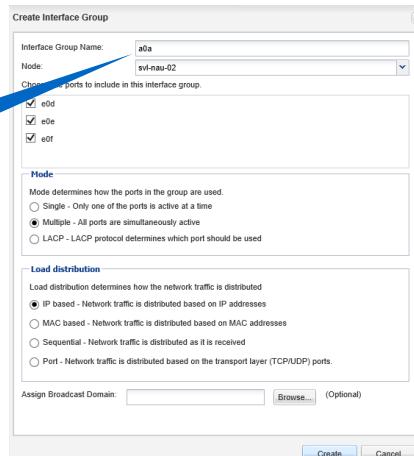
Dynamic multimode is similar to static multimode but complies with the IEEE 802.3ad (dynamic) standard. When switches that support Link Aggregation Control Protocol (LACP) are used, the switch can detect a loss of link status and dynamically route data. NetApp recommends that when you configure ifgroups, you use dynamic multimode with LACP and compliant switches.

All modes support the same number of interfaces per ifgroup, but the interfaces in the group should always be the same speed and type. The naming syntax for interface groups is the letter “a”, followed by a number, followed by a letter; for example, a0a.

Vendors might use terms such as link aggregation, port aggregation, trunking, bundling, bonding, teaming, or EtherChannel.

# Creating ifgroups

Name of ifgroup must be in  
a<number><letter> format.



```
rtp-nau::> network port ifgrp create -node rtp-nau-01 -ifgrp a0a  
-distr-func ip -mode multimode
```

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You can create ifgroups for higher throughput, fault tolerance, and elimination of single points of failure (SPOFs).

Manage ifgroups in a similar way, with the exception of the following:

- You must name ifgroups by using the syntax a<number><letter>.
- You cannot add a port that is already a member of one ifgroup to another ifgroup.
- Multimode load-balancing methods include the following:
  - **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.
  - **port:** Network traffic is distributed on the basis of the transport layer (TCP/UDP) ports.

For more information about load balancing, please refer to TR-4182: *Ethernet Storage Best Practices for ONTAP Configurations*.

# ifgroup Considerations

- Because of the limited capabilities of single mode, you should not use a single-mode ifgroup in ONTAP software.
- Use dynamic multimode (LACP) when you use ifgroups, to take advantage of performance and resiliency functionality:
  - An LACP-enabled switch is required.
  - All the interfaces in the group are active, share the same MAC address, and use load-balancing for outbound (not inbound) traffic.
  - A single host does not achieve larger bandwidth than any of the constituent connection (two 10-GbE does not equal one 20-GbE).
  - Dynamic multimode might not have any advantages for iSCSI hosts.

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You can configure ifgroups to add a layer of redundancy and functionality to an ONTAP software environment. You can also use ifgroups with a failover group to help protect against Layer 2 and Layer 3 Ethernet failures.

A **single-mode ifgroup** is an active-passive configuration (one port sits idle, waiting for the active port to fail) and cannot aggregate bandwidth. NetApp advises against using the single-mode type of ifgroup. To achieve the same level of redundancy, you can use failover groups or one of the two multimode methods.

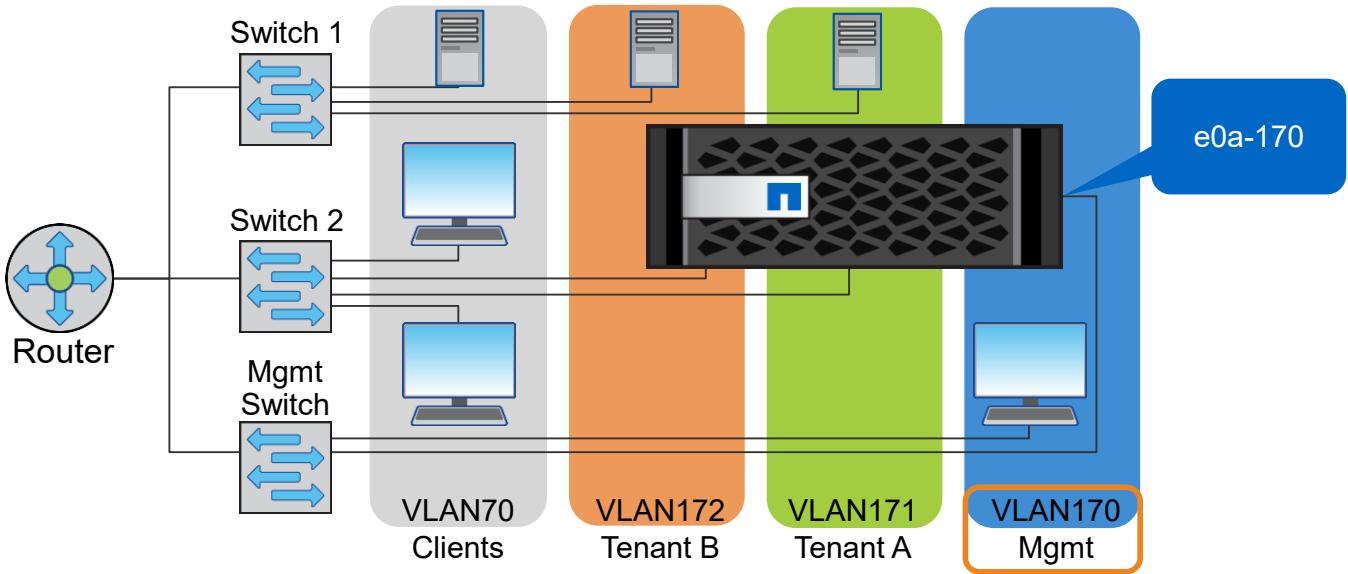
You might use a **static multimode ifgroup** if you want to use all the ports in the group to simultaneously service connections. Static multimode does differ from the type of aggregation that happens in a dynamic multimode ifgroup, in that no negotiation or automatic detection happens within the group in regard to the ports. A port sends data when the node detects a link, regardless of the state of the connecting port on the switch side.

You might use a **dynamic multimode ifgroup** to aggregate bandwidth of more than one port. LACP monitors the ports on an ongoing basis to determine the aggregation capability of the various ports and continuously provides the maximum level of aggregation capability achievable between a given pair of devices. However, all the interfaces in the group are active, share the same MAC address, and load-balance outbound traffic. A single host does not necessarily achieve larger bandwidth, exceeding the capabilities of any constituent connections. For example, adding four 10-GbE ports to a dynamic multimode ifgroup does not result in one 40-GbE link for one host. The situation is because of the way that both the switch and the node manage the aggregation of the ports in the ifgroup. A recommended best practice is to use the dynamic multimode type of ifgroup so that you can take advantage of all the performance and resiliency functionality that the ifgroup algorithm offers.

You can use two methods to achieve path redundancy when using iSCSI in ONTAP software: by using ifgroups or by configuring hosts to use multipath I/O over multiple distinct physical links. Because multipath I/O is required, ifgroups might have little value.

For more information, refer to TR-4182: *Ethernet Storage Best Practices for ONTAP Configurations*.

## VLANs

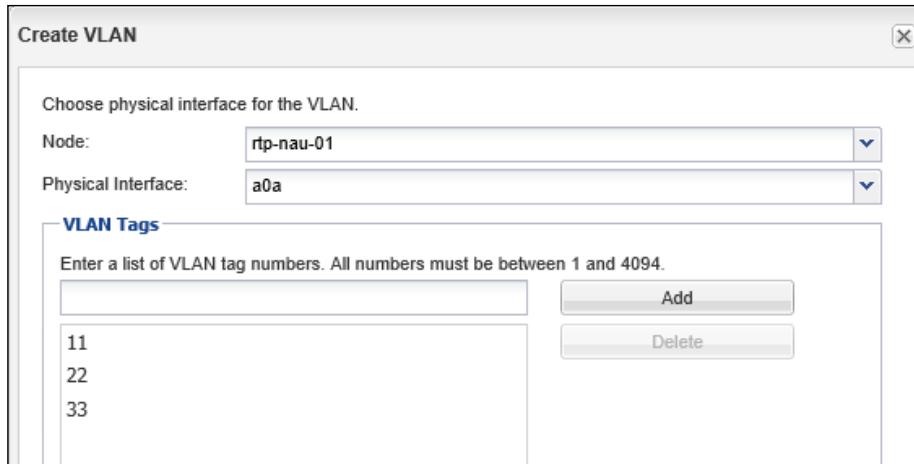


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A port or ifgroup can be subdivided into multiple VLANs. Each VLAN has a unique tag that is communicated in the header of every packet. The switch must be configured to support VLANs and the tags that are in use. In ONTAP software, a VLAN ID is configured into the name. For example, VLAN e0a-70 is a VLAN with tag 70 configured on physical port e0a. VLANs that share a base port can belong to the same or different IP spaces, and the base port can be in a different IP space than the VLANs that share the base port.

# Creating VLANs



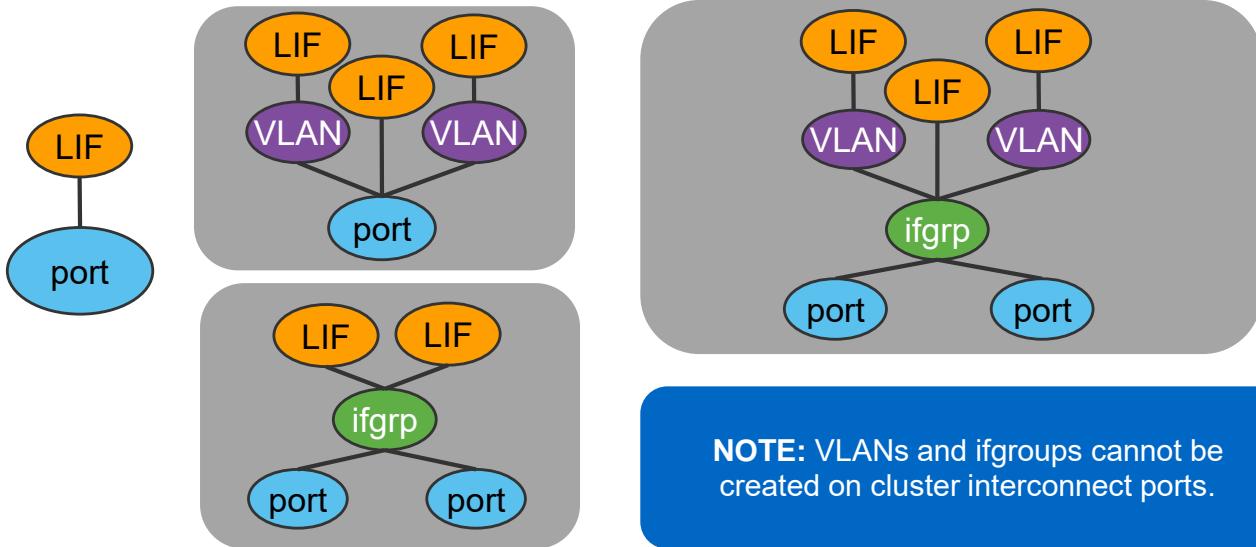
```
rtp-svl::> network port vlan create -node rtp-nau-01 -vlan-name a0a-11
```

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You can create a VLAN for ease of administration, confinement of broadcast domains, reduced network traffic, and enforcement of security policies.

# Ports, ifgroups, and VLANs



**NOTE:** VLANs and ifgroups cannot be created on cluster interconnect ports.

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Most small to medium environments and FC environments use physical ports.

Ethernet environments in which multiple physical networks are impossible often use VLANs to separate management traffic from data traffic. VLANs are also often used to separate differing workloads. For example, you might separate NAS traffic from iSCSI traffic for performance and security reasons.

In Ethernet environments where many application servers or hosts are sharing switches and ports, dynamic multimode ifgroups of four Ethernet ports per node are commonly used for load balancing.

Environments that use ifgroups typically use VLANs also, for segmentation of the network. The segmentation is typical for service providers with multiple clients that require the bandwidth that ifgroups provide and the security that VLANs provide.

And lastly, it is not uncommon for different types of ports to be used in mixed environments that have various workloads. For example, an environment might use ifgroups with VLANs that are dedicated to NAS protocols, a VLAN that is dedicated to management traffic, and physical ports for FC traffic.

ifgroups and VLANs cannot be created on cluster interconnect ports.

# ACTION: Complete an Exercise

Module 4: Managing Physical and Logical Network Resources



Duration: 20 minutes

## Access your lab equipment.

Use the login credentials that your instructor provided to you.

## Complete the specified exercises.

- Go to the exercise for the module.
- Start with Exercise 1.
- Stop at the end of Exercise 1.

## Participate in the review session.

- Share your results.
- Report issues.

## Share Your Experiences

Roundtable questions for the equipment-based exercises



Did you anticipate the failure of the ifgroup before you removed ports e0a and e0b from the broadcast domain?





## Lesson 3

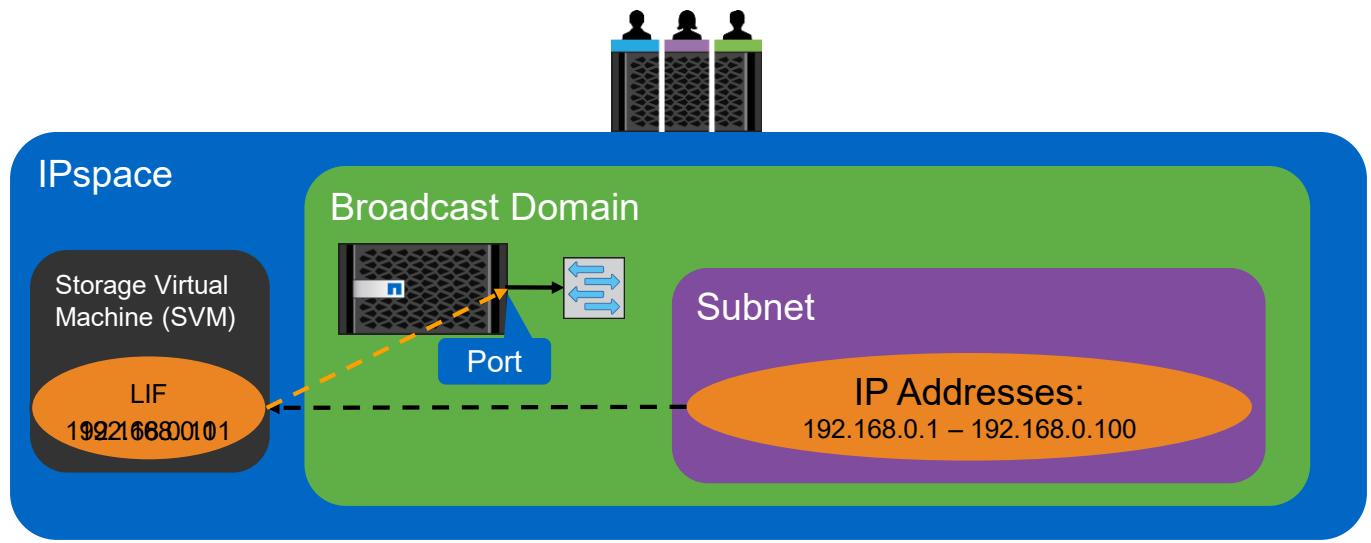
### IPspaces

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IPspaces were introduced to ONTAP in Data ONTAP 8.3.

# IPspace Review



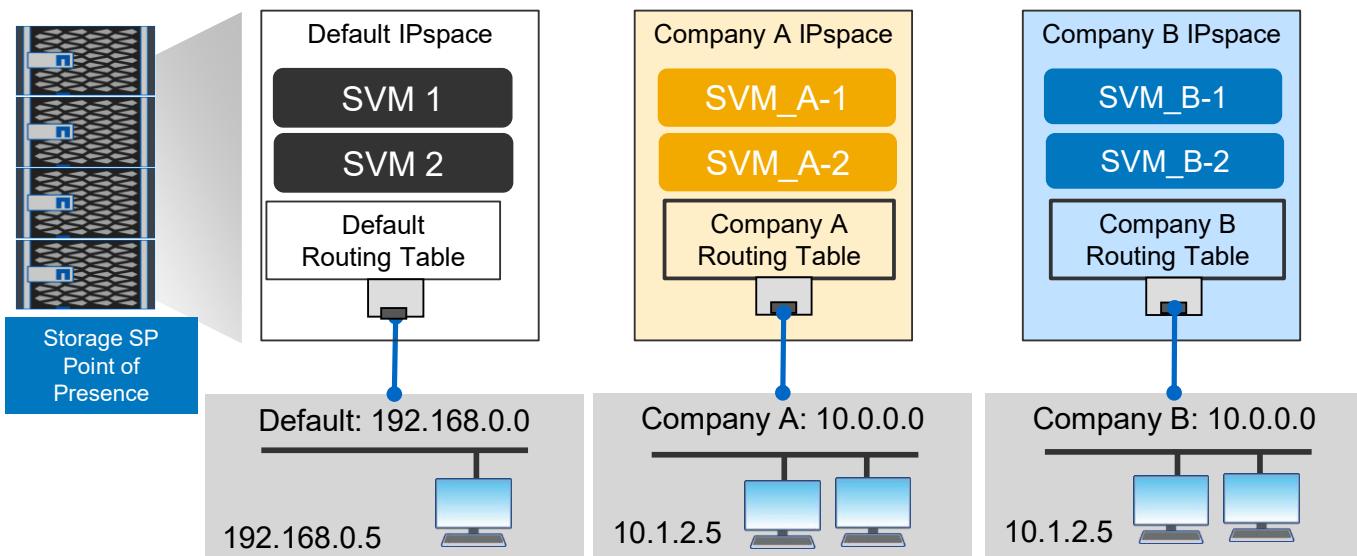
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ONTAP software has a set of features that work together to enable multitenancy. An IPspace is a logical container that is used to create administratively separate network domains. An IPspace defines a distinct IP address space that contains storage virtual machines (SVMs). The IPspace contains a broadcast domain, which enables you to group network ports that belong to the same Layer 2 network. The broadcast domain contains a subnet, which enables you to allocate a pool of IP addresses for your ONTAP network configuration.

When you create a logical interface (LIF) on the SVM, the LIF represents a network access point to the node. You can manually assign the IP address for the LIF. If a subnet is specified, the IP address is automatically assigned from the pool of addresses in the subnet, much like the way a Dynamic Host Configuration Protocol (DHCP) server assigns IP addresses.

# IPspaces



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The IPspace feature enables clients from more than one disconnected network to access a storage system or cluster, even if the clients use the same IP address.

An IPspace defines a distinct IP address space in which virtual storage systems can participate. IP addresses that are defined for an IPspace are applicable only within the IPspace. A distinct routing table is maintained for each IPspace. No cross-IPspace traffic routing occurs. Each IPspace has a unique assigned loopback interface. The loopback traffic on each IPspace is isolated from the loopback traffic on other IPspaces.

## Example

A storage SP needs to connect customers of companies A and B to a storage system on the storage SP premises. The storage SP creates SVMs on the cluster—one per customer—and provides a dedicated network path from one SVM to A's network and one from the other SVM to B's network.

The deployment should work if both companies use nonprivate IP address ranges. However, because the companies use the same private addresses, the SVMs on the cluster at the storage SP location have conflicting IP addresses.

To overcome the problem, two IPspaces are defined on the cluster—one per company. Because a distinct routing table is maintained for each IPspace, and no cross-IPspace traffic is routed, the data for each company is securely routed to the respective network, even if the two SVMs are configured in the 10.0.0.0 address space.

Also, the IP addresses that various configuration files (the /etc/hosts file, the /etc/hosts.equiv file, the /etc/rc file, and so on) refer to are relative to the IPspace. Therefore, the IPspaces enable the storage SP to use the same IP address for the configuration and authentication data for both SVMs, without conflict.

# Managing IPspaces

- You can create IPspaces when you need your SVMs to have distinct, secure storage, administration, and routing:

```
rtp-nau::> network ipspace create -ipspace IPspace_A
```



- IPspaces can be renamed and deleted:

```
rtp-nau::> network ipspace rename -ipspace IPspace_A -new-name  
IPspace_C
```



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IPspaces are distinct IP address spaces in which SVMs reside. All IPspace names must be unique within a cluster.

- If required, you can change the name of an existing IPspace (except for the two system-created IPspaces) by using the `network ipspace rename` command.
- If you no longer need an IPspace, you can delete it by using the `network ipspace delete` command.

**NOTE:** No broadcast domains, network interfaces, or SVMs can be associated with an IPspace that you want to delete. You cannot delete the system-defined Default and Cluster IPspaces.

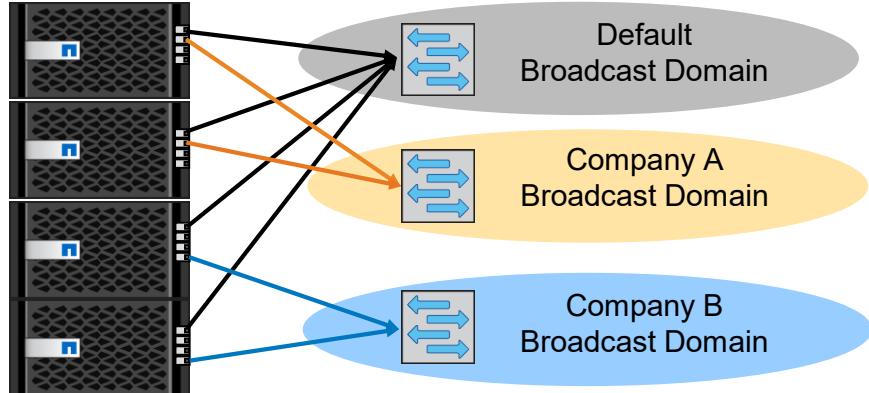
You can display the list of IPspaces that exist in a cluster, and you can view the SVMs, broadcast domains, and ports that are assigned to each IPspace.

After you create an IPspace but before you create the SVMs in the IPspace, you must create a broadcast domain that defines the ports that will be part of the IPspace.

# Broadcast Domains

## Overview

- Broadcast domains enable you to group network ports that belong to the same Layer 2 network.
- An SVM can then use the ports in the group for data or management traffic.



Broadcast domains can contain physical ports, ifgroups, and VLANs.

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Broadcast domains are often used when a system administrator wants to reserve specific ports for use by a certain client or group of clients. A broadcast domain should include ports from many nodes in the cluster, to provide high availability for the connections to SVMs.

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

- The Default broadcast domain, which was created automatically during cluster initialization, is configured to contain a port from each node in the cluster.
- The Company A broadcast domain was created manually and contains one port each from the nodes in the first HA pair.
- The Company B broadcast domain was created manually and contains one port each from the nodes in the second HA pair.
- The Cluster broadcast domain was created automatically during cluster initialization but is not shown in the figure.

The system administrator created the two broadcast domains specifically to support the customer IPspaces.

# Broadcast Domains

## Managing broadcast domains

You create broadcast domains to group ports for an IPspace:

Create Broadcast Domain

Specify the broadcast domain details and assign ports to it.

Name:	bcast_A
MTU:	1500
IPspace:	ipXYZ

Assign Ports: Ports that can be assigned to a new broadcast domain are shown below.

	Port Name	rtp-nau-01
<input checked="" type="checkbox"/>	a0a	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	a0a-11	<input checked="" type="checkbox"/>

```
rtp-nau::> network port broadcast-domain create -broadcast-domain bcast_A -mtu 1500  
-ipspace ipXYZ -ports rtp-nau-01:a0a,rtp-nau-01:a0a-11...  
rtp-nau::> network port broadcast-domain add-ports...  
rtp-nau::> network port broadcast-domain remove-ports...
```

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You create a broadcast domain to group network ports in a cluster that belongs to the same Layer 2 network. SVMs can then use the ports.

**NOTE:** The ports that you plan to add to the broadcast domain must not belong to another broadcast domain.

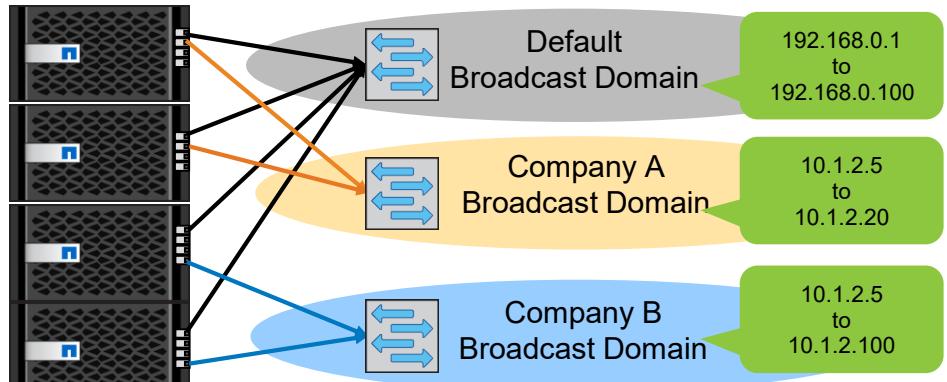
- All broadcast domain names must be unique within an IPspace.
- The ports that you add to a broadcast domain can be network ports, VLANs, or ifgroups.
- Add ports by using the `network port broadcast-domain add-ports` command.
- If the ports that you want to use belong to another broadcast domain but are unused, use the `network port broadcast-domain remove-ports` command to remove the ports from the existing broadcast domain.
- The maximum transmission units (MTU) value of the ports that you add to a broadcast domain are updated to the MTU value that is set in the broadcast domain.
- The MTU value must match all the devices that are connected to the Layer 2 network.
- If you do not specify an IPspace name, the broadcast domain is created in the Default IPspace.

You can rename or delete broadcast domains that you create but not the system-created Cluster and Default broadcast domains.

To make system configuration easier, a failover group of the same name is created automatically and contains the same ports. All failover groups that relate to the broadcast domain are removed when you delete the broadcast domain.

## Subnets

- Subnets enable the allocation of specific blocks, or pools, of IP addresses for easier LIF creation.
- A subnet is created within a broadcast domain and contains a pool of IP addresses that belong to the same Layer 3 subnet.



Subnets are recommended for easier LIF creation.

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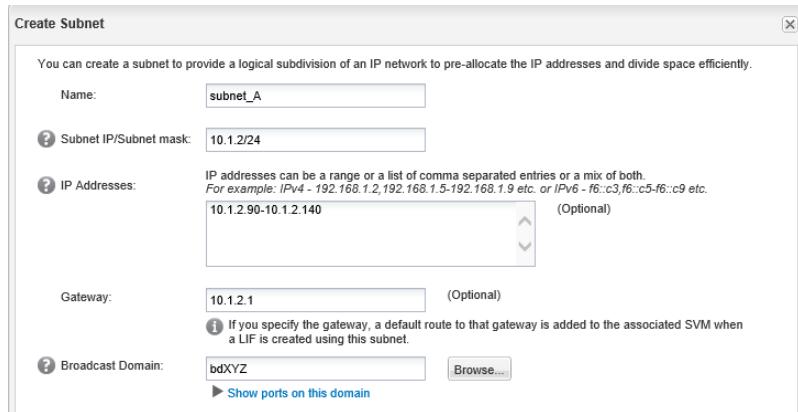
Subnets enable you to allocate specific blocks, or pools, of IP addresses for your ONTAP network configuration. The allocation enables you to create LIFs more easily when you use the `network interface create` command, by specifying a subnet name instead of specifying IP address and network mask values.

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.

You should use subnets because subnets simplify the management of IP addresses and the creation of LIFs. Also, 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.

# Creating Subnets

- The broadcast domain and IPspace where you plan to add the subnet must already exist.
- Subnet names must be unique within an IPspace.
- IP addresses in the specified range must not be in use by a LIF.



```
rtp-nau::> network subnet create -subnet-name subnet_A -broadcast-domain  
bdXYZ -ipspace ipXYZ -subnet 10.1.2.0/24 -gateway 10.1.2.1  
-ip-ranges 10.1.2.90-10.1.2.140 -force-update-lif-associations true
```

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You create a subnet to allocate, or reserve, specific blocks of IPv4 or IPv6 addresses for ONTAP network configuration.

When creating subnets, note the following:

- When adding IP address ranges to a subnet, no IP addresses in the network can overlap (so that different subnets, or hosts, do not attempt to use the same IP address).
- If you do not use subnets or do not specify a gateway when defining a subnet, then you must use the `route create` command to add a route to the SVM manually.
- The value `true` can be set for the `-force-update-lif-associations` option. The command fails if any SP or network interfaces currently use the IP addresses in the specified range. Setting the value to `true` associates any manually addressed interfaces with the current subnet and enables the command to succeed.

# Subnets

## Subnets and gateways

- When creating subnets:
  - If a gateway is specified, then a default route is added automatically to the SVM when a LIF is created using that subnet.
  - If you do not use subnets, or if you do not specify a gateway when defining a subnet, then you must use the `route create` command to add a route to the SVM manually.
- If you add or change the gateway IP address:
  - The modified gateway is applied to new SVMs when a LIF is created in an SVM that uses the subnet.
  - A default route to the gateway is created for the SVM, if the route does not already exist.

**NOTE:** You might need to manually add a new route to the SVM when you change the gateway IP address.

# Subnets

## Verifying subnets

To view broadcast domains:

rtp-nau::> network subnet show						
Subnet	Broadcast			Avail/		
Name	Subnet	Domain	Gateway	Total	Ranges	
subnet_def	192.168.0.0/24	Default	192.168.0.1	10/50	192.168.0.101-192.168.0.150	
subnet_A	10.1.2.0/24	bd_A	10.1.2.1	4/51	10.1.2.90-10.1.2.140	
subnet_B	10.1.2.0/24	bd_B	10.1.2.1	4/51	10.1.2.90-10.1.2.140	

Subnets A and B have the same subnet and gateway but different broadcast domains.

Notice how subnets A and B use overlapping IP ranges.

## ACTION: Topics for Discussion



When do I need to create IPspaces, broadcast domains, or subnets?





## Lesson 4

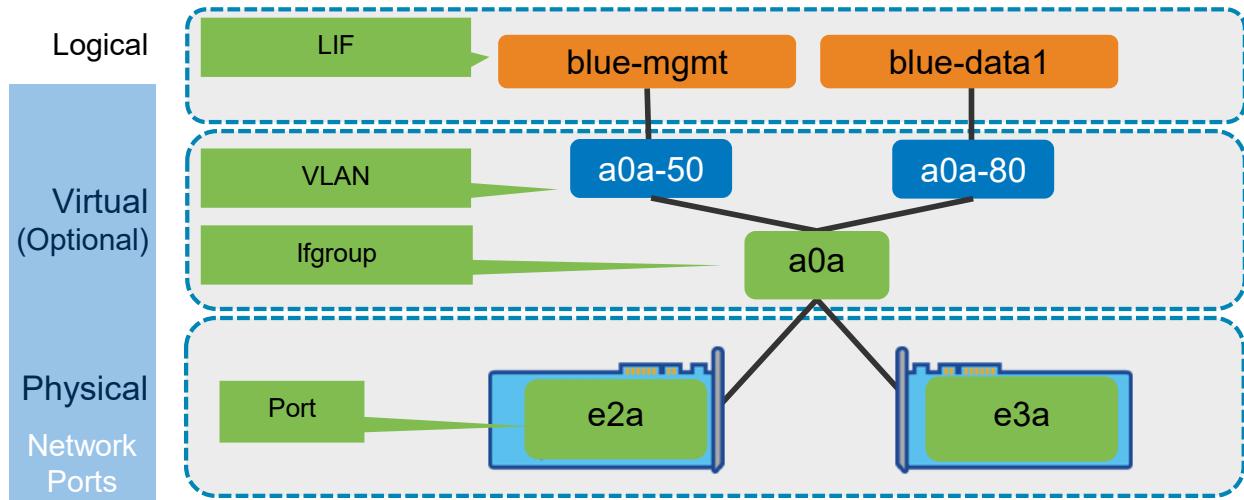
### Network Interfaces

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# Network Interfaces

Review



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A LIF is associated with a physical port, an ifgroup, or a VLAN. Virtual storage systems—VLANs and SVMs—own the LIFs. Multiple LIFs belonging to multiple SVMs can reside on a single port.

## Logical Interfaces

- An IP address or worldwide port name (WWPN) is associated with a LIF:
  - If subnets are configured (recommended), IP addresses are automatically assigned when a LIF is created.
  - If subnets are not configured, IP addresses must be manually assigned when LIF is created.
  - WWPNs are assigned automatically when an FC LIF is created.
- One node-management LIF exists per node.
- One cluster-management LIF exists per cluster.
- Two\* cluster LIFs exist per node.
- Multiple data LIFs are enabled per port (client-facing, for NFS, CIFS, iSCSI, and FC access).
- For intercluster peering, intercluster LIFs must be created on each node.

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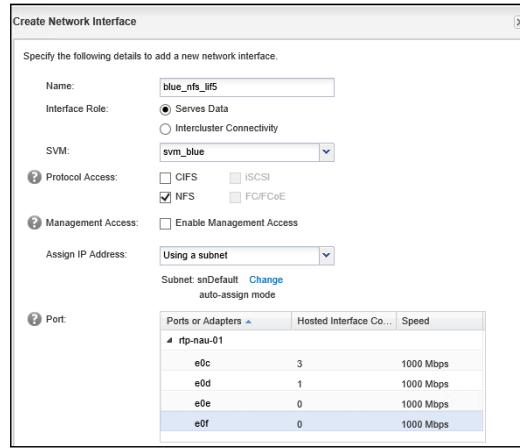
33

Data LIFs can have a many-to-one relationship with network ports: Many data IP addresses can be assigned to a single network port. If the port becomes overburdened, NAS data LIFs can be transparently migrated to different ports or nodes. Clients know the data LIF IP address but do not know which node or port hosts the LIF. If a NAS data LIF is migrated, the client might unknowingly be contacting a different node. The NFS mount point or CIFS share is unchanged.

A node can have a maximum of 128 NAS data LIFs (with failover enabled). For SAN LIF maximums, refer to the *SAN Configuration Guide* for your ONTAP release.

# Creating Data LIFs

- Specify the subnet name to automatically assign an IP address.
- You must specify the IP address when subnets are not configured.



```
rtp-nau::> network interface create -vserver svm_blue -lif blue_nfs_lif5  
-role data -data-protocol nfs -home-node rtp-nau-01 -home-port e0f  
-subnet-name snDefault
```

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A LIF is an IP address or worldwide port name (WWPN) that is associated with a physical port. If any component fails, most LIF types (excluding SAN) can fail over to or be migrated to a different physical port, thereby continuing to communicate with the cluster.

- The underlying physical network port must be 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.
- You can create IPv4 and IPv6 LIFs on the same network port.
- You cannot assign NAS and SAN protocols to a LIF.
- The supported protocols are CIFS, NFS, FlexCache, iSCSI, and FC.
- The `data-protocol` parameter must be specified when the LIF is created and cannot be modified later.
- If you specify `none` as the value for the `data-protocol` parameter, the LIF does not support any data protocol.
- The `home-node` parameter is the node to which the LIF returns when the `network interface revert` command is run on the LIF.
- The `home-port` parameter is the port or ifgroup to which the LIF returns when the `network interface revert` command is run on the LIF.
- All the name mapping and host-name resolution services—such as DNS, Network Information Service (NIS), Lightweight Directory Access Protocol (LDAP), and Active Directory—must be reachable from the data, cluster-management, and node-management LIFs of the cluster.
- A cluster LIF should not be on the same subnet as a management LIF or a data LIF.
- 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.

# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes

## Instructor begins polling session

- Questions appear in the polling panel.
- Answer each question.
- When finished, click “Submit.”

## Instructor ends polling session

- Correct answers have a green check mark.
- Compare your answers to the correct answers.

## Instructor leads debrief discussion

Raise your hand to ask a question or make a comment.



## Poll Question

Check your understanding

Which statement about LIFs is true?

- a. One cluster-management LIF exists per node.
- b. One port can host multiple data LIFs.
- c. Cluster LIFs and data LIFs can share a port.
- d. A data LIF can be associated with multiple SVMs.



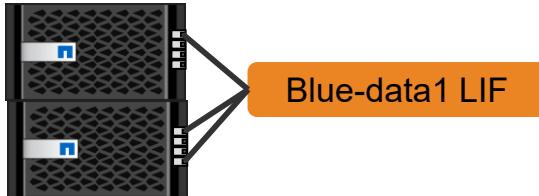
## Lesson 5

### Nondisruptive LIF Configuration

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# Nondisruptive LIF Features



- **LIF failover:** Automatic migration that occurs because of a link failure or reboot
- **LIF migrate:** Manual move of a LIF to another port
- **LIF revert:** Manually or automatically sending a LIF back to the home (node and) port

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Why migrate a LIF? It might be necessary for troubleshooting a faulty port or to offload a node whose data network ports are saturated with other traffic. The LIF fails over if its current node is rebooted.

Unlike storage failover (SFO), LIF failover or migration does not cause a reboot of the node from which the LIF is migrating. After a LIF is migrated, the LIF can remain on the new node for as long as the administrator wants.

Failover groups for LIFs can be broadcast domain-based or user-defined. 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. The failover group enables the system to reroute network traffic to other available ports in the cluster.

- The ports that are added to a failover group can be network ports, VLANs, or ifgroups.
- All the ports that are 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.

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. Failover policies can be:

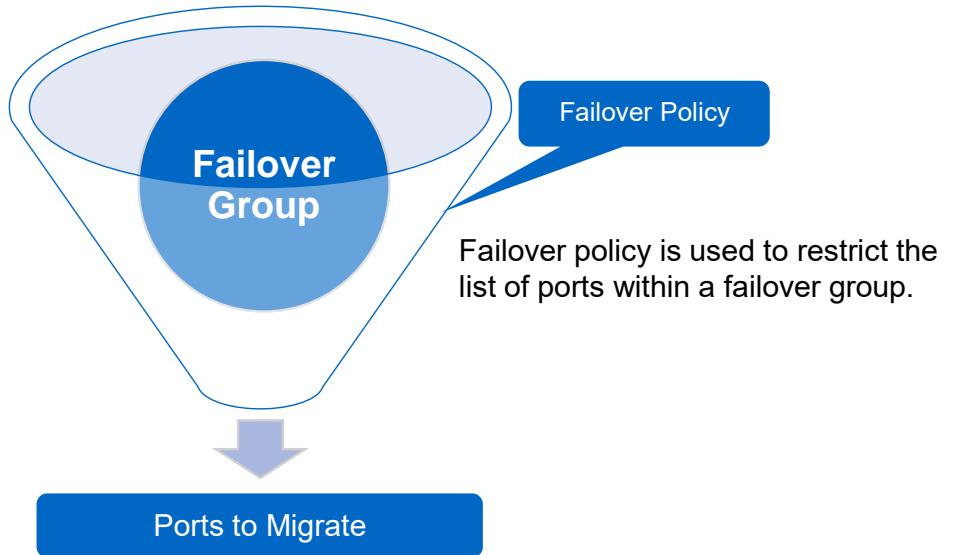
- **Broadcast-domain-wide:** All ports on all nodes in the failover group
- **System-defined:** Only those ports on the LIF's home node and a non-SFO partner
- **Local-only:** Only those ports on the LIF's home node
- **SFO-partner-only:** Only those ports on the LIF's home node and SFO partner
- **Disabled:** Not configured for failover

**NOTE:** LIFs for SAN protocols do not support failover and so are always set to *disabled*.

## Failover Groups Versus Failover Policies

Failover group is a list of ports (physical or virtual):

- Defines the targets for the LIF
- Is automatically created when you create a broadcast domain
- Does not apply to iSCSI or FC SAN LIFs



# Failover Groups

## Broadcast domain-based

Broadcast domain-based failover groups are created automatically, based on the network ports that are present in the broadcast domain:

- A Cluster failover group contains the ports in the Cluster broadcast domain.
- A Default failover group contains the ports in the Default broadcast domain.
- Additional failover groups are created for each broadcast domain that you create.

Two types of failover groups exist: those created automatically by the system when a broadcast domain is created, and those that a system administrator defines.

The ports in the Cluster broadcast domain are used for cluster communication and include all cluster ports from all nodes in the cluster.

The ports in the Default broadcast domain are used primarily to serve data, but also for cluster and node management.

Failover groups have the same name as the broadcast domain and contain the same ports as the groups in the broadcast domain.

# Failover Groups

## User-defined

Custom failover groups can be created for specific LIF failover functionality in the following circumstances:

- The automatic failover groups do not meet your requirements.
- You require only a subset of the ports that are available in the broadcast domain.
- You require consistent performance:
  - For example, create a failover group that consists of only 10-GbE ports, to enable LIFs to fail over only to high-bandwidth ports.
  - For example, create a failover group that consists of a set of ports for SnapMirror software over a WAN.

User-defined failover groups can be created for special failover situations when the default broadcast domain-based groups do not meet your needs.

# Failover Policies

Failover Policy	Available Target Ports	Details
Broadcast-domain-wide	The LIF fails over to a port in the same broadcast domain as the home port (including any port from any node in the failover group).	Default for cluster-management LIF
System-defined	The LIF fails over to a port on the home node or a non-SFO partner only.	Default for data LIFs <b>Recommended for nondisruptive software updates</b>
Local-only	The LIF fails over to a port on the home node of the LIF only.	Default for cluster LIFs, node management LIFs, and intercluster LIFs
SFO-partner-only	The LIF fails over to a port on the home node or SFO partner only.	
Disabled	Failover is disabled for the LIF.	LIF not configured for failover

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The table shows the default policies that should be used in most cases.

## Failover Policies and Groups

LIF Name	LIF Role	Default Failover Group	Default Failover Policy
clus1	Cluster	Cluster	Local-only
svl-nau-01_mgmt1	Node management	Default	Local-only
cluster_mgmt	Cluster management	Default	Broadcast-domain-wide
red_nas_lif01	Data	Default	System-defined

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The table shows how failover policies and groups work together. Groups include all possible failover targets, whereas policies limit targets within the group.

# Failover

Managing failover groups and LIFs

- Create a failover group:

```
rtp-nau::> net int failover-groups create -vserver svm_blue  
-failover-group fg_blue -targets rtp-nau-01:e0f,rtp-nau-02:e0f
```

- Add or remove targets from a failover group:

```
rtp-nau::> network interface failover-groups add-targets  
rtp-nau::> network interface failover-groups remove-targets
```

- Configure failover for an existing LIF:

```
rtp-nau::> net int modify -vserver svm_blue -lif blue_nfs_lif1  
-failover-policy broadcast-wide-domain -failover-group fg_blue
```

## ACTION: Topics for Discussion



- What are the benefits of each type of failover group and failover policy type?
- When should I use ifgroups or failover groups—or do I need both?





## Lesson 6

### Routing Management

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# Routing Management

## Overview

- Control the outbound traffic of LIFs by configuring route tables and static routes.
- **Route tables:**
  - Route tables are routes that are automatically created in an SVM when a service or application is configured for the SVM.
  - Routes are configured for each SVM, identifying the SVM, subnet, and destination.
  - Route tables are per-SVM, so routing changes to one SVM do not pose a risk of corrupting another SVM route table.
  - The system SVM of each IPspace has its own route table.
- **Static routes:**
  - A static route is a defined route between a LIF and a specific destination IP address.
  - The route can use a gateway IP address.

**NOTE:** If a default gateway is defined when you create a subnet, a default route to the gateway is added automatically to the SVM that uses a LIF from the subnet.

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Route tables: System SVMs can own LIFS, and the system SVMs might need route configurations that differ from the configurations on data SVMs.

# Routing Management

## Managing routes

- **Create a static route:**

```
rtp-nau::> network route create -vserver svm_blue -destination 0.0.0.0/0  
-gateway 192.168.0.1
```

- **Delete a static route:**

```
rtp-nau::> network route delete -vserver svm_blue -destination 0.0.0.0/0  
-gateway 192.168.1.1
```

- **Display static routes:**

```
rtp-nau::> network route show  
Vserver Destination Gateway Metric  
----- ----- -----  
svm_blue 0.0.0.0/0 192.168.0.1 20 ...
```

You can use the optional `-metric` parameter with the `network route create` command to specify a hop count for the route. The default settings for the parameter are 10 for management interfaces, 20 for data interfaces, and 30 for cluster interfaces. The parameter is used for source-IP address selection of user-space applications such as Network Time Protocol (NTP).

# Host-Name Resolution

## Overview

Host-name resolution is supported by two methods: DNS and hosts tables.

- Configure DNS and the hosts table in the admin SVM:
  - Best practice is to configure DNS when setting up the cluster.
  - Configurations are propagated to each node as nodes joins the cluster.
  - By default, the order of lookup is hosts table and then DNS.
- Cluster and SVM administrators can configure DNS in a data SVM.
- Each SVM has its own DNS configuration.

## Host-name resolution for the admin SVM

Only the cluster administrators can configure DNS and the hosts table for host-name lookup in the admin SVM. All applications except CIFS discovery use the host-name configuration of the admin SVM. You cannot use NIS configuration for the admin SVM.

Host-name resolution for the admin SVM is configured when the cluster is created.

- Hosts table configuration for the admin SVM: You can use the `vserver services dns hosts` command to configure the hosts table that resides in the root volume of the admin SVM.
- DNS configuration for the admin SVM: If you want to configure DNS after you set up the cluster, then use the `vserver services dns create` command.

## Host-name resolution for a data SVM

A cluster or SVM administrator can configure DNS for host-name lookup in a data SVM. DNS configuration is mandatory when CIFS is used for data access.

DNS services can also be configured on an SVM for FlexVol volumes by using the Vserver Setup wizard. If you want to configure DNS later, you must use the `vserver services dns create` command.

## Managing 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 SVM. An SVM administrator can configure the host name entries only for the assigned SVM.

# Host-Name Resolution

## Table entries

- Create a new hosts table entry:

```
rtp-nau::> vserver services name-service dns hosts create  
      -vserver svm_blue -address 192.168.0.11  
      -hostname test.example.com -alias test
```

- Create a new DNS table entry:

```
rtp-nau::> vserver services name-service dns create -vserver svm_blue  
      -domains example.com -name-servers 192.168.0.11
```

## References

- *ONTAP Network Management Guide*
- *ONTAP SAN Configuration and Administration Guides*
- *ONTAP File Access Management Guide*
- TR-4182: *Ethernet Storage Best Practices for ONTAP Configurations*
- TR-4080: *ONTAP SAN Best Practices*

# ACTION: Complete an Exercise

Module 4: Managing Virtual Network Resources



Duration: 30 minutes

## Access your lab equipment.

Use the login credentials that your instructor provided to you.

## Complete the specified exercises.

- Go to the exercise for the module.
- Start with Exercise 2.
- Stop at the end of Exercise 2.

## Participate in the review session.

- Share your results.
- Report issues.

# Share Your Experiences

Roundtable questions for the equipment-based exercises



When should I create a user-defined failover group?



## Module Review

This module focused on enabling you to do the following:

- Describe the interaction between physical and virtual network resources in a cluster
- Configure and manage physical and virtual networking resources



## Module 5

## Physical Storage

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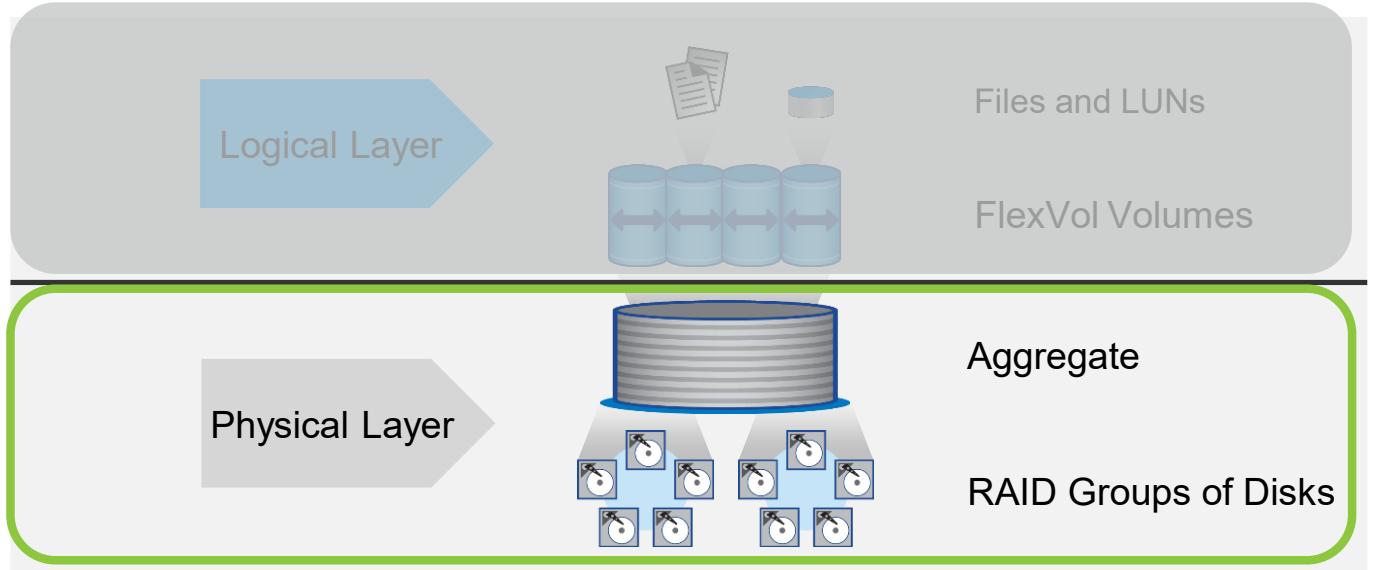
1

## About This Module

This module focuses on enabling you to do the following:

- Describe NetApp ONTAP storage architecture concepts
- Manage physical storage resources including disks, RAID groups, and aggregates
- Create RAID parity aggregates
- Create Flash Pool aggregates

# ONTAP Storage Architecture



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The NetApp ONTAP software storage architecture uses a dynamic virtualization engine, in which data volumes are dynamically mapped to physical space.

In ONTAP software, disks are grouped into RAID groups. An aggregate is a collection of physical disk space that contains one or more RAID groups. Each aggregate has a RAID configuration and a set of assigned disks. The disks, RAID groups, and aggregates make up the physical storage layer.

Within each aggregate, you can create one or more FlexVol volumes. A FlexVol volume is an allocation of disk space that is a portion of the available space in the aggregate. A FlexVol volume can contain files or LUNs. The FlexVol volumes, files, and LUNs make up the logical storage layer.



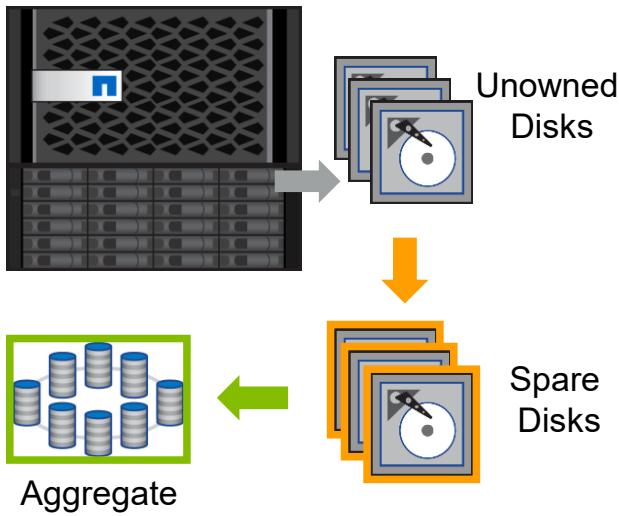
# Lesson 1

## Disks, RAID, and Aggregates

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# Disks and Aggregates



- What happens when a disk is inserted into a system:
  - The disk is initially unassigned.
  - By default, disk ownership is assigned automatically.
  - Disk ownership can be changed.
- What happens after ownership is assigned:
  - The disk functions as a hot spare.
  - The disk can be assigned to an aggregate.

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When a disk is inserted into a storage system disk shelf or when a new shelf is added, the controller takes ownership of the disk by default. In a high-availability (HA) pair, only one controller can own a particular disk, but ownership can be manually assigned to either controller.

When an aggregate is created or disks are added to an aggregate, the spare disks are used.

# Disk Ownership

- A disk is unusable until assigned to a controller.
- Disk ownership determines which controller owns a disk:
  - Ownership is automatically assigned (default).
  - Ownership can be manually assigned or changed.
  - Software disk ownership is made persistent by writing the ownership information onto the disk.
- Disks can be unassigned.

```
svl-nau::> storage disk show -container-type unassigned
      Usable          Container
Disk    Size   Shelf Bay   Type       Position  Aggregate Owner
-----+-----+-----+-----+-----+-----+-----+
  9.11.18     -        1      1 unassigned present      -      -
```

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ONTAP software automatically assigns disks to a controller during the initial disk setup and checks occasionally to determine whether new disks have been added. When the disk is assigned, the disk ownership information is written to the disk so that the assignment remains persistent.

Ownership can be modified or removed. The data contents of a disk are not destroyed when the disk is marked as unowned; only the disk-ownership information is erased. Unowned disks that reside on an FC-AL, where owned disks exist, have ownership information applied automatically to guarantee that all disks on the same loop have the same owner.

Automatic ownership assignment is enabled by default and is invoked at the following times:

- Every 5 minutes during normal system operation
- 10 minutes after the initial system initialization. (The delay enables the person who is configuring the system enough time to finish the initial disk assignments so that the results of the automatic ownership assignment are correct.)
- Whenever you enable automatic ownership assignment

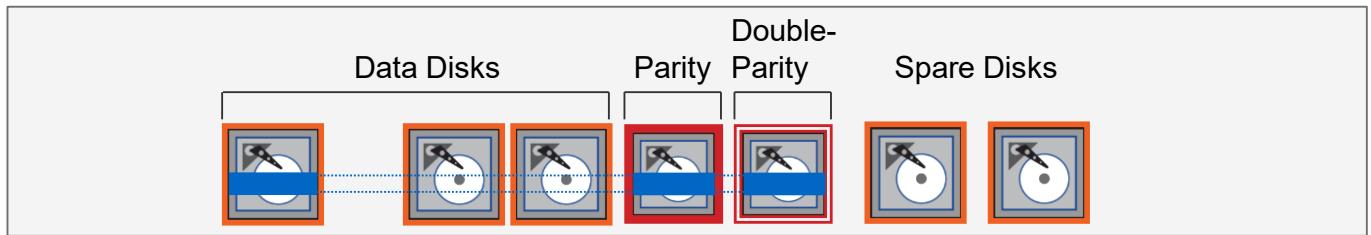
The automatic ownership assignment can also be initiated manually, by using the `disk assign` command with the `auto` parameter.

If your system is not configured to assign ownership automatically, or if your system contains array LUNs, you must assign ownership manually.

**NOTE:** NetApp best practice is to unassign only spare disks.

# Spare Disks

- Spare disks are used to do the following:
  - Create an aggregate
  - Increase aggregate capacity
  - Replace failed disks
- Disks must be zeroed before use:
  - Disks are automatically zeroed when they are added to an aggregate.
  - NetApp recommends manually zeroing disks before use.



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If you add a spare disk to an aggregate and the spare is larger than the other data disks, then the spare becomes the parity disk. However, the spare does not use the excess capacity unless another disk of similar size is added. The second largest additional disk has full use of additional capacity.

## Zeroing Used Disks

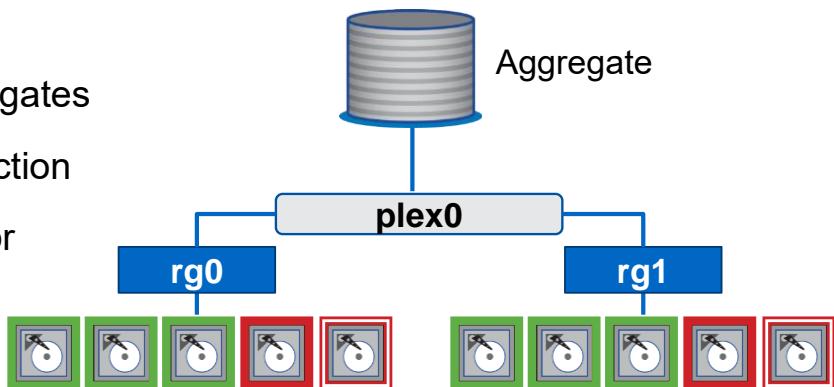
After you assign ownership to a disk, you can add the disk to an aggregate on the storage system that owns the disk. Alternatively, you can leave the disk as a spare disk on the storage system. If the disk has been used previously in another aggregate, you should use the `disk zero spares` command to zero the disk, to reduce delays when the disk is used.

## Zeroing Disks in ONTAP Software

Use the `storage disk zerospares` command to zero disks in ONTAP software.

# Aggregates

- **Aggregate:** Pool of storage
- **Plex:** Used for mirrored aggregates
- **RAID group:** Disk-level protection
- **Disk:** Hard disk drive (HDD) or solid-state drive (SSD)



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Aggregates provide storage to volumes. Aggregates are composed of RAID groups of disks or array LUNs, but not both. ONTAP software organizes the disks or array LUNs in an aggregate into one or more RAID groups. RAID groups are then collected into one or two plexes, depending on whether RAID-level mirroring (SyncMirror technology) is in use.

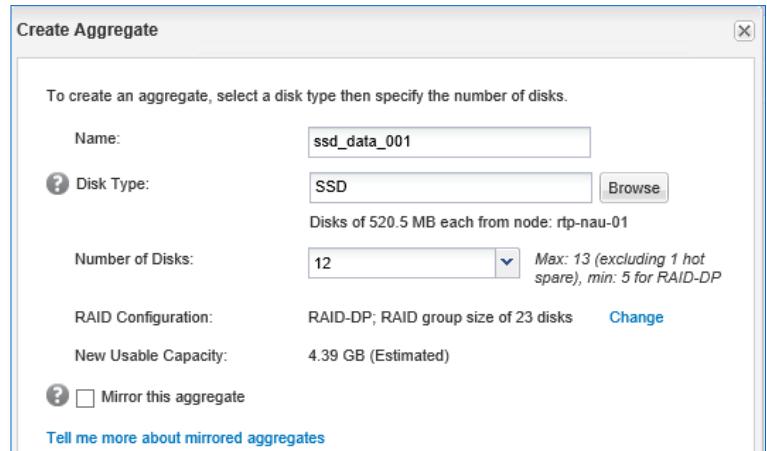
The ONTAP storage architecture contains the following:

- **Aggregates:** Each aggregate contains a plex or plexes, a RAID configuration, and a set of assigned physical disks to provide storage to the volumes that the aggregate contains.
- **Plexes:** Each plex is associated with an aggregate and contains RAID groups. Typically, an aggregate has only one plex. Aggregates that use SyncMirror technology have two plexes (plex0 and plex1); plex1 contains a mirror of the plex0 data.
- **RAID groups:** Each RAID group contains physical disks and is associated with a plex. A RAID group has either a RAID 4 or NetApp RAID-DP configuration.
- **Disks:** Disks play different roles at different times, depending on the state of the disk. Potential disk states include the following
  - Data
  - Parity
  - Double-parity
  - Spare
  - Broken
  - Unowned
  - Uninitialized (not zeroed)

# Create an Aggregate

Information to provide:

- Aggregate name
- Owning node
- Disk type
- Number of disks
- RAID type (RAID\_DP by default)



```
rtp-nau::> aggr create -aggregate ssd_data_001 -node rtp-nau-01  
-disktype SSD -diskcount 12
```

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## ACTION: Try This Task



Using svi-nau in your lab kit, try the following tasks:

1. Use the `aggr show` command:
  - Can you tell which node owns the aggregate?
  - What is the RAID status?
  - How can you determine how many disks are in each aggregate?
2. Different commands show similar things in different ways:
  - Enter `aggr show -aggregate aggr0_svl01`.
  - Enter `storage disk show -aggr aggr0_svl01`.
  - How do the outputs differ?
3. How can you find a “broken” disk?

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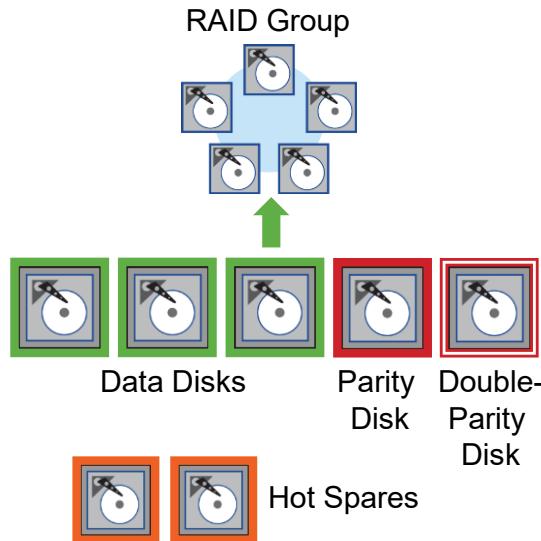
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- 1a. The owning node is listed in the Nodes column.
- 1b. RAID status should be raid\_dp, normal
- 1c. Use the –instance switch and check the “number of disks” field, or use the `aggr show -fields diskcount` command.
2. `aggr show` displays extensive information about the aggregate including the list of disks. `storage disk show` displays a list of disks in the aggregate and information about those disks.
3. Enter `storage disk show -broken`.

# RAID Groups

Disks are added to RAID groups:

- Disks must be the same type:
  - SAS, SATA, or SSD
  - Array LUNs
- Disks should be the same speed and size:
  - SAS 15K or 10K
  - SATA 7.5K
- Provide sufficient hot spares.
- Don't mix disk sizes and speeds



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A RAID group consists of one or more data disks or array LUNs, across which client data is striped and stored. A RAID group includes as many as two parity disks, depending on the RAID level of the aggregate that contains the RAID group. You change the size of RAID groups on a per-aggregate basis. You cannot change the size of an individual RAID group.

When sizing RAID groups of hard disk drives (HDDs) or solid-state drives (SSDs), observe the following guidelines:

- RAID groups are composed of the same disk type.
- All RAID groups in an aggregate should have the same number of disks.  
If you cannot follow the guideline, any RAID group with fewer disks should have only one disk less than the largest RAID group.  
**NOTE:** The SSD RAID group size can differ from the RAID group size for the HDD RAID groups in a flash pool aggregate. Usually, you should verify that you have only one SSD RAID group for a flash pool aggregate, to minimize the number of SSDs that are required for parity.
- The recommended range of RAID group size is as follows:
  - Between 12 and 20 for SATA HDDs
  - Between 20 and 28 for SAS HDDs and SSDs  
The reliability and smaller size (faster rebuild times) of performance HDDs can support a RAID group size of up to 28, if needed.
- NetApp recommends that you do not mix 10K-RPM and 15K-RPM disks in the same aggregate.  
Mixing 10K-RPM disks with 15K-RPM disks in the same aggregate effectively throttles all disks down to 10K RPM. Throttling results in longer times for corrective actions such as RAID reconstructions.

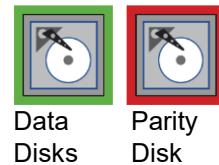
Recommendations about spares vary by configuration and situation. For information about best practices for working with spares, see Technical Report 3437: *Storage Subsystem Resiliency Guide*.

# RAID Types

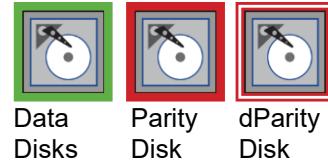
RAID groups can be one of the following:

- RAID 4 group
  - Single parity for single-disk failure
  - Minimum of two disks
- RAID-DP group (default)
  - Double parity for double-disk failure
  - Minimum of three disks
- RAID-TEC group (ONTAP 9 and later)
  - Triple parity for triple-disk failure
  - Minimum of four disks
  - Shorter failed-disk rebuild time for large disks

RAID 4



RAID-DP



RAID-TEC



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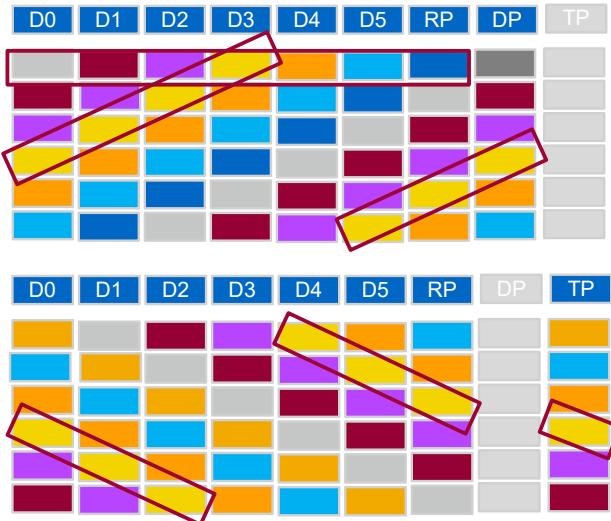
Understanding how RAID protects your data and data availability can help you administer your storage systems more effectively.

For native storage, ONTAP software uses NetApp RAID-DP (double-parity) technology or RAID 4 protection to provide data integrity within a RAID group, even if one or two of the disks fail. Parity disks provide redundancy for the data that is stored on the data disks. If a disk fails, the RAID subsystem can use the parity disks to reconstruct the data in the failed disk.

**NOTE:** NetApp imposes a five-disk minimum for RAID-DP and a four-disk minimum for RAID 4. The minimum is enforced at the aggregate level, not at the RAID group level.

# ONTAP RAID Technologies

## Description



- RAID 4 (row parity)
  - Add a *row parity* disk
  - Protect from single-disk failure, media error
- RAID-DP (double parity) technology
  - Adds a *diagonal parity* disk to a RAID 4 group
  - Protect from two disk failures, disk failure + media error, double media errors
- RAID-TEC (triple erasure coding) technology
  - Adds a *triple-parity* disk to a RAID-DP group
  - Protect from three disk failure, two disk failures + media error, triple media errors

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## RAID 4

In a RAID 4 group, parity is calculated separately for each row. In the example, the RAID 4 group contains seven disks, with each row containing six data blocks and one parity block.

## RAID-DP Technology

In a RAID-DP group, a diagonal parity set is created in addition to the row parity. Therefore, an extra double-parity disk must be added. In the example, the RAID-DP group contains eight disks, with the double parity calculated diagonally by using seven parity blocks.

- The number in each block indicates the diagonal parity set to which the block belongs.
- Each row parity block contains even parity of data blocks in that row, not including the diagonal parity block.
- Each diagonal parity block contains even parity of data and row parity blocks in same diagonal.

## RAID-TEC Technology

In a RAID-TEC group, an anti-diagonal parity set is created in addition to both the row parity and diagonal parity sets. Therefore, an extra third-parity disk must be added. In the example, the RAID-TEC group contains nine disks, with the triple parity calculated anti-diagonally using seven parity blocks.

- Seven diagonals (parity blocks) exist, but ONTAP software stores six diagonals ( $p-1$ ).
- The missed diagonal selection is arbitrary. Here, diagonal 6 is missing and is not stored or calculated.

Regarding diagonal numbers, the following guidelines apply:

- The set of diagonals collectively span all the data disks and the row parity disk.
- Each diagonal misses only one disk, and each diagonal misses a different disk. Each disk misses a different diagonal.
- The diagonal sequencing within a given disk starts with the diagonal number that corresponds with the given disk number. So the first diagonal on disk number 0 is diagonal 0, and the first diagonal on disk N is diagonal N. The diagonals on the disk wrap around when the end of the diagonal set is reached.

# RAID Group Sizes

- Default for the following:
  - Near-line class disks (SATA or NL-SAS) of size 6TB or larger HDDs
  - Required for 10TB and larger HDDs
- Optional for other disks (SSD or SAS)
- Default RAID group sizes:
  - 21 disks for SATA or NL-SAS disks
  - 24 disks for SAS disks
- Ability to upgrade and downgrade nondisruptively between RAID types

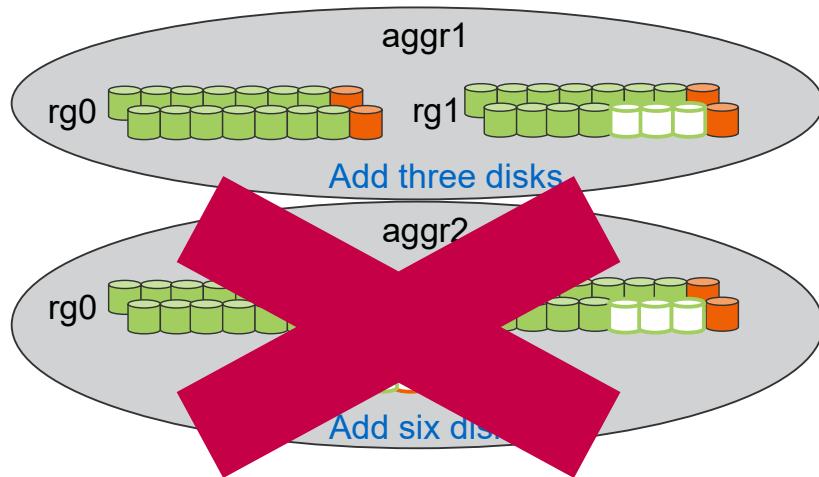
Disk Type	Group Type	Default	Maximum
SATA	RAID4	7	7
	RAID-DP	14	20
	<b>RAID-TEC</b>	<b>21</b>	<b>29</b>
NL-SAS	RAID4	7	7
	RAID-DP	14	20
	<b>RAID-TEC</b>	<b>21</b>	<b>29</b>
SAS	RAID4	8	14
	RAID-DP	16	28
	<b>RAID-TEC</b>	<b>24</b>	<b>29</b>
SSD	RAID4	8	14
	RAID-DP	23	28
	<b>RAID-TEC</b>	<b>24</b>	<b>29</b>

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To create a RAID-TEC aggregate, a minimum of seven disks is required.

## Adding Disks to RAID Groups



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You can add disks to an aggregate to provide more storage to associated volumes. To do so, add available spare disks to an existing aggregate. When adding disks, consider the size of your RAID groups. Plan to fill complete RAID groups to maximize the amount of usable space that is gained in comparison to the number of disks that are used for parity. In the aggr2 example, six disks are added to the aggregate, but only one more data disk adds capacity to the aggregate, compared to adding three disks.

When adding disks, also consider the following:

- Adding disks that the same system owns
- Benefits of keeping your RAID groups homogeneous for disk size and speed
- Which types of disks can be used together
- Checksum rules when disks of more than one checksum type are in use
- Adding the correct disks to the aggregate (the disk addition operation cannot be undone)
- How to add disks to aggregates from heterogeneous storage
- Minimum number of disks to add for best performance
- Number of hot spares to provide for protection against disk failures
- Requirements for adding disks from multidisk carrier disk shelves

# Adding Capacity to Aggregates

Provide the following information:

- Aggregate name
- Disk type
- Number of disks

You can not shrink aggregates.

Add Capacity

Review the existing disks of the aggregate and select disks to add to the aggregate.

Aggregate Name: ssd\_data\_001  
Node: rtp-nau-01  
Existing Usable Capacity: 3.52 GB

Existing Disks or Partitions:

Disk Type	Node	Disk Size	RPM	Checksum
SSD	rtp-nau-01	520.5 MB	-NA-	block

Disk Type to Add:

520.5 MB disks from node: rtp-nau-01

Number of Disks:  Max: 3 (excluding hot spares: 1)

Add Disks To: All RAID groups

New Usable Capacity: 4.83 GB (Estimated)

```
rtp-nau::> storage disk show -spare -owner rtp-nau-01
rtp-nau::> storage aggregate add-disks -aggr ssd_data_001 disks 3
```

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## ACTION: Topic for Discussion



What is one alternative to adding a few disks to an aggregate when all current RAID groups are full?



# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes

## Instructor begins polling session

- Questions appear in the polling panel.
- Answer each question.
- When finished, click "Submit."

## Instructor ends polling session

- Correct answers have a green check mark.
- Compare your answers to the correct answers.

## Instructor leads debrief discussion

Raise your hand to ask a question or make a comment.



## Poll Question

Check your understanding

What is the minimum number of disks that are required to create a RAID-TEC data aggregate (excluding hot spares)?

- a. three
- b. four
- c. five
- d. six
- e. seven

# ACTION: Complete an Exercise

Module 5: Managing Physical Storage



Duration: 30 minutes

## Access your lab equipment.

Use the login credentials that your instructor provided to you.

## Complete the specified exercises.

- Go to the exercise for the module.
- Start with Exercise 1.
- Stop at the end of Exercise 1.

## Participate in the review session.

- Share your results.
- Report issues.

# Share Your Experiences

Roundtable questions for the equipment-based exercises



How does our non-high-availability (non-HA) lab environment affect disks and disk ownership?



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## Lesson 2

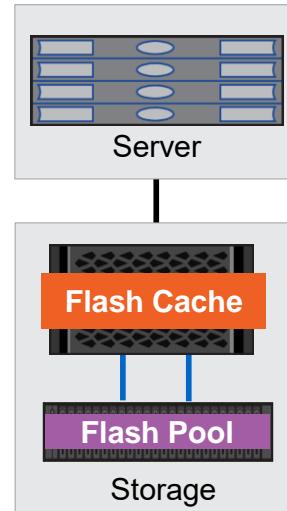
### Flash Cache and Flash Pool

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# NetApp Virtual Storage Tier

- Flash Cache intelligent caching:
  - Has highest performance for file services
  - Improves latency for random reads
  - Delivers predictable, high-speed data access
- Flash Pool intelligent caching:
  - Has highest performance for OLTP
  - Is best for SATA enablement across multiple workloads
  - Caches for random reads *and* writes
  - Automates the use of SSD technology



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At the storage level, there are two ways to implement Virtual Storage Tier (VST):

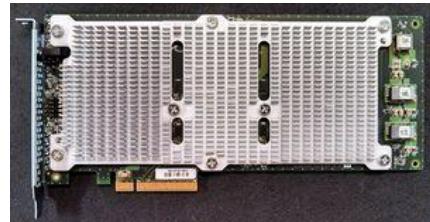
- The controller-based Flash Cache feature provides acceleration of random-read operations and generally provides the highest performance solution for file-services workloads.
- The Flash Pool feature is implemented at the disk-shelf level, enabling SSDs and traditional HDDs to be combined in a single ONTAP aggregate. In addition to read caching, Flash Pool technology also provides write caching and is well-suited for OLTP workloads, which typically have a higher percentage of write operations.

Both VST technologies improve overall storage performance and efficiency and are simple to deploy and operate.

## Flash Cache 2 Feature

- 512-GB, 1-TB, or 2-TB Peripheral Component Interconnect Express (PCIe) module
- Plug-and-play device (no required configuration)
- Support for all protocols
- An extension to the WAFL (Write Anywhere File Layout) file system buffer cache, saves evicted buffers
- Maintains deduplicated and compressed blocks in the cache
- Shared by all volumes on a node

See TR-3832 for more information.



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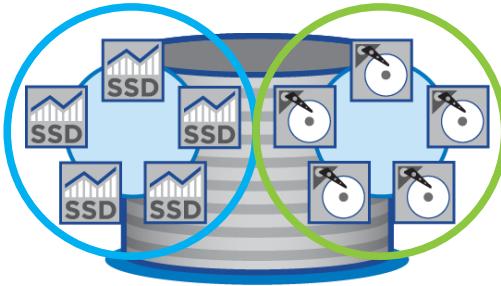
Flash Cache intelligent caching combines software and hardware within NetApp storage controllers to increase system performance without increasing the disk count. The Flash Cache plug-and-play Peripheral Component Interconnect Express (PCIe) module requires no configuration to use the default settings, which are recommended for most workloads. The original Flash Cache module is available in 256-GB, 51-GB, or 1-TB capacities and accelerates performance on all supported ONTAP client protocols. The Flash Cache controller-based solution is available to all volumes that are hosted on the controller. A common use case for Flash Cache is to handle VMware boot storms.

Flash Cache 2 is the second generation of Flash Cache performance accelerators. The new architecture of Flash Cache 2 accelerators enables even higher throughput.

For more information, see TR-3832: *Flash Cache Best Practice Guide*.

# Flash Pool Aggregates

- What flash pool aggregates contain:
  - SAS or SATA disks for user data
  - SSDs for high-performance caching
- How flash pools improve performance:
  - Offloads random read operations
  - Offloads repetitive random write operations
- Two types of flash pool:
  - Dedicated SSD
  - Shared storage pool
- Use case: OLTP workloads



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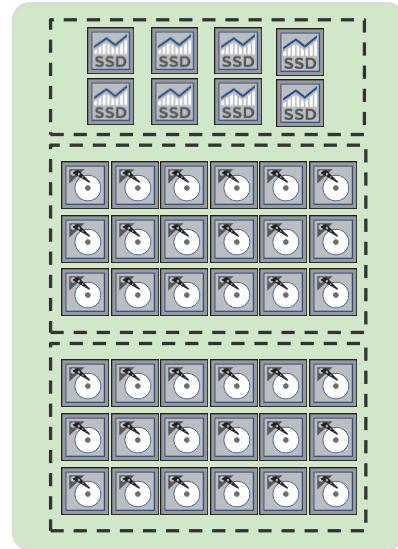
A flash pool aggregate is a special type of hybrid data aggregate.

A flash pool aggregate combines SAS or SATA disks and SSDs to provide high performance in a more economical way than an SSD aggregate. The SSDs provide a high-performance cache for the active dataset of the data volumes that are provisioned on the flash pool aggregate. The cache offloads random read operations and repetitive random write operations to improve response times and overall throughput for disk I/O-bound data-access operations.

Flash pools can improve workloads that use OLTP; for example, database application data. Flash pools do not improve performance of predominantly sequential workloads.

## Blocks in the SSD Tier

- Flash pool metadata
- Read-cached blocks:
  - Are a cached copy of the blocks from the HDD tier
  - Still exist on the HDD tier
- Write-cached blocks:
  - Are written directly to the SSD tier
  - Are not yet written to the HDD tier



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The following blocks are stored in the SSD tier of the flash pool:

**Flash pool metadata:** All metadata that is associated with the flash pool is stored in the SSD tier of the aggregate.

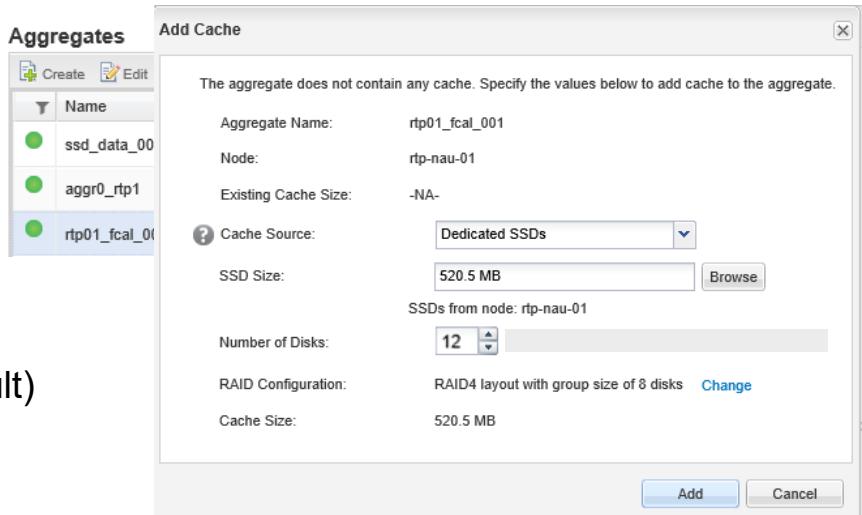
**Read-cached blocks:** Read-cached blocks are stored in the SSD tier. Almost all data from the active file system in a read/write volume is eligible to be read-cached into the SSD tier.

**Write-cached blocks:** Write-cached blocks are associated with a FlexVol volume that is written directly to the SSD tier of the aggregate. Only one copy of the block exists. A hard-disk block is reserved for write-cached blocks for an eventual move into the HDD tier after access to the block ceases.

# Create a Flash Pool Aggregate

Provide the following information:

- Existing aggregate name
- Cache source or disk type
- Number of disks
- RAID type (RAID\_4 by default)



```
rtp-nau::> aggr modify -aggregate rtp01_fcsl_001 -hybrid-enabled true  
rtp-nau::> aggr add-disks -aggr rtp01_fcsl_001 -disktype SSD -diskcount 12
```

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The SSD RAID group size can be different from the RAID group size for the HDD RAID groups in a Flash Pool aggregate. Usually, you should ensure that you have only one SSD RAID group for a Flash Pool aggregate, to minimize the number of SSDs required for parity.

For information about best practices for working with aggregates, see Technical Report 3437: *Storage Subsystem Resiliency Guide*.

To see the physical and usable capacity for a specific disk, see the Hardware Universe at [hwu.netapp.com](http://hwu.netapp.com).

# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes

## Instructor begins polling session

- Questions appear in the polling panel.
- Answer each question.
- When finished, click "Submit."

## Instructor ends polling session

- Correct answers have a green check mark.
- Compare your answers to the correct answers.

## Instructor leads debrief discussion

Raise your hand to ask a question or make a comment.



## Poll Question

Check your understanding

What does a flash pool aggregate contain?

- a. [HDDs only](#)
- b. [SSDs only](#)
- c. [HDDs for data storage and SSDs for caching](#)
- d. [HDDs and SSDs that are all used for data caching](#)

## SSD Partitioning for Flash Pool Intelligent Caching

- Increased storage utilization for SSDs in flash pool aggregates
- Ability to share spares between HA partners
- Better utilization of SSD performance



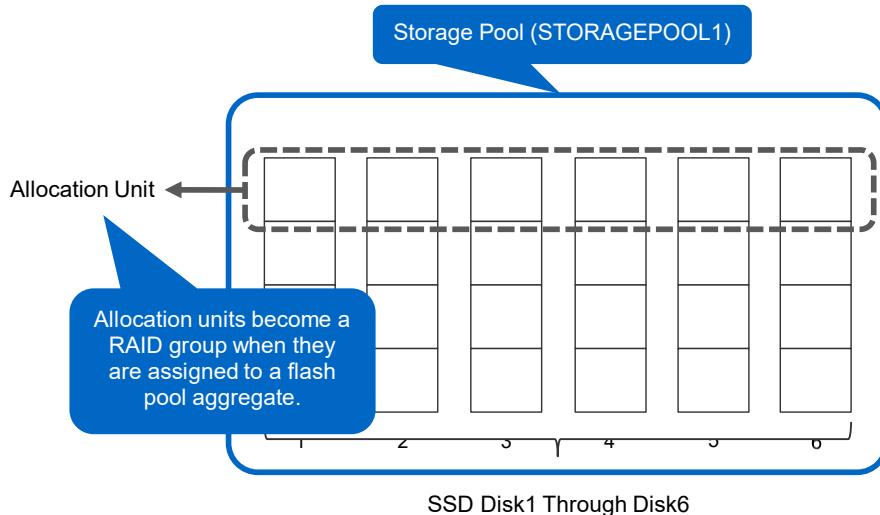
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SSD partitioning for Flash Pool intelligent caching enables customers to group SSDs into a shared resource, which is allocated to multiple flash pool aggregates. The feature spreads the cost of the parity SSDs over more aggregates, increases SSD allocation flexibility, and maximizes SSD performance.

# SSD Partitioning for Flash Pool Cache

## Creation



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SSD storage pools provide SSD caching to two or more flash pool aggregates. Creating an SSD storage pool requires between 2 and 28 spare SSD disks.

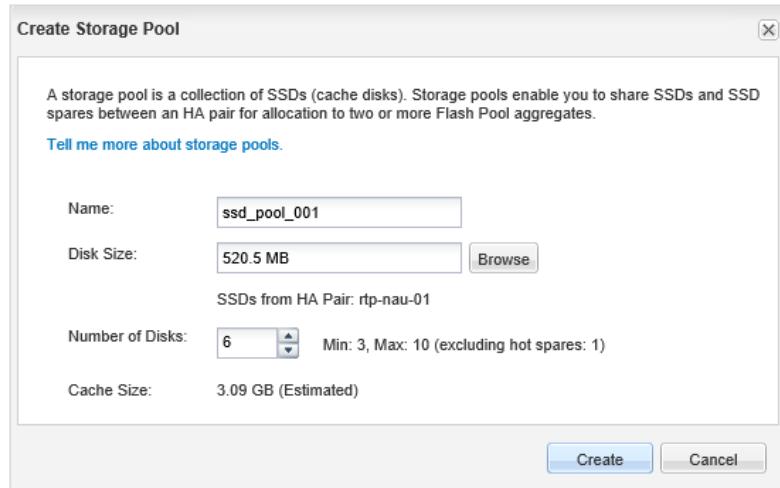
In the example, SSD Disk1 through Disk6 are available as spares. The `storage pool create` command is used to create the storage pool. The unit of allocation for an SSD storage pool is equal to a single slice from each SSD disk in the storage pool. The `storage pool create` command slices each SSD disk into four equal pieces, making an allocation unit that equals one fourth of all the SSD disks in the storage pool.

An allocation unit becomes a RAID group when assigned to a flash pool aggregate.

# Create an SSD Storage Pool

Provide the following information:

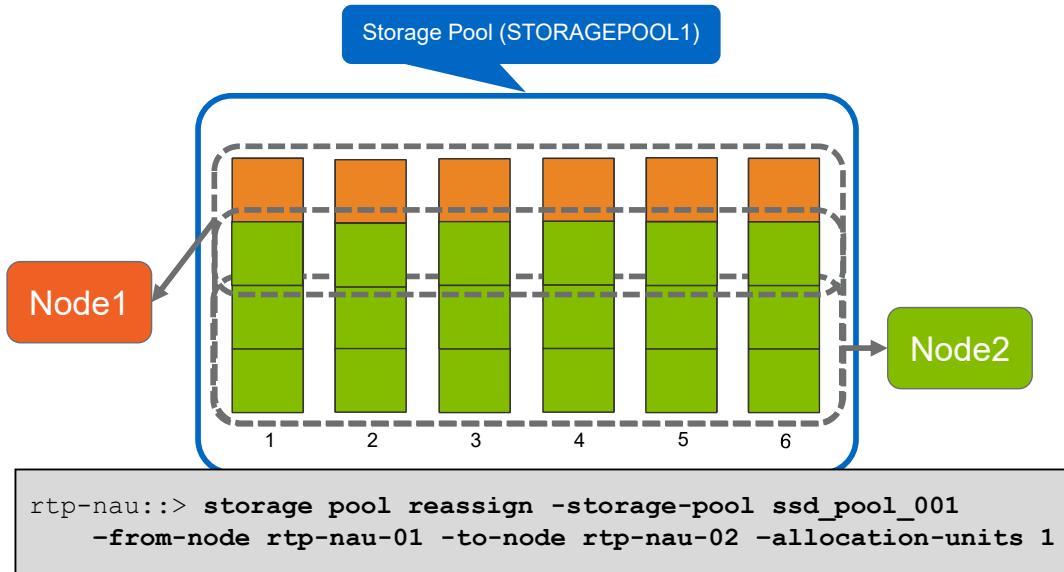
- Storage pool name
- Number of disks
- Size of SSDs from HA pair  
(if multiple sizes are available)



```
svl-nau::> storage pool create -storage-pool ssd_pool_001 -disk-count 6
```

# SSD Partitioning for Flash Pool Cache

## Ownership



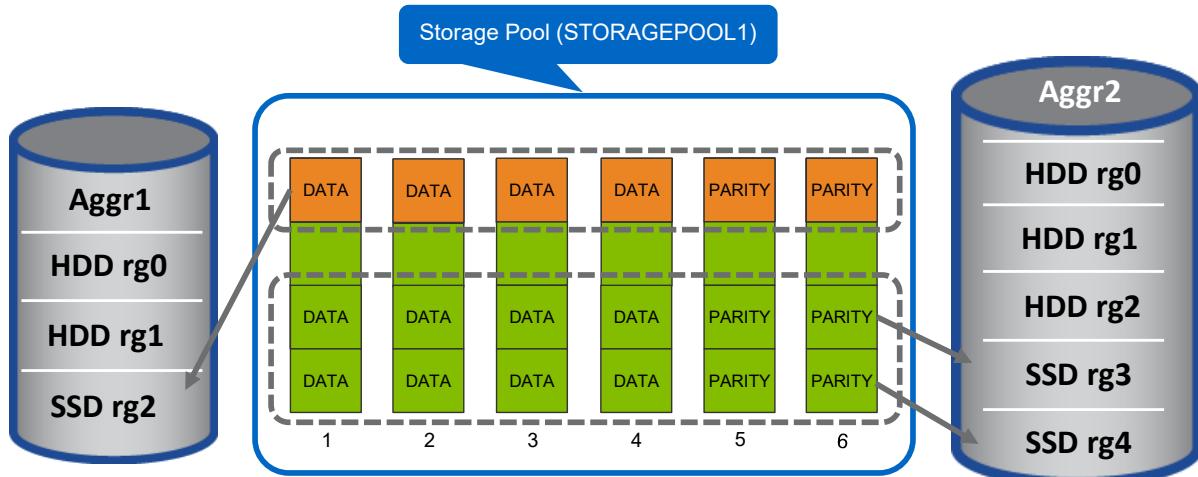
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By default, two allocation units are assigned to each node in the HA pair. To change the ownership of one or more allocation units of a storage pool from one HA partner to the other, use the `storage pool reassign` command. In the example, one allocation unit is reassigned from Node1 to Node2.

# SSD Partitioning for Flash Pool Cache

## Ownership



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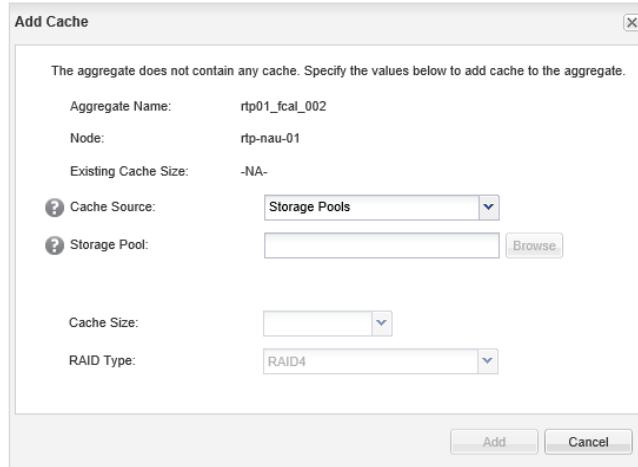
34

By default, two allocation units are assigned to each node in the HA pair. To change the ownership of one or more allocation units of a storage pool from one HA partner to the other, use the `storage pool reassign` command. In the example, one allocation unit is reassigned from Node1 to Node2.

## Create a Flash Pool Using an SSD Storage Pool

Provide the following information:

- Existing aggregate name
- Storage pool name



```
svl-nau::> storage aggregate add-disks -aggregate rtp01_fcsl_002  
-allocation-units 1 -storage-pool ssd_pool_001
```

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# NetApp Virtual Storage Tier

## Feature comparison

FLASH CACHE	FLASH POOL
What is the feature? <ul style="list-style-type: none"><li>▪ A controller-based PCIe card</li><li>▪ A plug-and-play device</li></ul>	What is the feature? Storage-level, RAID-protected cache (specific to aggregates)
What does the feature do? <ul style="list-style-type: none"><li>▪ Provides per-controller cache</li><li>▪ Caches random reads</li></ul>	What does the feature do? <ul style="list-style-type: none"><li>▪ Caches random reads and overwrites</li><li>▪ Provides cached data persistence through failovers</li></ul>
Where does the feature fit? <ul style="list-style-type: none"><li>▪ With random-read workloads; for example, file services</li><li>▪ With volumes that span multiple aggregates</li></ul>	Where does the feature fit? <ul style="list-style-type: none"><li>▪ With random-overwrite-heavy workloads; for example, OLTP</li><li>▪ With consistent performance (required)</li></ul>

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The Flash Cache and Flash Pool features bring flash technology to the ONTAP software. The table compares the primary uses and benefits of both features.

## ACTION: Topic for Discussion



Will Virtual Storage Tier (VST) help an older system run faster?





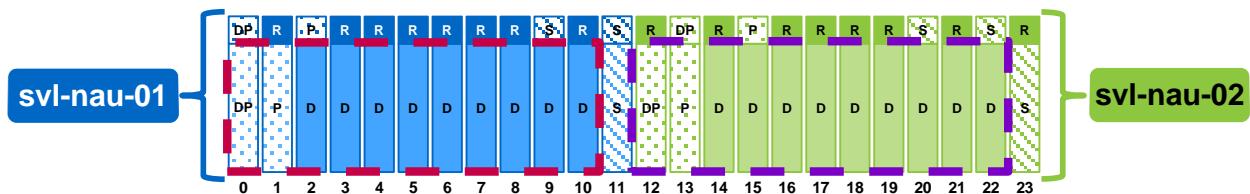
## Lesson 3

### Advanced Root Drive Partitioning

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## Root-Data Advanced Drive Partitioning

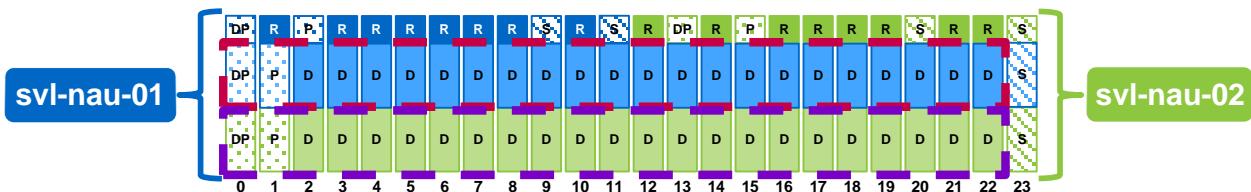


- SSDs are partitioned into one small root partition and one large data partition.
- Standard aggregate configuration per node is as follows:
  - A root aggregate RAID group of 8 data + 2 parity partitions, and 2 spare root partitions
  - A data aggregate RAID group of 9 data + 2 parity partitions, and 1 spare data partition
- Total usable capacity is 18 data partitions out of a total of 24—75% efficiency.

The figure shows the default configuration for a single-shelf All Flash FAS system in Data ONTAP 8.3.x software.

# Root-Data-Data Advance Drive Partitioning

## ONTAP 9 and later



- SSDs are partitioned into one small root and two data partitions, each of which is half the size of a root-data partition.
  - Standard aggregate configuration per node is as follows:
    - A root aggregate RAID group of 8 data + 2 parity partitions, and 2 spare root partitions (no change from root-data partition)
    - A data aggregate RAID group of 21 data + 2 parity partitions, and 1 spare data partition
  - Total usable capacity is 42 data partitions out of a total of 48—87.5% efficiency, or 16.7% more usable capacity ( $0.875 / 0.75$ )

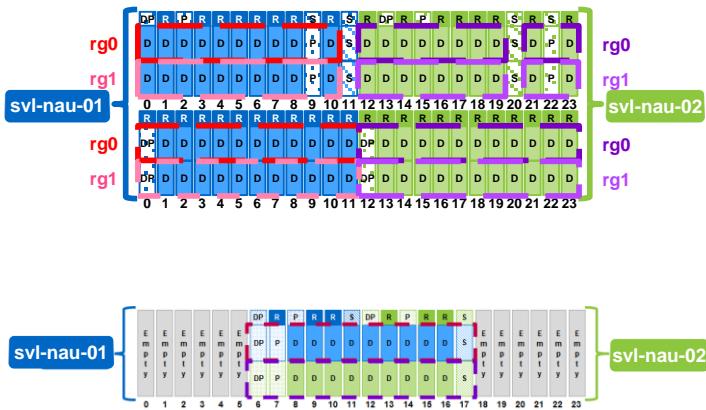
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The figure shows the default configuration for a single-shelf All Flash FAS system in ONTAP 9 software.

# Root-Data-Data Advance Drive Partitioning

Additional root-data-data partitioning information



- Supported on All Flash FAS systems only:
  - Default root aggregate provisioning method for All Flash FAS
  - Unsupported on entry-level FAS or All Flash FAS MetroCluster software
- Data partition assignments with two shelves are similar to root-data partitioning:
  - Data partitions on an SSD are assigned to same node.
  - Twice as many RAID groups are used.
- Half-shelf All Flash FAS systems have 50% more usable capacity than with root-data partitioning; All Flash FAS systems with 12x 3.8TB or 12x 15.3TB SSDs are available with ONTAP 9 only.

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The figures show the default configuration for the two-shelf and half-shelf All Flash FAS systems in ONTAP 9 software.

For root-data partitioning and root-data-data partitioning, RAID uses the partitions in the same way as physical disks. If a partitioned disk is moved to another node or used in another aggregate, the partitioning persists. You can use the disk only in RAID groups that are composed of partitioned disks. If you add an unpartitioned drive to a RAID group that consists of partitioned drives, the unpartitioned drive is partitioned to match the partition size of the drives in the RAID group, and the rest of the disk is unused.

# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes

## Instructor begins polling session

- Questions appear in the polling panel.
- Answer each question.
- When finished, click "Submit."

## Instructor ends polling session

- Correct answers have a green check mark.
- Compare your answers to the correct answers.

## Instructor leads debrief discussion

Raise your hand to ask a question or make a comment.



## Poll Question

Check your understanding

An SSD storage pool is divided into how many allocation units?

- a. one for each node in the HA pair
- b. one for each disk in the storage pool
- c. one for each flash pool that is assigned to the storage pool
- d. four

## References

- *ONTAP System Administration Guide*
- *ONTAP Physical Storage Management Guide*
- *TR4070: NetApp Flash Pool Design and Implementation Guide*

# ACTION: Complete an Exercise

Module 5: Exploring RAID-TEC and Creating a Flash Pool



Duration: 30 minutes

## Access your lab equipment.

Use the login credentials that your instructor provided to you.

## Complete the specified exercises.

- Go to the exercise for the module.
- Start with Exercise 2.
- Stop at the end of Exercise 2.

## Participate in the review session.

- Share your results.
- Report issues.

# Share Your Experiences

Roundtable questions for the equipment-based exercises



Why couldn't we create an SSD storage pool in our lab environment?



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## Module Review

This module focused on enabling you to do the following:

- Describe NetApp ONTAP storage architecture concepts
- Manage physical storage resources including disks, RAID groups, and aggregates
- Create RAID parity aggregates
- Create Flash Pool aggregates



## Module 6

## Logical Storage

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## About This Module

This module focuses on enabling you to do the following:

- Create and manage FlexVol volumes
- Manage Snapshot copies
- Move a volume within a storage virtual machine (SVM)



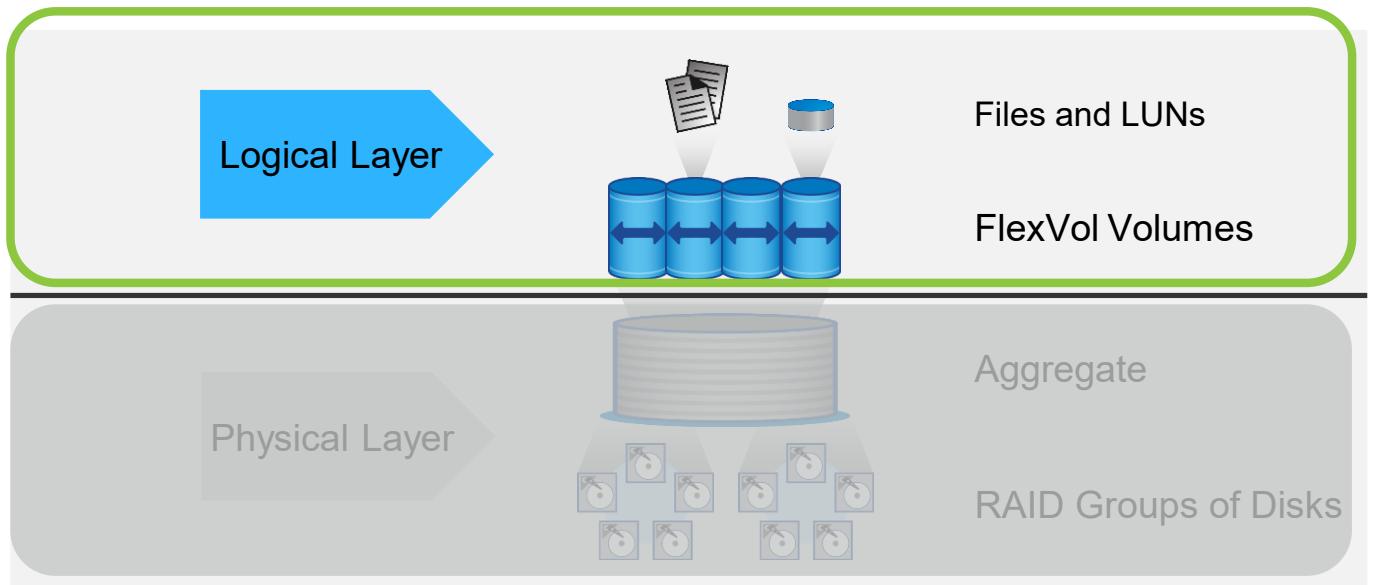
## Lesson 1

# Flexible Volumes

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# NetApp ONTAP Storage Architecture



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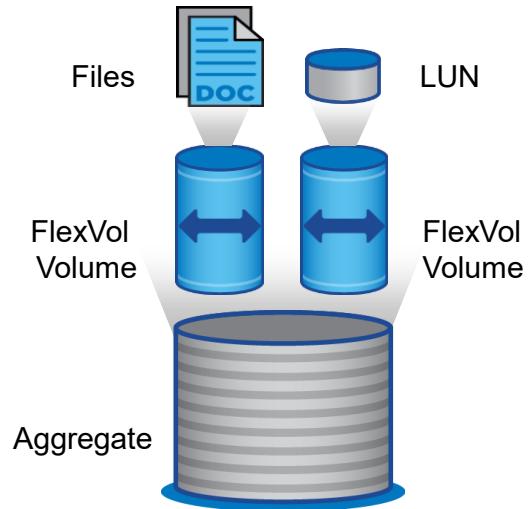
The NetApp ONTAP storage architecture uses a dynamic virtualization engine, in which data volumes are dynamically mapped to physical space.

In ONTAP, disks are grouped into RAID groups. An aggregate is a collection of physical disk space that contains one or more RAID groups. Each aggregate has a RAID configuration and a set of assigned disks. The disks, RAID groups, and aggregates make up the physical storage layer.

Within each aggregate, you can create one or more FlexVol volumes. A FlexVol volume is an allocation of disk space that is a portion of the available space in the aggregate. A FlexVol volume can contain files or LUNs. The FlexVol volumes, files, and LUNs make up the logical storage layer.

# FlexVol Volumes

- FlexVol volumes:
  - Depend on the associated aggregate for physical storage
  - Can increase or decrease in size as needed
- Aggregates: Can contain multiple FlexVol volumes
- Data containers:
  - **NAS**: Contain file systems for user data
  - **SAN**: Contain LUNs



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A FlexVol volume is a volume that is loosely coupled to a containing aggregate, which the volume can share with other FlexVol volumes. Therefore, one aggregate can be the shared source of all the storage that is used by all the FlexVol volumes that the aggregate contains.

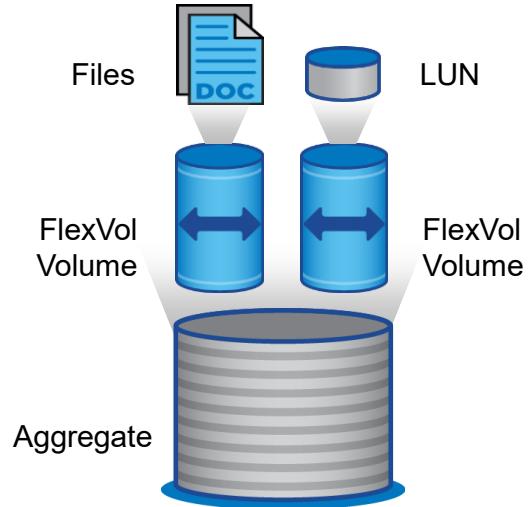
Because a FlexVol volume is managed separately from the aggregate, you can create small FlexVol volumes (20 MB or larger). You can also increase or decrease the size of FlexVol volumes in increments as small as 4 KB.

FlexVol volumes have one of two formats: 64-bit or 32-bit. A 64-bit volume has a larger maximum size than a 32-bit volume. A newly created FlexVol volume has the same format as the associated aggregate. However, a volume can have a different format than the associated aggregate in certain cases. The maximum size of a 64-bit volume is determined by the size of the associated aggregate, which depends on the storage system model. A 32-bit volume has a maximum size of 16 TB.

# FlexVol Volumes

## Types

- System (or node root):
  - Typically named vol0
  - Should contain only configuration and logs
  - Should not contain user data
  - Owned by node storage virtual machine (SVM)
- SVM root volume:
  - Top level of the namespace
  - Should not contain user data
- Data:
  - **NAS:** Contain file systems for user data
  - **SAN:** Contain LUNs



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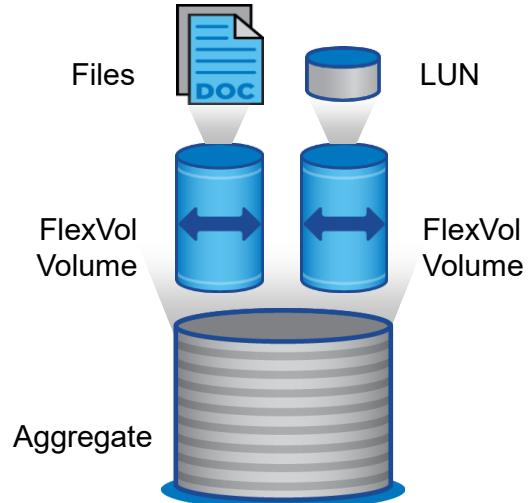
6

FlexVol volumes are used for the following:

- As node root volumes to hold state data for the node and for the cluster
- As the root of a storage virtual machine (SVM) namespace
- To store user data within an SVM

## Files and LUNs

- **File:** Refers to any data that is exported or shared to NAS clients (including text file, spreadsheet, database)
- **LUN:** Represents a logical disk that a SCSI protocol (FC or iSCSI) addresses:
  - Block level
  - Data accessible only by a properly mapped SCSI host



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Data that is stored in a volume for a NAS environment is stored as files. Files can be documents, database files and logs, audio and video, or application data. ONTAP software manages the file system operations, and clients access the data.

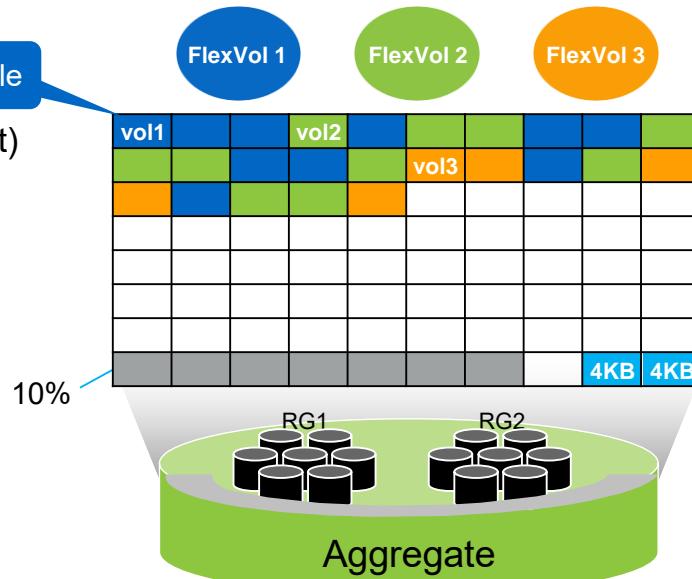
Data that is stored in a SAN environment is stored in a logical container that represents a SCSI disk. The container is called a *LUN*. The LUN is presented to a host, which treats the LUN like a standard SCSI disk and writes data to the LUN in 512-byte logical blocks. Therefore, SAN is often called block-level storage—because data is stored in 512-byte SCSI blocks. ONTAP software is “unaware” of the stored files and is “aware” only of the 512-byte blocks that the host is reading or writing to.

**NOTE:** Because SAN data (block data) and NAS data (file data) are treated differently, files and LUNs should not be placed in the same FlexVol volume.

# Volumes in Aggregates

- Aggregate:
  - 4-KB blocks
  - WAFL (Write Anywhere File Layout) file system reserving 10%

- Volume:
  - Provisioning types:
    - **Thick:** Volume guarantee = volume
    - **Thin:** Volume guarantee = none
  - Dynamic mapping to physical space



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One or more FlexVol volumes can be created in an aggregate. To understand how space is managed, examine how space is reserved in the aggregate.

The WAFL (Write Anywhere File Layout) file system writes data in 4-KB blocks that are contained in the aggregate. When the aggregate is created, WAFL reserves 10% capacity for overhead. The remainder of the aggregate is available for volume creation.

A FlexVol volume is a collection of disk space that is provisioned from the available space within an aggregate. FlexVol volumes are loosely tied to their aggregates. FlexVol volumes are striped across all the disks of the aggregate, regardless of the volume size. In the example, the blue block that is labeled "vol1" represents the inode file for the volume, and the other blue blocks contain the user data.

When a volume is created, the volume guarantee setting must be configured. The volume guarantee setting is the same as the space reservations. If space is reserved for the volume, the volume is thick-provisioned. If space is not reserved during creation, the volume is thin-provisioned. FlexVol volumes are dynamically mapped to physical space. Whether the volume is thick-provisioned or thin-provisioned, blocks are not consumed until data is written to the storage system.

A FlexVol volume can be as small as 20 MB or as large as the controller model supports. Also, the volume can grow or shrink, regardless of the provisioning type.

# Volume Properties

## Actions that can be taken on volumes:

- Create
- Edit
- Resize
- Delete
- Clone
- Move



## Volume options:

- Storage efficiency
- Storage quality of service (QoS)\*

\*Discussed in Module 8.



## Tools to protect volumes:

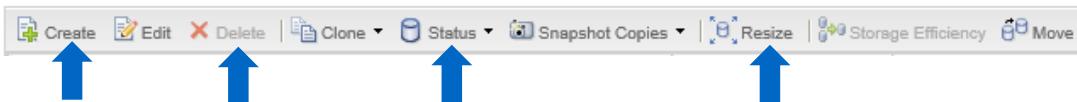
- Snapshot copies
- Mirrors\*\*
- Vaults\*\*

\*\*Covered in *ONTAP Data Protection Administration*



# Management of FlexVol Volumes

## Volumes



- Create

```
rtp-nau::> volume create -vserver svm_blue -name blue_vol1 -aggr rtp01_fc1_001  
-size 200gb
```

- Resize

```
rtp-nau::> vol modify -vserver svm_blue -name blue_vol1 -size +10gb
```

- Offline and online

```
rtp-nau::> vol offline -vserver svm_blue -name blue_vol1  
rtp-nau::> vol online -vserver svm_blue -name blue_vol1
```

- Destroy

```
rtp-nau::> vol delete -vserver svm1 -name blue_vol1
```

Must be offline

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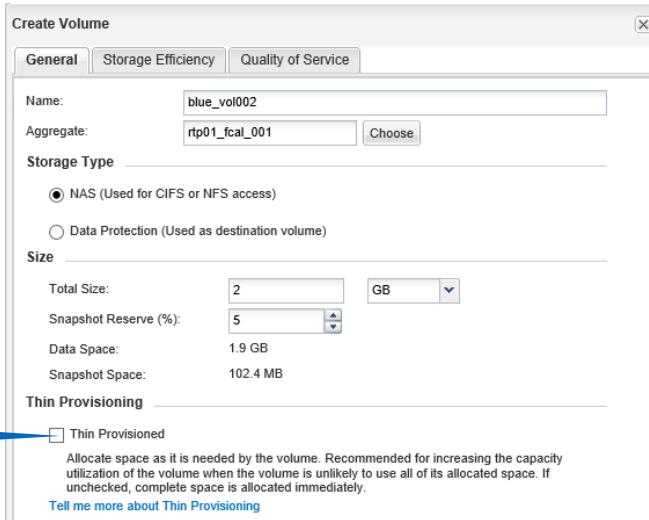
Volume clustershell options correspond to actions on the volume toolbar in NetApp OnCommand System Manager.

# Create a Flexible Volume in an SVM

Information to provide:

- Volume name
- Aggregate name
- Capacity
- Storage type (available data protocols, by default)

Discussed later



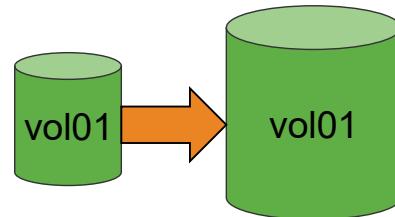
```
rtp-nau::> volume create -vserver svm_blue -name blue_vol002 -aggr rtp01_fc1_001  
-junction-path /vol002 -size 200gb
```

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## Automatic Resizing of Volumes

- Automatic resizing of volumes enables a FlexVol volume to automatically grow or shrink the maximum space capacity of the volume.
- You can specify a mode:
  - **Off:** Volume does not grow or shrink.
  - **Grow:** Volume automatically grows when space in the volume reaches a threshold.
  - **Grow\_shrink:** Volume automatically grows or shrinks in response to the amount of used space.
- In addition, you can specify the following:
  - Maximum to grow (default is 120% of volume size)
  - Minimum to shrink (default is volume size)
  - Grow and shrink thresholds



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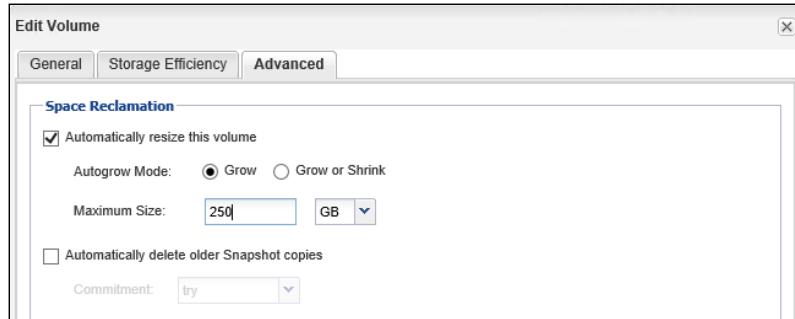
You can enable or disable automatic resizing of volumes. If you enable the capability, ONTAP automatically increases the capacity of the volume up to a predetermined maximum size. Space must be available in the containing aggregate to support the automatic growth of the volume. Therefore, if you enable automatic resizing, you must monitor the free space in the containing aggregate and add more when needed.

The capability cannot be triggered to support Snapshot creation. If you attempt to create a Snapshot copy and the volume has insufficient space, the Snapshot creation fails, even when automatic resizing is enabled.

For more information about using automatic resizing, see the *SAN Administration Guide*.

## Enabling Automatic Resizing

1. From Edit Volume, click the **Advanced** tab.
2. Select the **Automatically resize this volume** checkbox.
3. Select an Autogrow Mode option.
4. Specify the Maximum Size.



```
rtp-nau::> volume autosize -vserver svm_blue -volume blue_vol002 -mode grow  
-maximum-size 250GB
```

## ACTION: Try This Task



Using svi-nau on your lab kit:

1. Enter the **vol show** command.
2. Enter the **vol show -instance** command.
3. Enter the **vol show -fields comment** command.
4. Answer the following questions:
  - What was different about the output?
  - Can you think of other reasons to use **-fields**?
  - How can you get a list of all the fields that are available for a command?

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1. The difference is the amount of information displayed about each volume.
2. To customize the command output for your requirements.
3. Type a ? after the **-fields** parameter.



## Lesson 2

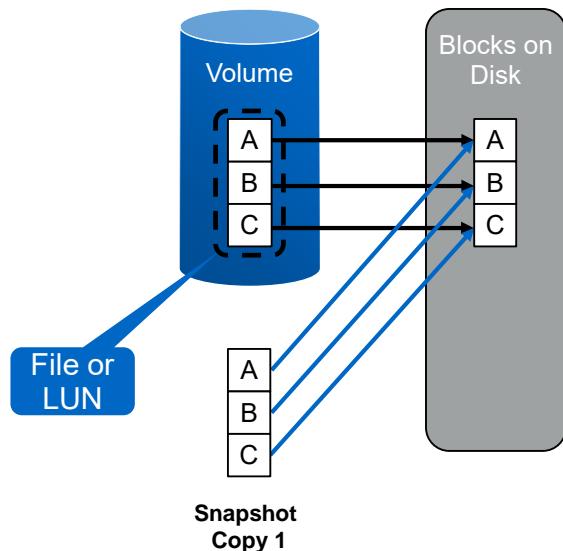
### Managing Snapshot Copies

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# Snapshot Copy Technology

## Create Snapshot copy 1



### 1. Create Snapshot copy 1:

- Pointers are copied.
- No data is moved.

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Understanding the technology that is used to create a Snapshot copy helps you to understand how space is utilized. Furthermore, understanding the technology also helps you to understand features such as FlexClone technology, deduplication, and compression.

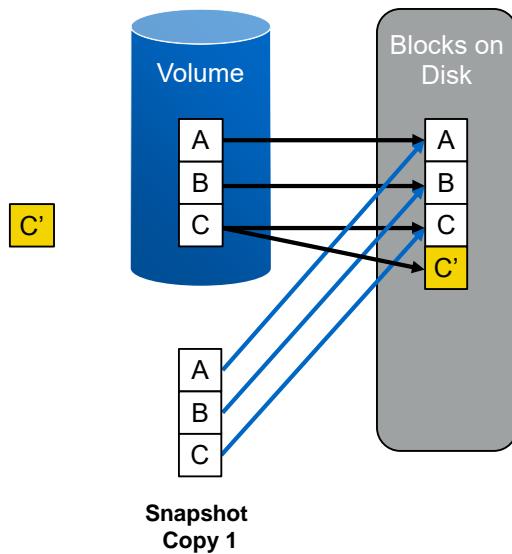
A Snapshot copy is a local, read-only, point-in-time image of data. Snapshot copy technology is a built-in feature of WAFL storage virtualization technology and provides easy access to old versions of files and LUNs.

When ONTAP creates a Snapshot copy, ONTAP starts by creating pointers to physical locations. The system preserves the inode map at a point in time and then continues to change the inode map on the active file system. ONTAP then retains the old version of the inode map. No data is moved when the Snapshot copy is created.

Snapshot technology is highly scalable. A Snapshot copy can be created in a few seconds, regardless of the size of the volume or the level of activity on the NetApp storage system. After the copy is created, changes to data objects are reflected in updates to the current version of the objects, as if the copy did not exist. Meanwhile, the Snapshot copy of the data remains stable. A Snapshot copy incurs no performance overhead. Users can store as many as 255 Snapshot copies per volume. All the Snapshot copies are accessible as read-only and online versions of the data.

# Snapshot Copy Technology

Continue writing data



1. Create Snapshot copy 1.
2. Continue writing data:
  - Data is written to a new location on the disk.
  - Pointers are updated.

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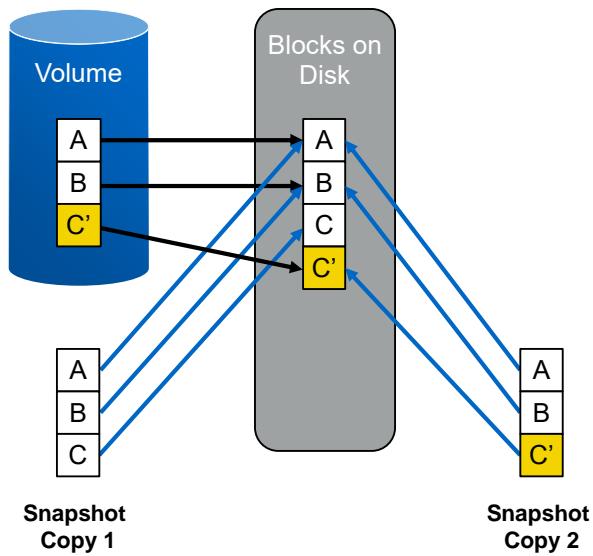
17

When ONTAP writes changes to disk, the changed version of block C is written to a new location. In the example, C' is the new location. ONTAP changes the pointers rather than moving data.

The file system avoids the parity update changes that are required if new data is written to the original location. If the WAFL file system updated the same block, then the system would need to perform multiple parity reads to update both parity disks. The WAFL file system writes the changed block to a new location, again writing in complete stripes and without moving or changing the original data blocks.

# Snapshot Copy Technology

## Create Snapshot copy 2



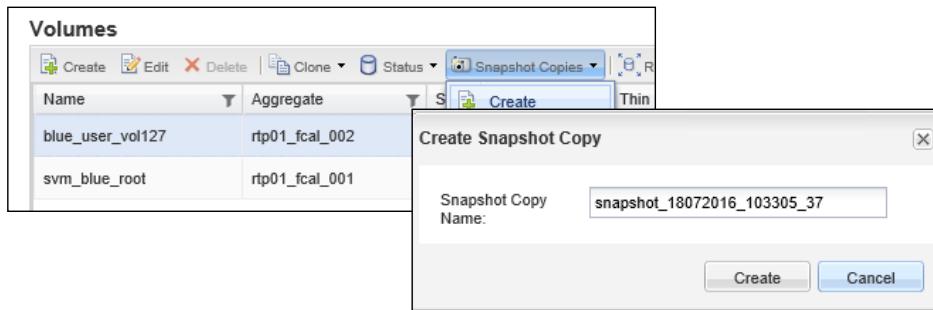
1. Create Snapshot copy 1.
2. Continue writing data.
3. Create Snapshot copy 2:
  - Pointers are copied.
  - No data is moved.

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When ONTAP creates another Snapshot copy, the new Snapshot copy points only to the unchanged blocks A and B and to block C'. Block C' is the new location for the changed contents of block C. ONTAP does not move any data; the system keeps building on the original active file system. The method is simple and so is good for disk use. Only new and updated blocks use additional block space.

## Create a Snapshot Copy



```
rtp-nau::> snapshot create -vserver svm_blue -volume blue_user_vol127
```

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You can use OnCommand System Manager or clustershell to create, schedule, and maintain Snapshot copies for volumes and aggregates.

# Snapshot Copy Design

- Understand that Snapshot copy design is highly dependent on the customer environment.
- Study the customer recovery time objective (RTO) and recovery point objective (RPO) requirements.
- Do not create more Snapshot copies than necessary.
- Check and adjust the aggregate and volume Snapshot copy reserve defaults.
- To control storage consumption, configure Snapshot copy automatic deletion and volume automatic increase.

Snapshot copies are the first line of defense against accidental data loss or inconsistency. Before you implement a Snapshot copy solution, you should thoroughly understand the customer needs and environment. Each customer has unique requirements for the recovery time objective (RTO) and recovery point objective (RPO).

## RTO

The RTO is the amount of time within which the service, data, or process must be made available again to avoid undesirable outcomes.

## RPO

The RPO is a point to which data must be restored or recovered to be acceptable to the organization's acceptable data loss policy.

To provide efficient use of disk space, deploy only the required number of Snapshot copies on each volume. If you deploy more Snapshot copies than are required, the copies consume more disk space than necessary.

You might need to adjust default settings for Snapshot copy reserve for volumes and aggregates:

- Snapshot copy reserve guarantees that you can create Snapshot copies until the reserved space is filled.
- When Snapshot copies fill the reserved space, then Snapshot blocks compete for space with the active file system.

# Naming Conventions for Snapshot Copies

- A Snapshot copy name can have a prefix or schedule name, timestamp, comment, and label:

vserver	volume	snapshot
Svm_blue	blue_user_vol127	2HourSnapshot.2016-07-11_1030
		

- Snapshot copy names cannot be longer than 255 characters.

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By taking advantage of the Snapshot copy prefix, timestamp, and comment features system, administrators can easily determine why a Snapshot copy was created.

## The Prefix or Schedule

- The prefix is an optional string of characters that you can specify for an automatic Snapshot copy. If a prefix is specified, then the Snapshot name is made up of the *prefix* and *timestamp*. Prefix names must be unique within a policy.
  - A schedule cannot have more than one prefix. The number of characters in the prefix counts toward the 255-character limit on the Snapshot name.

If a prefix is specified in the Snapshot schedule, then the schedule name is not used. The schedule name is used if the prefix is not specified for a Snapshot schedule:

```
volume snapshot policy add-schedule -policy <snapshot policy> -schedule <text> -  
count <integer> [-prefix <text>]
```

## The Comment

Use the `volume snapshot modify` command to change the text comment that is associated with a Snapshot copy.

## The Label

The Vaulting subsystem uses the SnapMirror label when you back up Snapshot copies to the Vault Destination. If an empty label ("") is specified, the existing label is deleted.

# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes

## Instructor begins polling session

- Questions appear in the polling panel.
- Answer each question.
- When finished, click "Submit."

## Instructor ends polling session

- Correct answers have a green check mark.
- Compare your answers to the correct answers.

## Instructor leads debrief discussion

Raise your hand to ask a question or make a comment.



## Poll Question

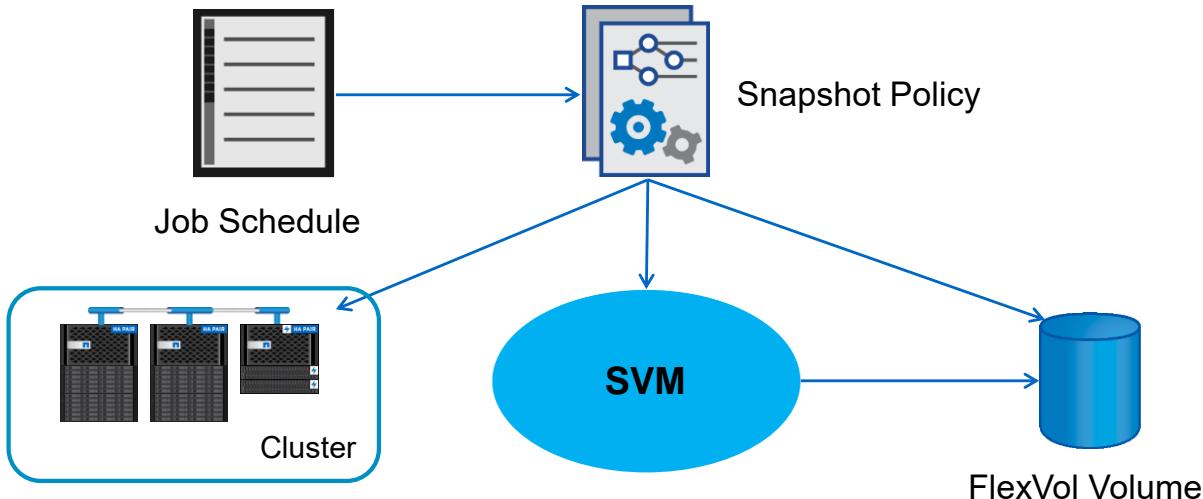
Check your understanding

Data can be written to a Snapshot copy.

- a. True
- b. False

# The Snapshot Policy

Automatically manage Snapshot copy schedules and retention.



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A Snapshot policy enables you to configure the frequency and maximum number of Snapshot copies that are created automatically:

- You can create Snapshot policies as necessary.
- You can apply one or more schedules to the Snapshot policy.
- The Snapshot policy can have zero schedules.

When you create an SVM, you can specify a Snapshot policy that becomes the default for all FlexVol volumes that are created for the SVM. When you create a FlexVol volume, you can specify which Snapshot policy you want to use, or you can enable the FlexVol to inherit the SVM Snapshot policy.

The default Snapshot policy might meet your needs. The default Snapshot copy policy is useful if users rarely lose files.

The default Snapshot policy specifies the following:

- Weekly schedule to keep two weekly Snapshot copies
- Daily schedule to keep two daily Snapshot copies
- Hourly schedule to keep six hourly Snapshot copies

However, if users often lose files, then you should adjust the default policy to keep Snapshot copies longer:

- Weekly schedule to keep two weekly Snapshot copies
- Daily schedule to keep six daily Snapshot copies
- Hourly schedule to keep eight hourly Snapshot copies

For typical systems, only 5% to 10% of the data changes each week: six daily and two weekly Snapshot copies consume 10% to 20% of disk space. Adjust the Snapshot copy reserve for the appropriate amount of disk space for Snapshot copies.

Each volume on an SVM can use a different Snapshot copy policy. For active volumes, create a Snapshot schedule that creates Snapshot copies every hour and keeps them for just a few hours, or turn off the Snapshot copy feature.

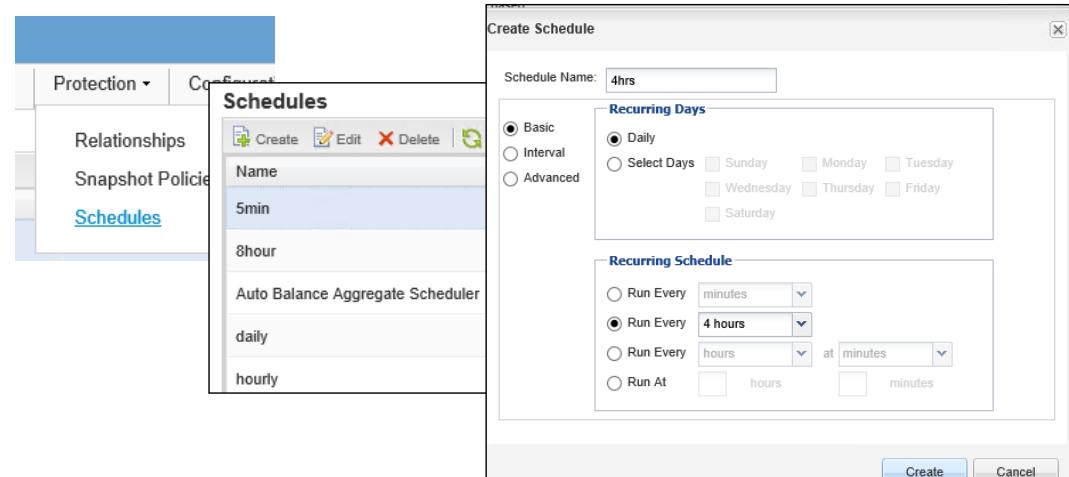
You back up Snapshot copies to the Vault Destination. If an empty label ("") is specified, the existing label is deleted.

## Typical Workflow

1. Create a job schedule, or use the default.
2. Create a Snapshot policy, and then specify the job schedule.
3. Assign the Snapshot policy to a FlexVol volume, or inherit a Snapshot policy from the SVM.



## Create a Job Schedule



```
rtp-nau::> job schedule cron create -name 4hrs -dayofweek all  
-hour 4,8,12,16,20 -minute 0
```

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# Create a Snapshot Policy

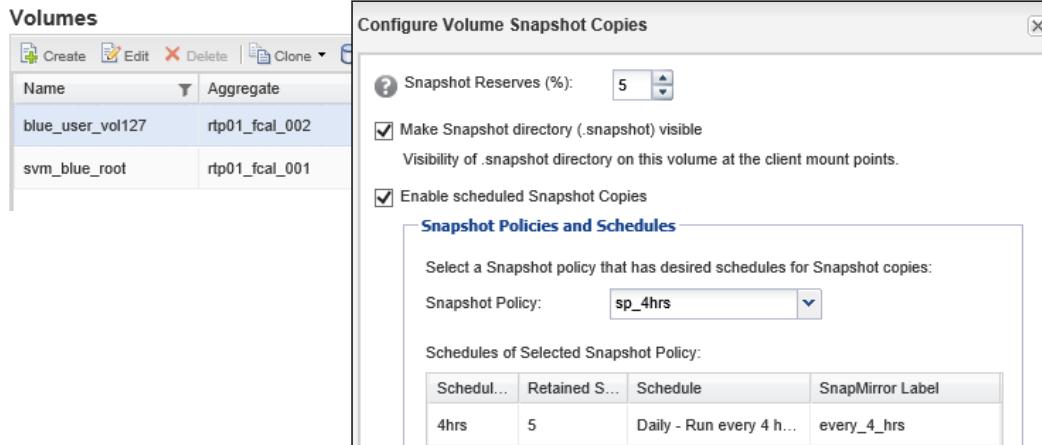
The screenshot shows the 'Snapshot Policies' configuration screen. On the left, there's a sidebar with 'Protection' dropdown, 'Relationships', 'Snapshot Policies' (selected), and 'Schedules'. The main area lists existing policies: 'default' (enabled), 'default-1weekly' (enabled), and 'none' (disabled). A blue callout box points from this list to a tooltip: 'Policies can run on multiple schedules and use different labels and retention counts for each.' To the right, a 'Create Snapshot Policy' dialog is open. It has fields for 'Name' (set to 'sp\_4hrs'), 'Schedules' (a table with one row: '4hrs' under 'Schedule Name', '5' under 'Maximum Snapshot Copies to be Retained', and 'every\_4\_hours' under 'SnapMirror Label'), and 'Add' (button). Below the dialog is a link 'Tell me more about Snapshot policies'.

```
rtp-nau::> volume snapshot policy create -vserver svm_blue  
-policy sp_4hrs -schedule1 4hrs -count1 5 -prefix1 every_4_hours
```

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## Apply Snapshot Policy to Volume



```
rtp-nau::> vol modify -vserver svm_blue -volume blue_user_vol127  
-snapshot-policy sp_4hrs
```

## ACTION: Topics for Discussion



- Should all hourly Snapshot copies run on the hour?
- Why or why not?



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## Lesson 3

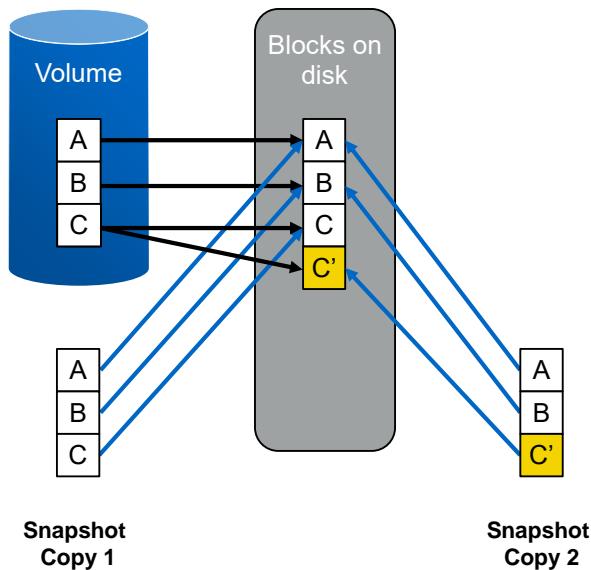
### Restoring Data from a Snapshot Copy

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# Snapshot Copy Technology

## Restore from a Snapshot copy



- To restore a file or LUN from Snapshot copy 1, use SnapRestore data recovery software.
- Snapshot copies that were created after Snapshot copy 1 are deleted.
- Unused blocks on disk are made available as free space.

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Suppose that after the Snapshot copy is created, the file or LUN becomes corrupted, which affects logical block C'. If the block is physically bad, RAID can manage the issue without recourse to the Snapshot copies. In the example, block C' becomes corrupted because part of the file is accidentally deleted. You want to restore the file.

To easily restore data from a Snapshot copy, use the SnapRestore feature. SnapRestore technology does not copy files; SnapRestore technology moves pointers from files in the good Snapshot copy to the active file system. The pointers from the good Snapshot copy are promoted to become the active file system pointers. When a Snapshot copy is restored, all Snapshot copies that were created after that point in time are destroyed. The system tracks links to blocks on the WAFL system. When no more links to a block exist, the block is available for overwrite and is considered free space.

Because a SnapRestore operation affects only pointers, the operation is quick. No data is updated, nothing is moved, and the file system frees any blocks that are used after the selected Snapshot copy. SnapRestore operations generally require less than one second. To recover a single file, the SnapRestore feature might require a few seconds or a few minutes.

# Recovering Data

Recover Snapshot Data	Copy from a Snapshot Copy	Use SnapRestore Technology
<ul style="list-style-type: none"><li>▪ Copy data from Snapshot data.</li><li>▪ Use SnapRestore data recovery software.</li><li>▪ Use the Windows Previous Versions feature.</li></ul>	<ul style="list-style-type: none"><li>▪ Locate the Snapshot copy.</li><li>▪ Copy the file to the original location.</li><li>▪ Copy the file to a new location.</li></ul>	<ul style="list-style-type: none"><li>▪ Requires a SnapRestore license</li><li>▪ Restores entire volumes</li><li>▪ Quickly restores large files</li></ul>

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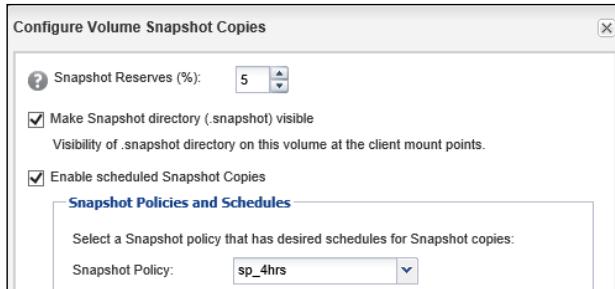
32

You can use Snapshot copies to recover data in two ways:

- **Copy a file from a Snapshot directory:** To copy a lost or corrupted file from a Snapshot copy, navigate to the Snapshot directory on the client host. Locate the Snapshot copy that contains the correct version of the file. You can copy the file to the original location and overwrite existing data or copy the file to a new location.
- **Use the SnapRestore feature to recover data:** To revert a volume or a file from a Snapshot copy, you need the SnapRestore license. You can revert a volume or file from the storage CLI or from the OnCommand System Manager interface.

# Snapshot Visibility to Clients

Enable client access to a Snapshot directory.



```
rtp-nau::> vol modify -vserver svm1 -vol vol01 -snapdir-access true  
rtp-nau::> vserver cifs share modify -vserver svm1 -share svm1v01  
-share-properties showsnapshot
```

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CLI commands are available to control the visibility of Snapshot directories on a volume from NAS clients.

**NOTE:** Show Hidden Files and Folders must be enabled on your Windows system.

To make the .snapshot directory invisible to NFS clients, turn on the `nfs.hide_snapshot` option. Turn off the `nosnapdir` option for each volume for which you want directories to be visible.

Access to .snapshot and ~snapshot is controlled at the volume level by setting the `-snapdir-access` switch. In addition, you can control access to ~snapshot from CIFS clients at the share level with the `showsnapshot` share property.

## ACTION: Topic for Discussion



What are the advantages and disadvantages of enabling clients to restore their own data?



## Snapshot View from a UNIX Client

```
# ls /system/vol01/.snapshot
weekly.2014-09-15_0015    daily.2014-09-18_0010
daily.2014-09-19_0010     hourly.2014-09-19_0605
hourly.2014-09-19_0705   hourly.2014-09-19_0805
hourly.2014-09-19_0905   hourly.2014-09-19_1005
hourly.2014-09-19_1105   hourly.2014-09-19_1205
snapmirror.3_2147484677.2014-09-19_114126
```

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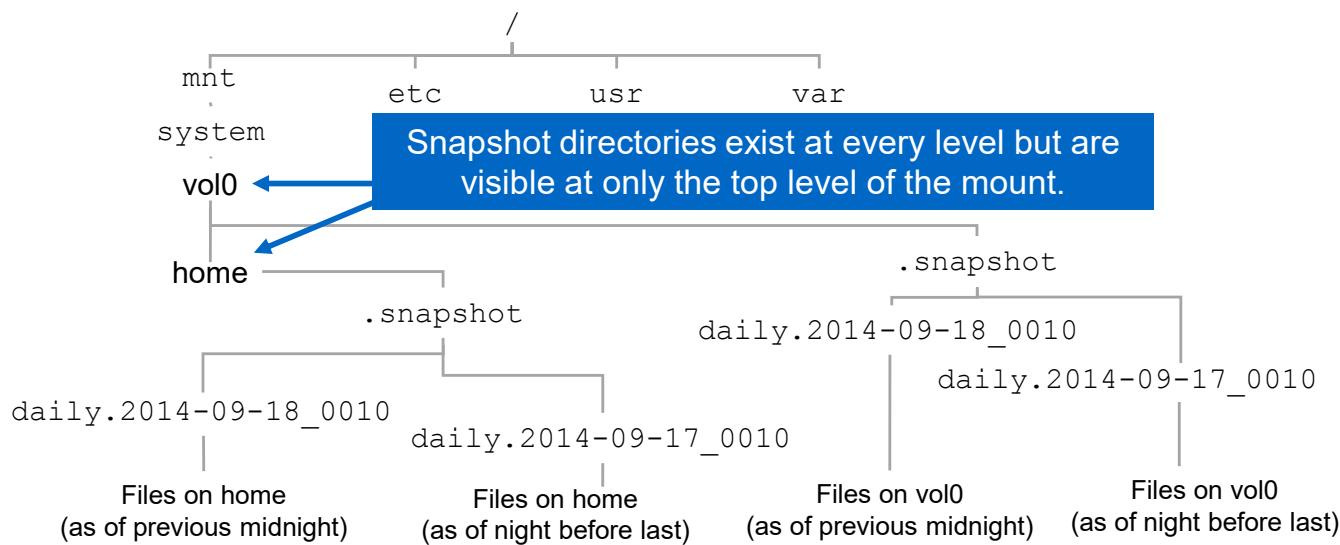
35

Every volume in your file system contains a special Snapshot subdirectory that enables users to access earlier versions of the file system to recover lost or damaged files.

The Snapshot directory appears to NFS clients as .snapshot. The .snapshot directory is usually hidden and is not displayed in directory listings, unless you use the `ls` command with the `-a` option.

When client Snapshot directories are listed, the timestamp is usually the same for all directories. To find the actual date and time of each Snapshot copy, use the `snap list` command on the storage system.

# Recovering Files from the .snapshot Directory of a UNIX Host



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The .snapshot directory is at the root of a storage system volume.

In the example, the directory structure is shown for an NFS client that has mounted vol0 of a storage system to the mount point /mnt/system on the UNIX host.

The home directory and the .snapshot directory are visible at the root of the vol0 mount.

You can open the .snapshot directory and access the files in the two Snapshot copies that are subdirectories of the .snapshot directory.

To restore a file from the .snapshot directory, rename or move the original file, then copy the file from the .snapshot directory to the original directory.

# Recovering Files from the ~snapshot Directory

Snapshot copies are visible to Windows clients that have File Manager configured to display hidden files.

Name	Date modified	Type	Size
~snapshot	10/6/2016 12:33 PM	File folder	
Financial	10/28/2016 3:38 PM	File folder	
Misc	10/28/2016 3:37 PM	File folder	
Projects	10/28/2016 3:37 PM	File folder	
7_JulyData	10/28/2016 3:44 PM	Text Document	0 KB
8_AugustData	10/28/2016 3:44 PM	Text Document	0 KB
file1	10/6/2016 12:33 PM	Text Document	0 KB
file2	10/28/2016 3:41 PM	Text Document	1 KB

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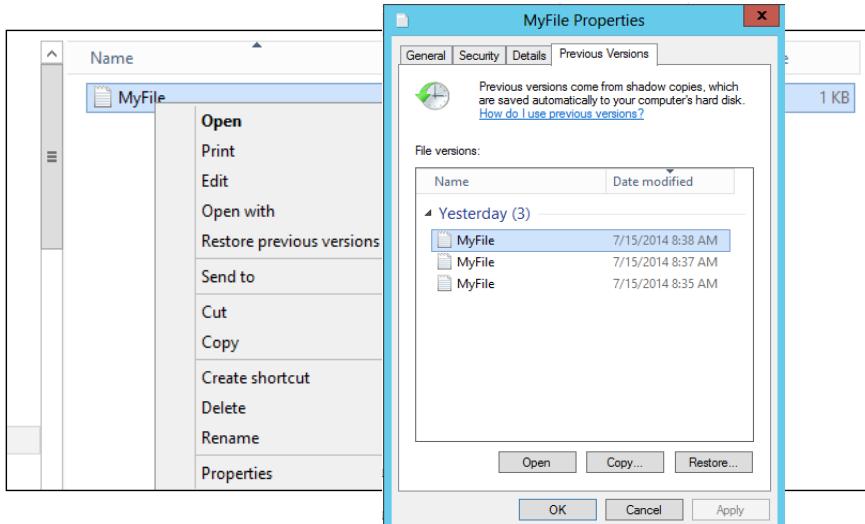
37

Snapshot directories are hidden on Windows clients. To view them, you must first configure File Manager to display hidden files, then navigate to the root of the CIFS share and find the directory folder.

The subdirectory for Snapshot copies appears to CIFS clients as ~snapshot. Both automatic and manually created Snapshot copies are listed.

To restore a file from the ~snapshot directory, rename or move the original file, then copy the file from the ~snapshot directory to the original directory.

# Restoring Previous Versions in Windows

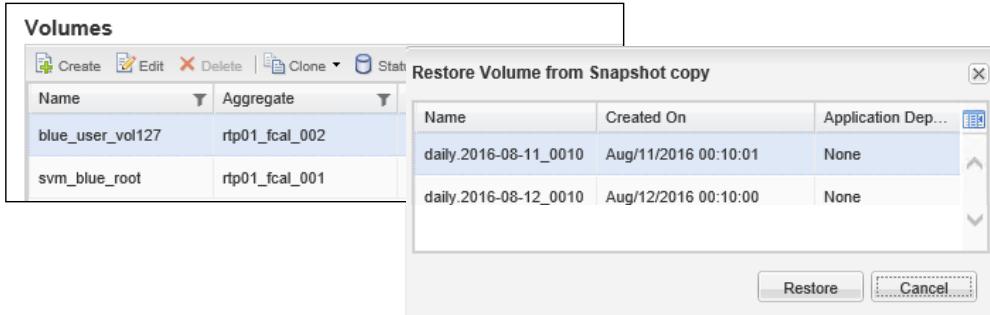


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In Windows, right-click the file, and from the list, select **Restore previous versions**.

## Reverting and Restoring a File



1. Verify that the volume is online and writable.
2. List the Snapshot copies in the volume.  

```
rtp-nau::> volume snapshot show -vserver svm_blue -volume vol01
```
3. Notify network users about the reversion.
4. If you know the names of the Snapshot copy and the file to restore, initiate the reversion.  

```
rtp-nau::> volume snapshot restore-file -vserver svm_blue -volume vol01  
snapshot vol01_snap -path /vol3/myfile.txt
```

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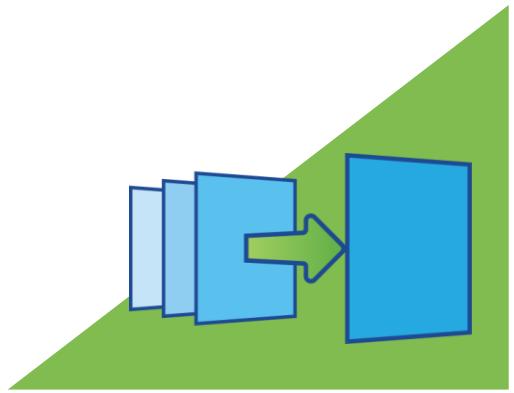
After you complete the steps to revert a file, ONTAP software displays a warning message and prompts you to confirm your decision to revert the file. Press **Y** to confirm that you want to revert the file. If you do not want to proceed, press **Ctrl+C** or press **N**.

If you confirm that you want to revert the file that exists in the active file system, the file is overwritten by the version in the Snapshot copy.

## SnapRestore Technology Versus Copying

If a file is large (such as a database), you should use SnapRestore technology to revert instead of copying the file:

- Copying requires double the storage and time.
- Reverting saves time and reinstates the data.
- For reliability, NetApp recommends SnapRestore technology over alternative technologies.

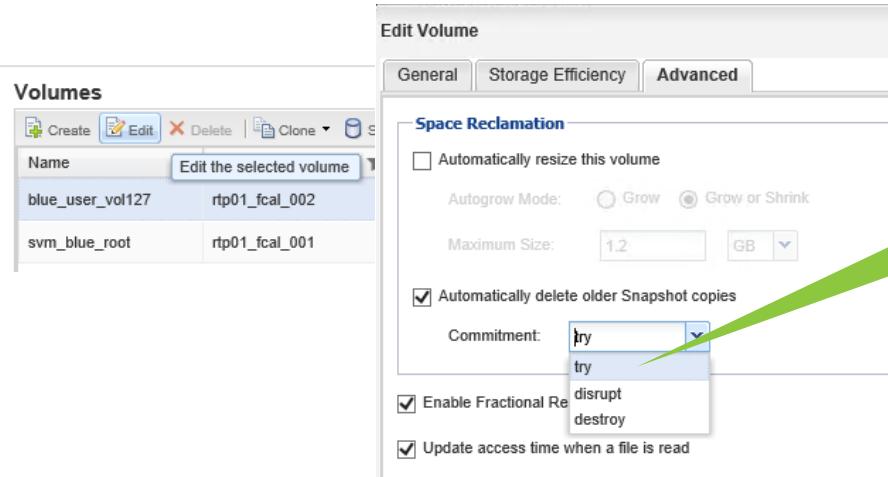


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Whether you restore by copying files from a Snapshot directory or from tape, copying large quantities of data can be time consuming. Instead, use the SnapRestore function to restore by reverting the volume or file.

# Snapshot Automatic Delete



```
rtp-nau::> volume snapshot autodelete modify -vserver svm_blue -volume  
blue_user_vol127 -enabled true
```

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Snapshot automatic delete determines when or if Snapshot copies are automatically deleted. The option is set at the volume level.

# ACTION: Complete an Exercise

Module 6: Managing Data Volumes and Snapshot Copies



Duration: 30 minutes

## Access your lab equipment.

Use the login credentials that your instructor provided to you.

## Complete the specified exercises.

- Go to the exercise for the module.
- Start with Exercise 1.
- Stop at the end of Exercise 1.

## Participate in the review session.

- Share your results.
- Report issues.

# Share Your Experiences

Roundtable questions for the equipment-based exercises



- Why do you need FlexVol volumes?
- Why not place data directly on the aggregate?



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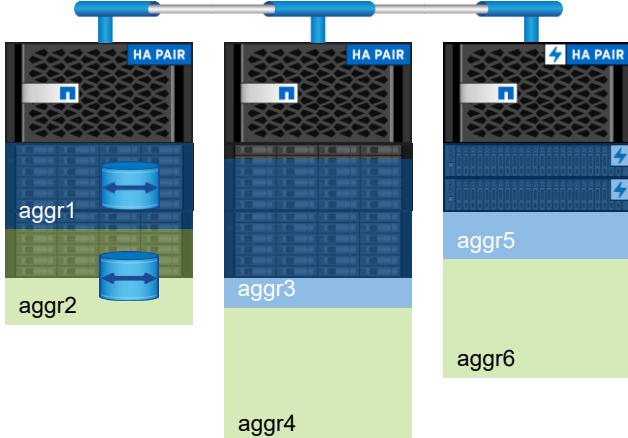
## Lesson 4

### Volume Moves

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# Moving Volumes



- Rules:

- To any aggregate in the cluster
- Only within the SVM
- Nondisruptively to the client

- Use cases:

- Capacity: Move a volume to an aggregate with more space.
- Performance: Move a volume to an aggregate with different performance characteristics.
- Servicing: Move volumes to newly added nodes or from nodes that are being retired.

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FlexVol volumes can be moved from one aggregate or node to another within the same storage virtual machine (SVM). A volume move does not disrupt client access during the move.

You can move volumes for capacity use, such as when more space is needed. You can move volumes to change performance characteristics, such as from a controller with hard disk drives (HDDs) to one that uses SSDs. You can also move volumes during service periods.

## How a Volume Move Works

- A volume is created on the destination aggregate.
- A Snapshot copy of the source volume is created.
- The Snapshot copy is replicated to the destination volume.
- When replication is complete, client access is temporarily blocked.
- A final replication is performed to reach consistency.
- **Cutover is initiated:** `-cutover-action`
  - `retry_on_failure (default)`
  - `defer_on_failure`
  - `abort_on_failure`
  - `force`
  - `wait`
- Clients access the destination volume and the source volume is cleaned up.

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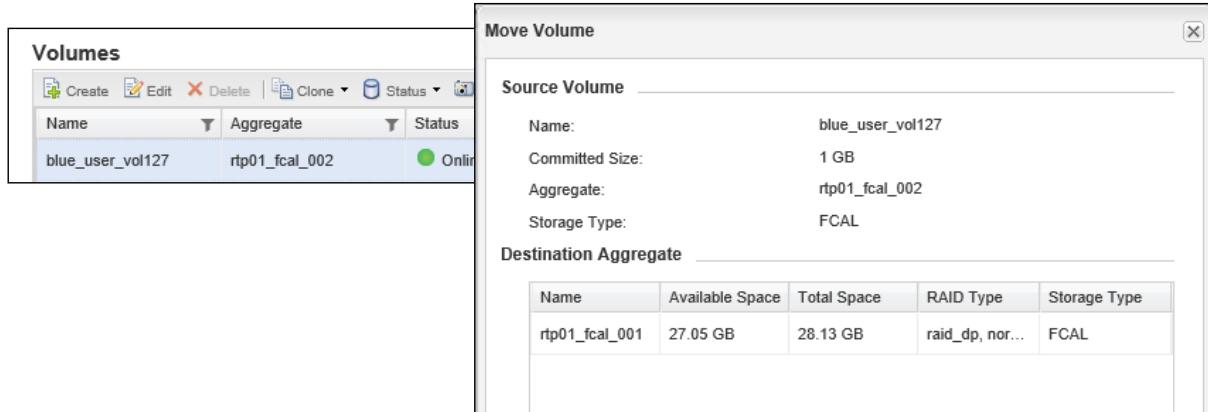
46

When a volume move is initiated, a Snapshot copy of the source volume is created and is used as the basis to populate the destination volume. Client systems continue to access the volume from the source destination until all data is moved. At the end of the move process, client access is temporarily blocked. Meanwhile, the system performs a final replication from the source volume to the destination volume, swaps the identities of the source and destination volumes, and changes the destination volume to the source volume. When the move is complete, the system routes client traffic to the new source volume and resumes client access.

Occasionally, especially when heavy client traffic exists on the source volume, ONTAP software is unable to complete a replication in a time frame that is transparent to clients. You can specify the `-cutover-action` option on a `volume move start` command to indicate what should happen in such situations:

- If the default action, `defer_on_failure`, is specified, the job tries to cut over until the cutover attempts are exhausted. If the system fails to cut over, then the system moves into the “cutover deferred state.” The volume move job waits for the user to issue a `volume move trigger-cutover` command to restart the cutover process.
- If the `abort_on_failure` action is specified, the job tries to cut over until cutover attempts are exhausted. If the system fails to cut over, then the system performs a cleanup and ends the operation.
- If the `force` action is specified, the job tries to cut over until the cutover attempts are exhausted, and then forces the cutover to occur at the expense of disrupting the clients.
- If the `wait` action is specified, then the job does not cut over automatically after reaching the decision point. Instead, the job waits for the user to issue a `volume move trigger-cutover` command as the signal to try the cutover.

# The volume move Command



```
rtp-nau::> vol move start -vserver svm_blue -vol blue_user_vol127
destination-aggr rtp01_fcav_001
rtp-nau::> vol move trigger-cutover -vserver svm_blue -vol blue_user_vol127
```

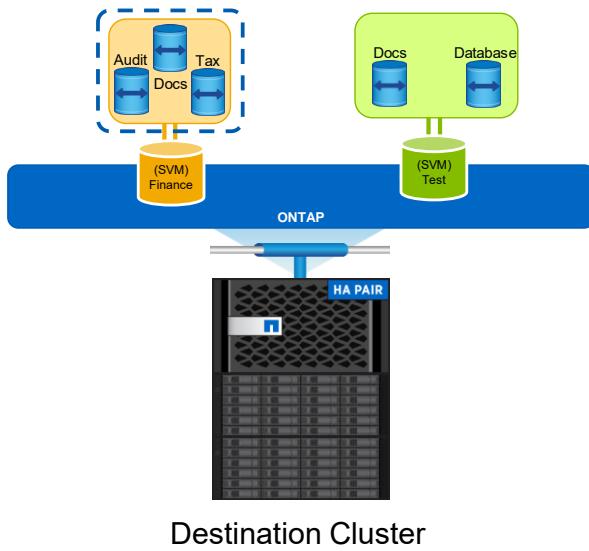
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ONTAP software enables you to move a volume from one aggregate or node to another within the same SVM to utilize capacity, improve performance, and satisfy SLAs. The volume move is a nondisruptive operation. During the volume movement process, the original volume is intact and available for clients to access. You can move a FlexVol volume to a different aggregate, node, or both within the same SVM. The data is transferred to the destination node through the cluster interconnect.

Use the `volume move start` command to initiate the volume transfer. If the cutover action is `defer_on_failure`, and the cutover state moves to “cutover deferred”, use the `volume move trigger-cutover` command to complete the move. To bypass any confirmation before cutover, use `-force true` on the `volume move start` command. The bypass can cause client I/O disruptions.

# Volume Rehost Within a Cluster



## Steps to rehost a volume:

1. Identify the source volume and SVM.
2. Identify the destination SVM within the cluster.
3. Prevent access to the volume that is being rehosted.
4. Rehost the volume to the destination SVM by using the `rehost` command.
5. Configure access to the volume in the destination SVM.

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The `volume rehost` command rehosts a volume from a source SVM to a destination SVM. The volume name must be unique among the other volumes on the destination SVM.

If the volume contains a LUN, you can specify that the LUN needs to be unmapped. In addition, you can specify whether you want the LUN to be automatically remapped on the destination SVM.

**NOTE:** Volume rehost is a disruptive operation and requires you to reconfigure access to the volume at the destination. Access to the volume must be prevented before a rehost to prevent data loss or inconsistency.

# Reference

*ONTAP Logical Storage Management Guide*



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# ACTION: Complete an Exercise

Module 6: Managing FlexVol Volumes



Duration: 20 minutes

## Access your lab equipment.

Use the login credentials that your instructor provided to you.

## Complete the specified exercises.

- Go to the exercise for the module.
- Start with Exercise 2.
- Stop at the end of Exercise 2.

## Participate in the review session.

- Share your results.
- Report issues.

# Share Your Experiences

Roundtable questions for the equipment-based exercises



Did your volume move operation disrupt the workload on the volume that was moved?



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## Module Review

This module focused on enabling you to do the following:

- Create and manage FlexVol volumes
- Manage Snapshot copies
- Move a volume within a storage virtual machine (SVM)



## Module 7

# Storage Efficiency

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## About This Module

This module focuses on enabling you to do the following:

- Implement storage efficiency features
- Use FlexClone volumes



## Lesson 1

### Thin Provisioning

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# Thick and Thin Provisioning of Volumes

- Thick provisioning of volumes (guarantee = volume):
  - Requires reserved space within the aggregate for volume creation
  - Cannot overcommit an aggregate
  - Simplifies storage management
- Thin provisioning of volumes (guarantee = none):
  - Does not require reserved space within the aggregate for volume creation
  - Enables more aggressive allocation
  - Can overcommit an aggregate
  - Requires more complex storage management

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4

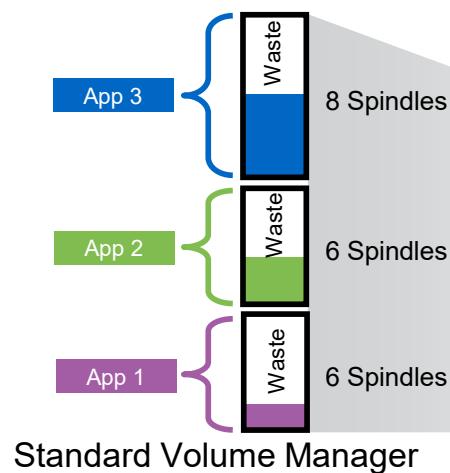
Administrators can manage storage systems by allocating volumes in one of two ways:

- Thick provisioning of volumes uses a space guarantee for a volume or file. A guarantee of a volume requires reserved space in the aggregate when the volume is created. A guarantee of file guarantees space for LUNs in the volume. Thick provisioning is a conservative approach that prevents administrators from overcommitting space to an aggregate. Thick provisioning simplifies storage management at the risk of wasting unused space.
- Thin provisioning of volumes uses a space guarantee of none, meaning that no space within the aggregate is reserved for the volume when the volume is created.

**NOTE:** The file guarantee is no longer supported as of NetApp Data ONTAP 8.3 software.

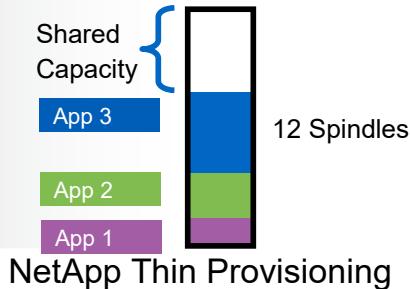
# Thin Provisioning

Typical: 40% use



NetApp: More than 70% use

- Buy 50% less storage.
- Save 50% power, cooling, and space.



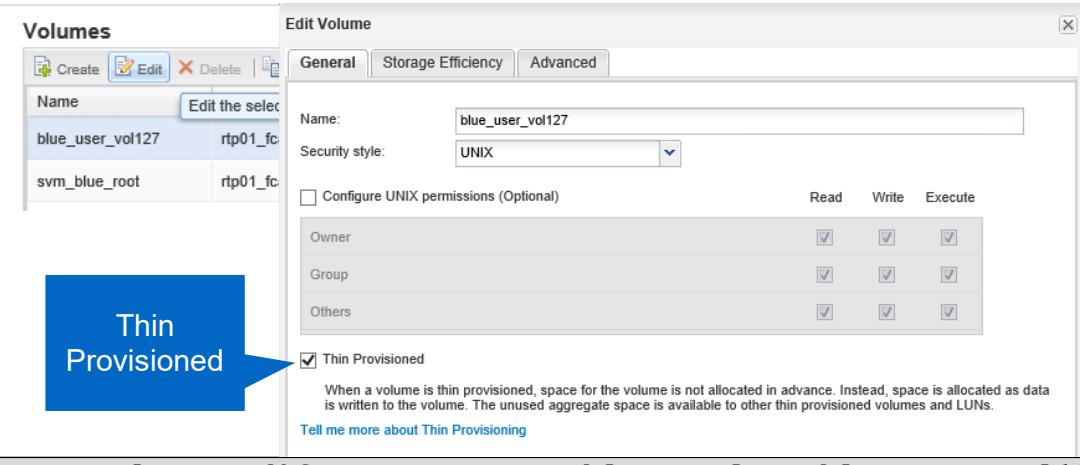
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When you compare the NetApp storage use approach to competitive approaches, one feature stands out. Flexible dynamic provisioning with FlexVol technology provides high storage use rates and enables customers to increase capacity without the need to physically reposition or repurpose storage devices. NetApp thin provisioning enables users to overcommit data volumes, resulting in high use models. You can think of the approach as “just-in-time” storage.

To manage thin provisioning on a cluster, use the `volume` command.

# Enable Thin Provisioning



```
rtp-nau::> volume modify -vserver svm_blue -volume blue_user_vol127  
-guarantee none
```

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## Lesson 2

### Deduplication and Compression

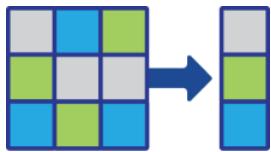
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# Volume Efficiency

## Deduplication:

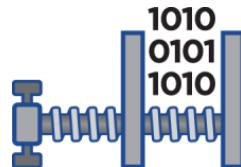
- Elimination of duplicate data blocks
- Inline or postprocess
- Inline deduplication for All Flash FAS and Flash Pool systems to reduce the number of writes to solid-state drives (SSDs)



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## Data compression:

- Compression of redundant data blocks
- Inline or postprocess
- Two compression methods:
  - **Secondary:** 32-KB compression groups
  - **Adaptive:** 8-KB compression groups, which improve read performance



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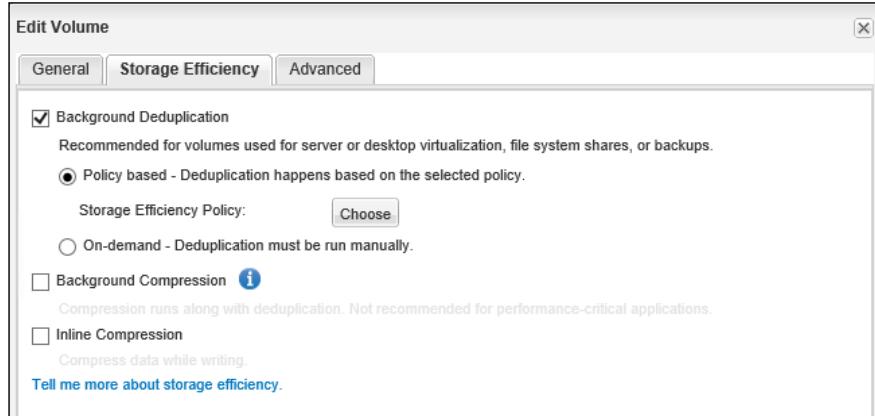
ONTAP software provides two features that can increase volume efficiency: deduplication and data compression. You can run deduplication and data compression together or independently on a FlexVol volume to reduce the amount of physical storage that a volume requires.

To reduce the amount of physical storage that is required, deduplication eliminates the duplicate data blocks and data compression compresses redundant data blocks. Depending on the version of ONTAP software and the type of disks that are used for the aggregate, the volume efficiency features can be run inline or postprocess.

Inline deduplication can reduce writes to solid-state drives (SSDs). Starting with Data ONTAP 8.3.2, inline deduplication is enabled by default on all new volumes that are created on the All Flash FAS systems. Inline deduplication can also be enabled on new and existing Flash Pool volumes.

Data compression combines multiple 4-KB WAFL (Write Anywhere File Layout) blocks together into compression groups before compression. Starting with Data ONTAP 8.3.1, two data compression methods can be used: secondary and adaptive.

# Enable Deduplication



```
rtp-nau::> volume efficiency on -vserver svm_blue -volume  
blue_user_vol127
```

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Deduplication improves physical storage-space efficiency by eliminating redundant data blocks within a FlexVol volume. Deduplication works at the block level on an active file system and uses the WAFL block-sharing mechanism. Each block of data has a digital signature that is compared with all the other blocks in the data volume. If an exact match is identified, the duplicate block is discarded. A data pointer is modified so that the storage system references the copy of the data object that is stored on disk. The deduplication feature works well with datasets that have large quantities of duplicated data or white space. You can configure deduplication operations to run automatically or according to a schedule. You can run deduplication on new or existing data on any FlexVol volume.

# Characteristics of Data Compression

- **Inline compression:**
  - Parallelism is increased.
  - Path length is decreased.
  - Latency is increased.
- **Postprocess compression:**
  - Decompressed data is compressed during idle time.
  - Only previously decompressed blocks are compressed.
  - Compression takes place before deduplication.
  - Data ONTAP 8.2 and later releases can detect incompressible data before wasting cycles.

See TR-4476: *NetApp Deduplication, Compression, and Compaction Deployment and Implementation Guide* for more information.

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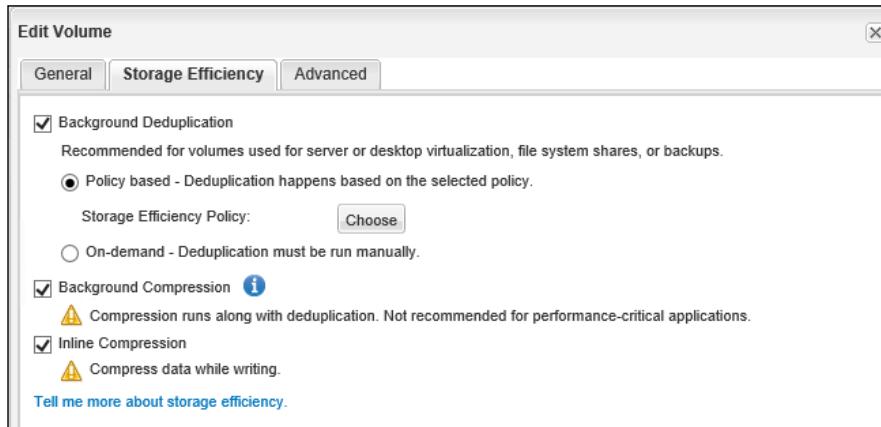
There are two types of data compression: inline and postprocess.

With inline compression, all writes to a volume are compressed immediately before being written to the volume. Inline compression increases parallelism because all compression and decompression algorithms are multiprocessor-capable and because writes are compressed outside the consistency point. Because operations do not need to be suspended and resumed, inline compression also reduces path length. However, because processing is required for compression and decompression, latency affects performance.

Postprocess compression runs as a background task. Decompressed data that is written after deduplication is compressed and rewritten to the volume when the controller is not busy. If inline and postprocess compression are enabled for the same volume, postprocess compression compresses only the blocks on the volume that were not compressed previously. If compression and deduplication are enabled, compression always occurs before deduplication.

For more information, see TR-3966: *NetApp Data Compression and Deduplication Deployment and Implementation Guide*.

# Configuring Data Compression



```
rtp-nau::> volume efficiency modify -vserver svm_blue -volume  
blue_user_vol127 -compression true -inline-compression true
```

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Data compression enables you to reduce the physical capacity that is required to store data on a cluster, by compressing data blocks within a FlexVol volume. Data compression is available only on FlexVol volumes that are created on 64-bit aggregates. Data compression optimizes the storage space and bandwidth that are required to replicate data during volume operations, such as moving volumes and performing SnapMirror transfers. You can compress standard data files, virtual disks, and LUNs, but not file system internal files, alternate data streams, or metadata.

To manage compression on a cluster, use the `volume efficiency` command.

# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes

## Instructor begins polling session

- Questions appear in the polling panel.
- Answer each question.
- When finished, click “Submit.”

## Instructor ends polling session

- Correct answers have a green check mark.
- Compare your answers to the correct answers.

## Instructor leads debrief discussion

Raise your hand to ask a question or make a comment.



## Poll Question

Check your understanding

Which types of data compression are available in ONTAP?

- a. inline and external
- b. inline and preprocess
- c. inline and postprocess
- d. inline and reclaimable

# ACTION: Complete an Exercise

Module 7: Managing Storage Efficiency



Duration: 30 minutes

## Access your lab equipment.

Use the login credentials that your instructor provided to you.

## Complete the specified exercises.

- Go to the exercise for the module.
- Start with Exercise 1.
- Stop at the end of Exercise 1.

## Participate in the review session.

- Share your results.
- Report issues.

## Share Your Experiences

Roundtable questions for the equipment-based exercises



Were you able to observe storage-efficiency benefits in your lab environment?





## Lesson 3

### Flash Efficiency

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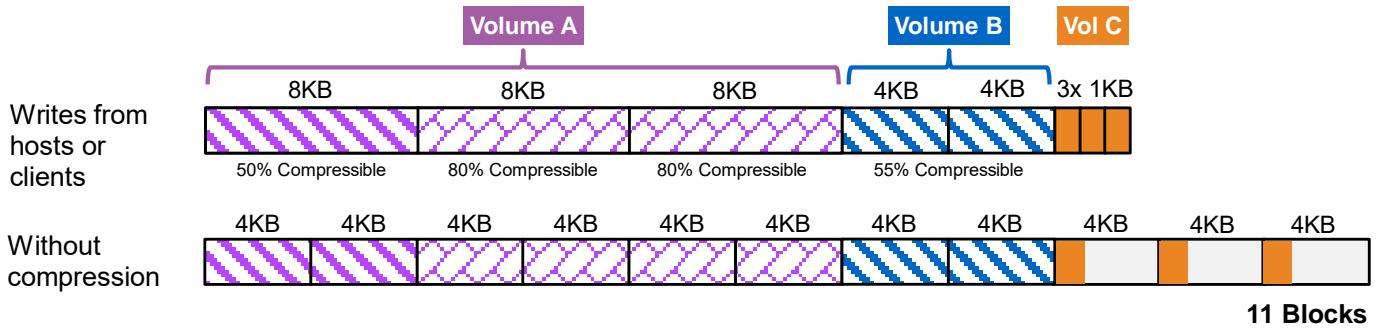
16

## Inline Data Compaction

- Writes multiple logical data blocks in the same volume to one 4-KB block on storage:
  - Compaction occurs during consistency point (CP) operation just before write to media.
  - Compression of 4-KB I/O also occurs when possible—adaptive compression ignores I/O of less than 8 KB.
  - Compaction occurs after inline adaptive compression and inline deduplication.
- Provides the following benefits:
  - Additional savings with highly compressible data—multiplies adaptive compression
  - Space savings for I/O and files of or less than 2 KB and larger I/O with a lot of “white space”
  - Limited preliminary test results showing that space savings with inline adaptive compression and inline data compaction can be as much as double the savings from adaptive compression alone
- Is enabled by default for new All Flash FAS systems that ship with ONTAP 9:
  - Optional policy for Flash Pool aggregates
  - Optional policy for hard disk drive (HDD)-only aggregates

# Storage Consumption

No inline storage efficiency



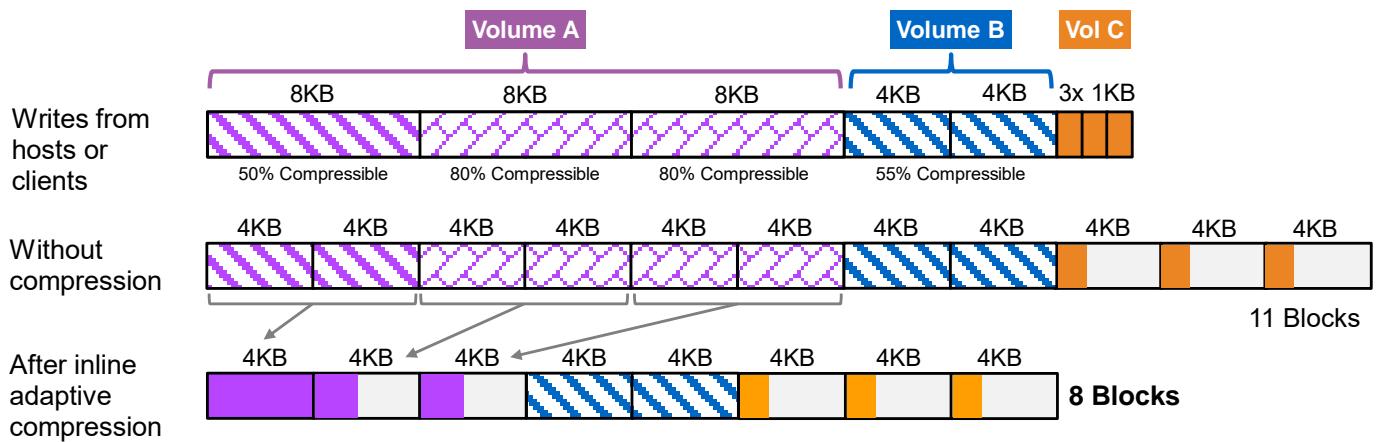
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The figure shows the writes for a host or client and the amount of space on disk without any efficiency features enabled.

# Storage Consumption

## Inline Adaptive Compression



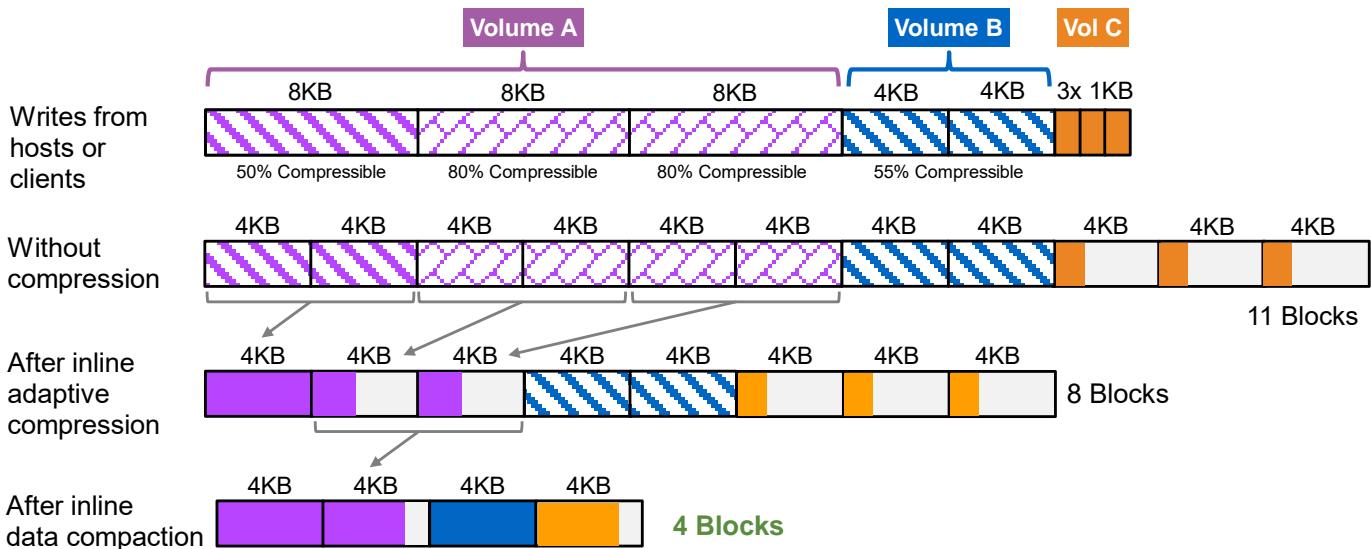
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Default policy for All Flash FAS systems running Data ONTAP 8.3.1 software and later.

# Storage Consumption

## Inline Adaptive Compression and Inline Data Compaction



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Default policy for All Flash FAS systems running ONTAP 9 software.

Data compaction is an inline operation and occurs after inline compression and inline deduplication. On an AFF system, the order of execution is as follows:

1. Inline zero-block deduplication. All zero blocks are detected, and no user data is written to physical storage; only metadata and reference counts are updated.
2. Inline adaptive compression. Compresses 8K logical blocks into 4K physical blocks; very efficient in determining compressibility of the data and doesn't waste lot of CPU cycles trying to compress incompressible data.
3. Inline deduplication. Opportunistically deduplicates incoming blocks to already existing blocks on physical storage.
4. Inline adaptive data compaction. Combines multiple <4K logical blocks into a single 4K physical block to maximize savings. It also tries to compress any 4K logical blocks that are skipped by inline compression to gain additional compression savings.



## Lesson 4

### FlexClone Volumes

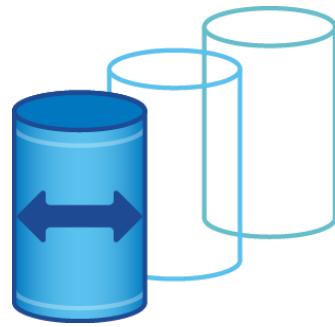
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# FlexClone Volume Clones

FlexClone technology:

- Enables the creation of multiple, instant dataset clones with no storage overhead
- Provides dramatic improvement for application test and development environments



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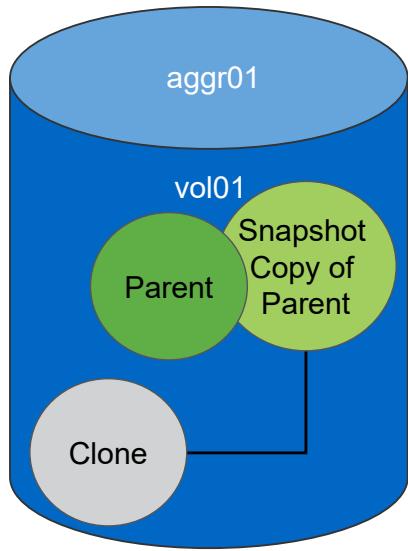
22

FlexClone volume clones provide an efficient way to copy data for the following purposes:

- Manipulation
- Projection operations
- Upgrade testing

ONTAP software enables you to create a volume duplicate in which the original volume and clone volume share disk space for storing unchanged data.

# How Volume Cloning Works



- Volume cloning does the following:
  - Starts with a volume
  - Creates a Snapshot copy of the volume
  - Creates a clone (a new volume based on the Snapshot copy)
- Modifications of the original volume are separate from modifications of the cloned volume.
- **Result:** Independent volume copies are efficiently stored.

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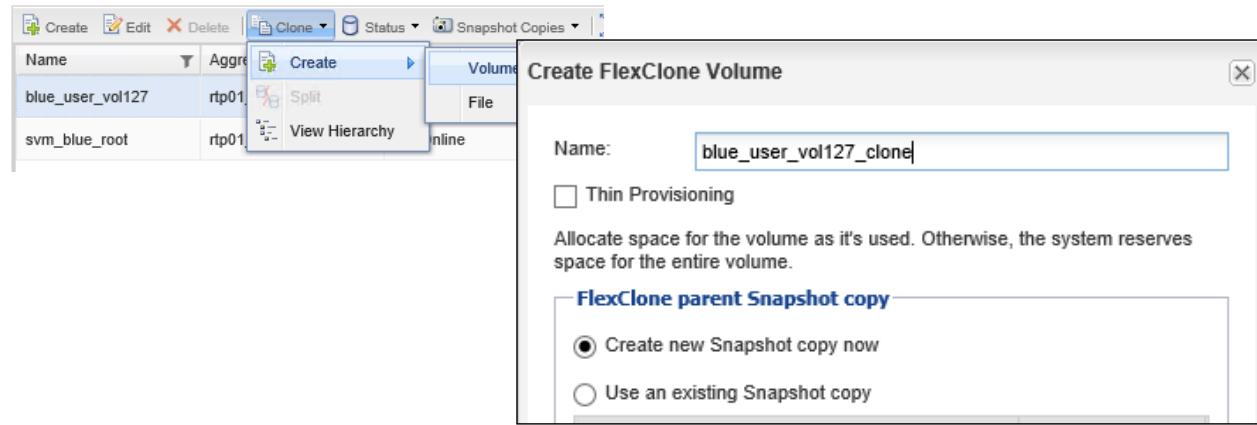
23

FlexClone volumes are managed similarly to regular FlexVol volumes, with a few key differences:

- A FlexClone volume is a point-in-time, writable copy of the parent volume. Changes that are made to the parent volume after the FlexClone volume is created are not reflected in the FlexClone volume.
- You can clone FlexVol volumes. To create a copy of a traditional volume, you must use the vol copy command, which creates a distinct copy with its own storage.
- FlexClone volumes are fully functional volumes that are managed, as is the parent volume, by using the vol command.
- FlexClone volumes always exist in the same aggregate as parent volumes.
- FlexClone volumes and parent volumes share disk space for common data. Therefore, creating a FlexClone volume is instantaneous and requires no additional disk space (until changes are made to the clone or parent).
- A FlexClone volume is created with the same space guarantee as the parent.
- You can sever the connection between the parent and the clone. The severing is called *splitting* the FlexClone volume. Splitting removes all restrictions on the parent volume and causes the FlexClone to use its own storage.  
**IMPORTANT:** Splitting a FlexClone volume from the parent volume deletes all existing Snapshot copies of the FlexClone volume and disables the creation of new Snapshot copies during the splitting operation.
- Quotas that are applied to a parent volume are not automatically applied to the clone.
- When a FlexClone volume is created, existing LUNs in the parent volume are also present in the FlexClone volume, but the LUNs are unmapped and offline.

# Clone a Volume

## Volumes



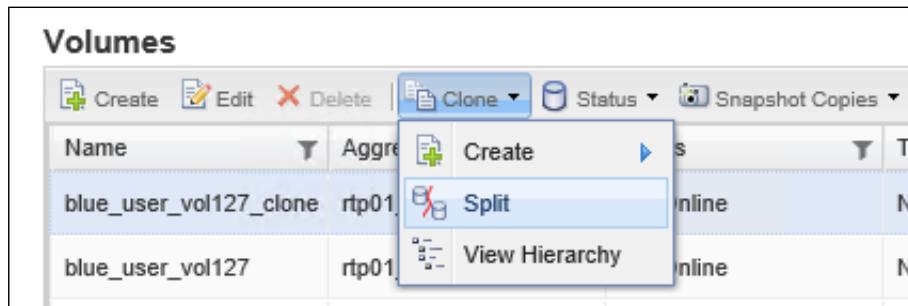
```
rtp-nau::> volume clone create -vserver svml -flexclone  
blue_user_vol127_clone -parent-volume blue_user_vol127
```

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Use the `volume clone create` command to create a FlexClone volume.

## Split a Cloned Volume



```
rtp-nau::> volume clone split start -vserver svm_blue -flexclone  
blue_user_vol127_clone
```

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Use the `volume clone split start` command to initiate a split of the clone from the parent.

# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes

## Instructor begins polling session

- Questions appear in the polling panel.
- Answer each question.
- When finished, click "Submit."

## Instructor ends polling session

- Correct answers have a green check mark.
- Compare your answers to the correct answers.

## Instructor leads debrief discussion

Raise your hand to ask a question or make a comment.



## Poll Questions

Check your understanding

1. Data can be written to a FlexClone volume.
  - a. [True](#)
  - b. [False](#)
2. A FlexClone volume, by definition, shares no data blocks with the parent volume.
  - a. [True](#)
  - b. [False](#)

## References

- *ONTAP Logical Storage Management Guide*
- *TR-4148-0313: Operational Best Practice—Thin Provisioning*
- *TR-3966: Compression and Deduplication for ONTAP, Deployment and Implementation Guide*



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# ACTION: Complete an Exercise

Module 7: Managing FlexClone Volumes



Duration: 30 minutes

## Access your lab equipment.

Use the login credentials that your instructor provided to you.

## Complete the specified exercises.

- Go to the exercise for the module.
- Start with Exercise 2.
- Stop at the end of Exercise 2.

## Participate in the review session.

- Share your results.
- Report issues.

# Share Your Experiences

Roundtable questions for the equipment-based exercises



What are some popular uses for FlexClone volumes?



## Module Review

This module focused on enabling you to do the following:

- Implement storage efficiency features
- Use FlexClone volumes



## Module 8

## NAS Protocols

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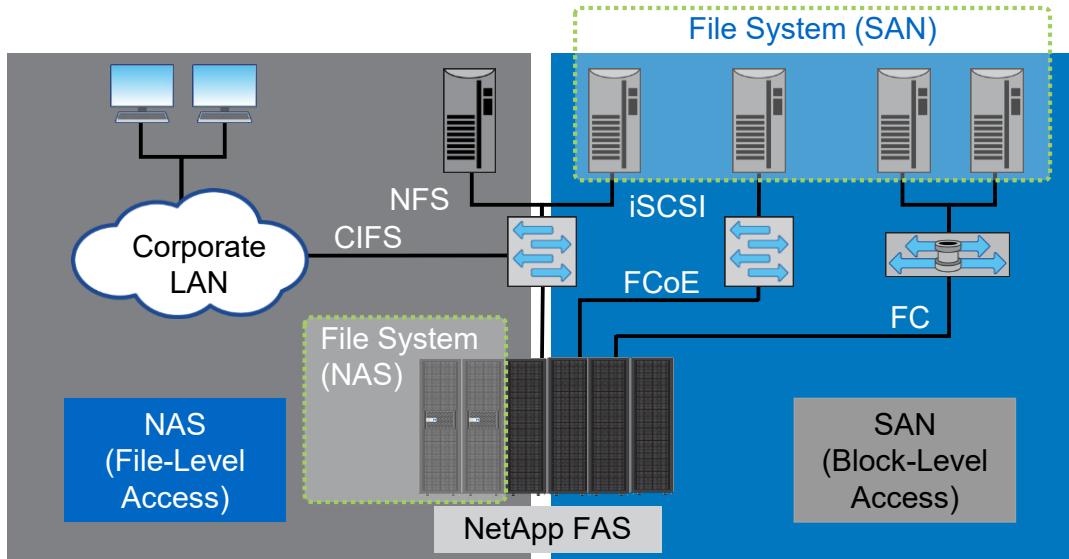
## About This Module

This module focuses on enabling you to do the following:

- Describe NAS support on NetApp ONTAP software
- Create NFS and SMB servers within a storage virtual machine (SVM)

# Unified Storage

Review



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A SAN is a block-based storage system that uses FC, FCoE, and iSCSI protocols to make data available over the network.



## Review Activity: Terminology

Match each term to the appropriate function.

<b>NAS</b>	Provides file-level access to data on a storage system
<b>SAN</b>	Provides block-level access to data on a storage system
<b>CIFS</b>	Is a distributed file system that uses shares
<b>NFS</b>	Is a distributed file system that uses exports
<b>Namespace</b>	Is a logical grouping of volumes
<b>SVM root volume</b>	Provides an entry point to the namespace
<b>Data volume</b>	Is a logical container for client files



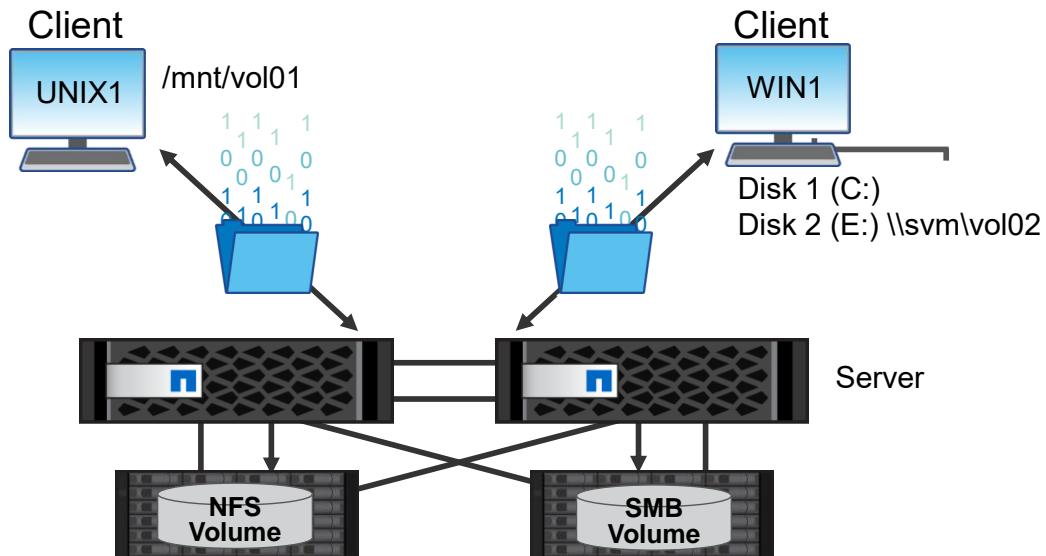
# Lesson 1

## File System Structure

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# The NAS File System



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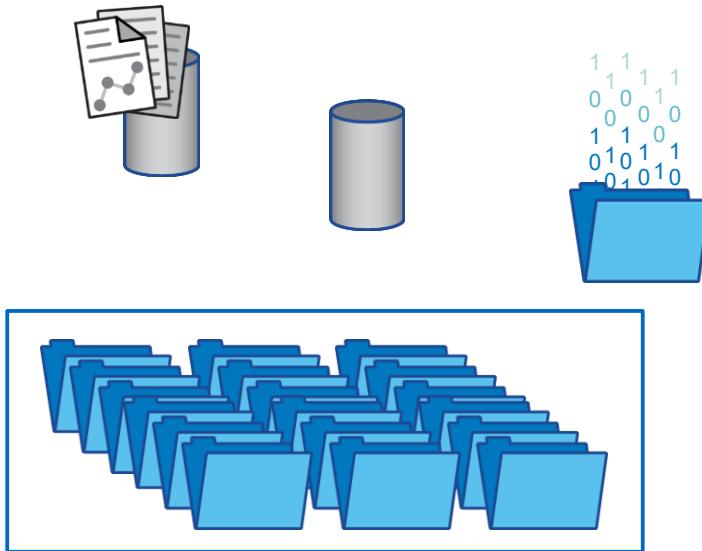
NAS is a distributed file system that enables users to access resources, such as volumes, on a remote storage system as if the resources were located on a local computer system.

NAS provides services through a client-server relationship. Storage systems that enable file systems and other resources to be available for remote access are called *servers*. The server is set up with a network address and provides file-based data storage to other computers, called *clients*, that use the server resources.

The NetApp ONTAP software supports the NFS and SMB protocols. (SMB is also known as CIFS.)

# Storage System Resources

- Volume
- Qtree
- Directory



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With the NAS protocols, you need to create file systems and other resources that are available to clients through either NFS or SMB.

Volumes are the highest level of logical storage object. FlexVol volumes are data containers that enable you to partition and manage your data. In a NAS environment, volumes contain file systems. The first resource to create is the volume.

In ONTAP software, the volume is associated with a storage virtual machine (SVM). The SVM is a virtual management entity, within which you create a namespace. Volumes are joined to the namespace through junctions. The junctions are exported.

Qtrees enable you to partition FlexVol volumes into smaller segments that you can manage individually. ONTAP software creates a default qtree, called qtree0, for each volume. If you do not create and put data in another qtree, all the data resides in qtree0. Qtrees enable you to partition data without incurring the overhead that is associated with creating another FlexVol volume. You might create qtrees to organize data or to manage one or more of the following factors: quotas, security style, or opportunistic lock (oplock) settings.

You can also create a directory or a file on the client in a FlexVol volume, to use as a resource to export or share. A qtree is a partition that is created on the storage system. A directory is a partition that is created on the client within a FlexVol volume.

# NFS Implementation

## Targets and access

- Create a projects volume under the SVM root:

```
rtp-nau::> volume create -vserver svm_blue  
-aggregate sas_data_23 -volume projects  
-size 5GB -state online -type RW  
-policy Default -security-style unix  
-junction-path /projects -junction-active true
```

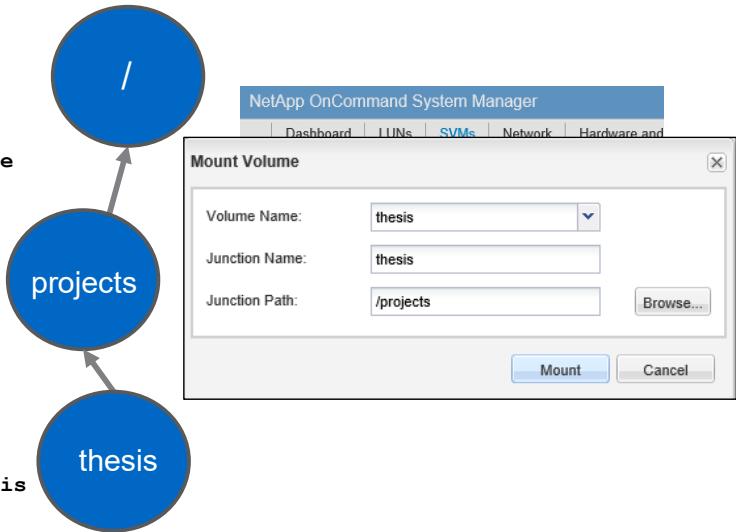
OR

- Create a second named project volume:

```
rtp-nau::> volume create -vserver svm_blue  
-aggregate sas_data_18 -volume thesis  
-size 10GB -state online -type RW  
-policy Default -security-style unix
```

- Mount the second volume under /projects:

```
rtp-nau::> volume mount -vserver svm_blue  
-volume theseus -junction-path /projects/thesis  
-active true -policyOverride false
```



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The following is an abbreviated list of parameters that are used to mount a volume:

- **Junction path of the mounting volume:** `-junction-path <junction path>`  
The junction path name is case insensitive and must be unique within an SVM namespace.
- **Active junction path:** `[-active {true|false}]`  
The optional parameter specifies whether the mounted volume is accessible. The default setting is `false`. If the mounted path is inaccessible, then the path does not appear in the SVM namespace.
- **Override the export policy:** `[-policyOverride {true|false}]`  
The optional parameter specifies whether the parent volume's export policy overrides the mounted volume's export policy. The default setting is `false`.

## Junctions

**From the storage system:** rtp-nau::> **volume show -vserver svm\_blue -volume \* -fields junction-path**

Vserver	Volume	Junction Path
svm_blue	blue_root	/
svm_blue	Acct	/acct
svm_blue	pro_1	/project1
svm_blue	pro_2	/project2
svm_blue	pro_3	/project2/project3

**From an NFS client:** root@unix1 vs1\_root# ls -al

```
unix1# drwxr-xr-x.  2 root root 4096 Mar 15 2014 ..
unix1# drwxr-xr-x.  2 root root 4096 Mar 15 2014 acct
unix1# drwxr-xr-x.  2 root root 4096 Mar 15 2014 project1
unix1# drwxr-xr-x.  2 root root 4096 Mar 15 2014 project2
```

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Volume junctions are a way to join individual volumes into a single logical namespace. Volume junctions are transparent to CIFS and NFS clients. When NAS clients access data by traversing a junction, the junction appears to be an ordinary directory.

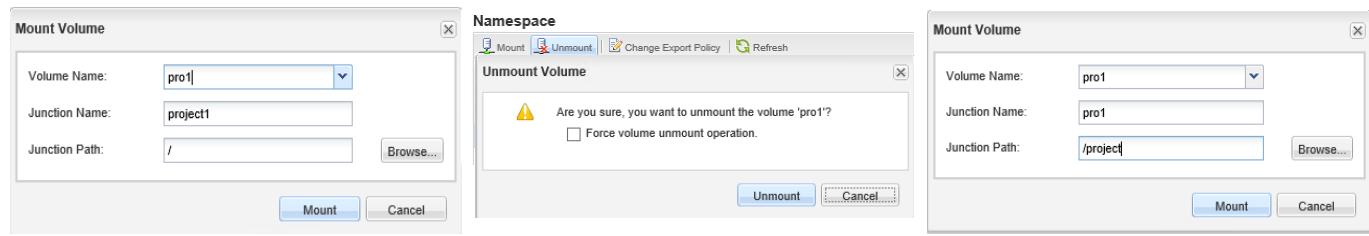
A junction is formed when a volume is mounted to a mount point below the root and is used to create a file-system tree. The top of a file-system tree is always the root volume, which is represented by a slash mark (/). A junction points from a directory in one volume to the root directory of another volume.

A volume must be mounted at a junction point in the namespace to enable NAS client access to contained data. Although specifying a junction point is optional when a volume is created, data in the volume cannot be exported and a share cannot be created until the volume is mounted to a junction point in the namespace. A volume that was not mounted during volume creation can be mounted post-creation. New volumes can be added to the namespace at any time by mounting them to a junction point.

**NOTE:** Use the storage system to mount volumes to junction paths.

# Mounting Junction Paths

Mounting	Unmounting	Mounting to a New Path
<pre>rtp-nau::&gt; vol mount -vserver svm_blue -volume pro1 -junction-path /project1</pre>	<pre>rtp-nau::&gt; vol unmount -vserver svm_blue -volume pro1</pre>	<pre>rtp-nau::&gt; volume mount -vserver svm_blue -volume pro1 -junction-path /project/pro1</pre>



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When volumes are created by using the `volume create` command, a junction path is usually specified. The junction path is optional; a volume can be created and not mounted into the namespace. To put a volume without a junction path into use, you must use the `volume mount` command to assign a junction path to the volume.

A volume can be mounted to the namespace of the SVM in only one place.

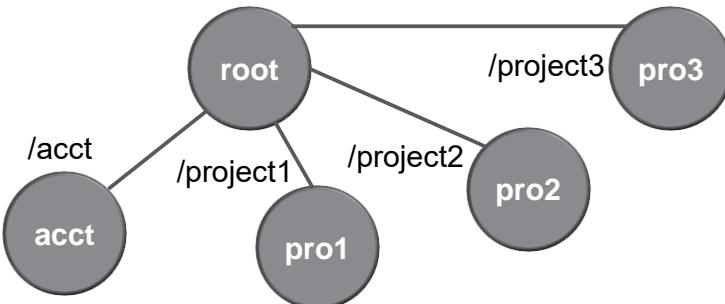
When you unmount a volume, you take the volume out of the namespace. An unmounted volume is inaccessible to NFS and CIFS clients but is still online and can be mirrored, backed up, moved, and so on.

You can then mount the volume again to the same location or to a different location in the namespace and in relation to other volumes. For example, you can unmount a volume from one parent volume, and then mount the volume to another parent volume.

Be careful when unmounting and remounting a volume to a new path. Because rejunctioning changes the location of a flexible volume inside the namespace, the namespace is not transparent to client access. The client now has to access the data at the new directory location.

# NAS Namespace Architecture

Multiple standalone volumes



SVM	Volume	Junction Path
svm_blue	blue_root	/
svm_blue	acct	/acct
svm_blue	pro1	/project1
svm_blue	pro2	/project2
svm_blue	pro3	/project3

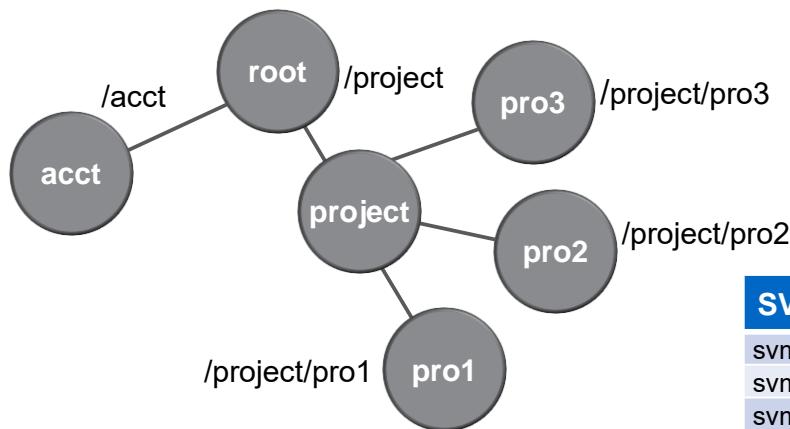
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In an architecture with standalone volumes, every volume has an insertion point to the root of the SVM namespace. No volume is junctioned below another volume. Each volume has a unique path and is junctioned directly below the root.

# NAS Namespace Architecture

Namespace with branched trees



SVM	Volume	Junction Path
svm_blue	blue_root	/
svm_blue	acct	/acct
svm_blue	project	/project
svm_blue	pro1	/project/pro1
svm_blue	pro2	/project/pro2
svm_blue	pro3	/project/pro3

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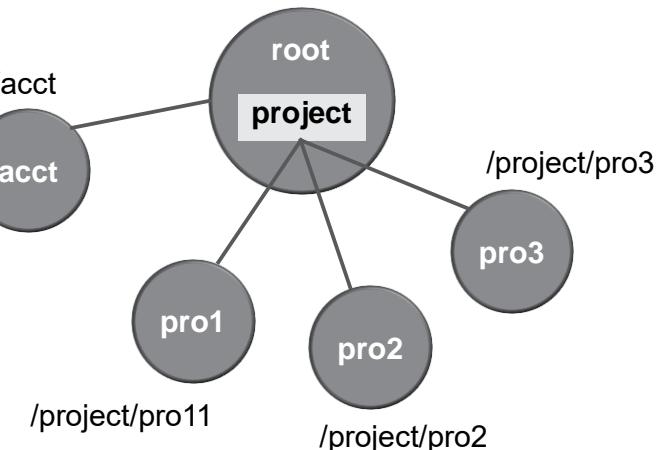
12

An architecture with multiple branched trees has multiple insertion points to the root of the SVM namespace. The insertion points can be junctioned volumes, directories, or qtrees beneath the root. All other volumes are mounted at junction points beneath the insertion points (which can be volumes, directories, or qtrees).

The figure shows a typical volume junction configuration, with two insertion points to the root volume of the SVM. One insertion point is a junctioned volume “acct”, and one insertion point is a junctioned volume “project.” The other volumes are junctioned under the “project” volume.

# NAS Namespace Architecture

Namespace with directory



SVM	Volume	Junction Path
svm_blue	blue_root	/
svm_blue	acct	/acct
svm_blue	pro1	/project/pro1
svm_blue	pro2	/project/pro2
svm_blue	pro3	/project/pro3

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The example has two insertion points. One insertion point is from the root to the “acct” volume. The second insertion point is a directory that was created from either an export of the root volume to a UNIX host or from within a share of the root volume to a Windows host.

The second insertion point can also be a qtree in place of the directory.

## ACTION: Topics for Discussion



How do NFS and SMB clients see junctions in a namespace?





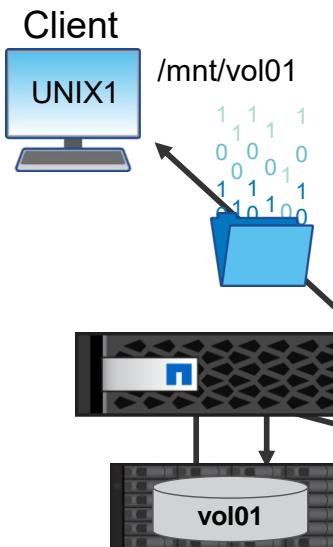
## Lesson 2

### Deploying NFS

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# NFS



- vol01 is **exported** to UNIX1 with read/write access.
- UNIX1 **mounts** vol01 to /mnt/project with read/write access.

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NFS is a distributed file system that enables users to access resources, such as volumes, on remote storage systems as if the resources were located on a local computer system.

NFS provides services through a client-server relationship.

- Storage systems that enable the file systems and other resources to be available for remote access are called *servers*.
- The computers that use a server's resources are called *clients*.
- The procedure of making file systems available is called *exporting*.
- The act of a client accessing an exported file system is called *mounting*.

When a client mounts a file system that a server exports, users on the client machine can view and interact with the mounted file systems on the server within the permissions granted.

## NFSv3 Implementation Steps

1. Verify or add the NFS protocol license.
2. Enable the NFS functionality on the SVM.
3. Export the available resources.
4. Configure NFS authentication.
5. Authorize the user.
6. Mount the exported resources.



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The figure shows the basic process for implementing the NFS protocol between a UNIX host and an ONTAP storage system. The process consists of several steps.

First, you need to enable the NFS functionality, license NFS, and then enable the feature on the storage system.

Second, you need resources to export, so you create volumes and qtrees.

Third, you determine which clients have which type of access to the resources. You need a way to authenticate client access and authorize users with appropriate permissions, including read-only or read/write.

Finally, when the client has been granted access to the exported resource, the client mounts the resource and grants access to the users.

# NFSv3 Implementation

Enable NFS

The screenshot shows the SVM Settings interface. In the left sidebar, under 'Protocols', 'NFS' is selected. In the main panel, the 'Server Status' is shown as 'Enabled'. Under 'Configuration', 'Version 3 Support' is set to 'Enabled', 'Version 4 Support' is set to 'Disabled', and 'Version 4.1 Support' is set to 'Disabled'.

```
rtp-nau::> vserver nfs create...
```

## Best practice:

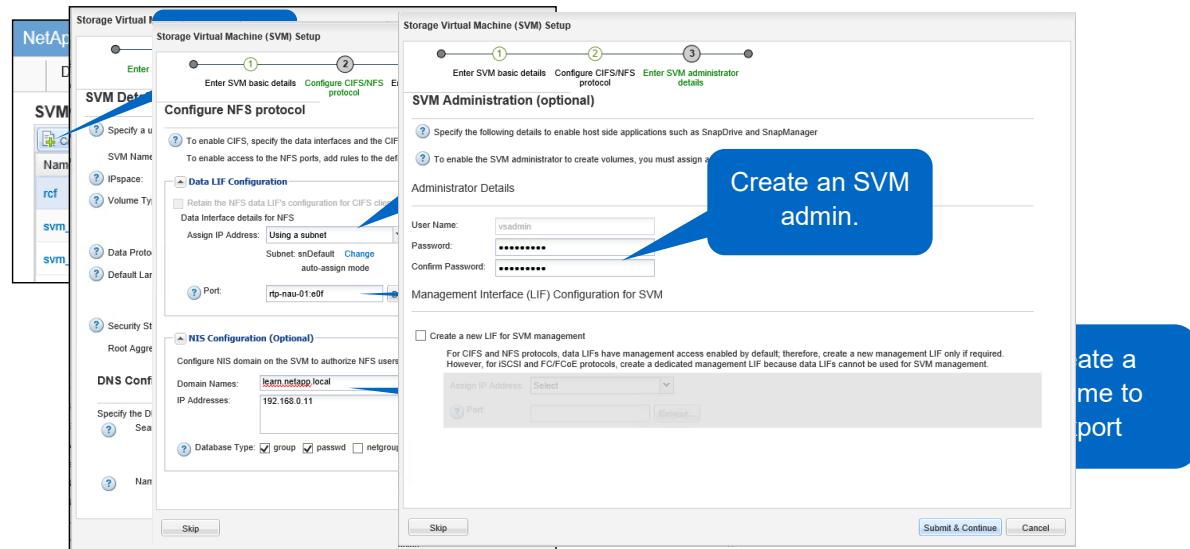
Configure NAS protocols through  
NetApp OnCommand System  
Manager.

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After you license NFS, enable the protocol. You can enable NFS through the CLI or NetApp OnCommand System Manager. NetApp recommends using the tools and wizards that are available through System Manager.

# SVM Create Wizard Walkthrough: NFS



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# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes

## Instructor begins polling session

- Questions appear in the polling panel.
- Answer each question.
- When finished, click "Submit."

## Instructor ends polling session

- Correct answers have a green check mark.
- Compare your answers to the correct answers.

## Instructor leads debrief discussion

Raise your hand to ask a question or make a comment.



## Poll Question

Check your understanding

A volume vs1\_vol2 is created on aggregate aggr2 and mounted in the vs1 namespace at /vs1/vol2. An administrator moves the volume to the aggr1 aggregate.

After the move, what is the path to the volume?

- a. [/aggr1/vs1/vs1\\_vol2](#)
- b. [/vs1/vol2](#)
- c. [/vol/vs1\\_vol1](#)
- d. [/aggr1/vs1\\_vol2](#)

## Exporting

- Create an export policy or use an existing policy; the first policy is named “default”.
- Add rules to the policies:
  - A rule is automatically created in the default export policy if you use OnCommand System Manager.
  - Specify access permissions to volumes for one or more clients that are specified by host name, IP, network mask, and netgroup.
  - Rules are processed in the order in which they appear in the export policy (the rule index number).
- Export policies and rules replace /etc(exports:
  - You do not need to create a separate export entry for each export.
  - Apply a single policy to many exports.

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ONTAP software uses export policies and rules to control host access.

# Client Specification

```
vserver export-policy rule create -clientmatch <text>
```

<b>Host:</b> Use the host name or IP address.	unix1 192.168.0.10 fd20:8b1e:b255:4071::100:a
<b>Netgroup:</b> Use the group name.	@mygroup
<b>Subnet:</b> Specify the subnet address.	192.168.0.0/24 192.168.0.0/255.255.255.0 fd20:8b1e:b255:4071::/64
<b>DNS Subdomain</b>	.learn.netapp.local

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-clientmatch <text>

The `clientmatch` parameter specifies the client or clients to which the export rule applies. You can specify the match in any of the following formats:

- As a host name; for example, host1
- As an IPv4 address; for example, 10.1.12.24
- As an IPv4 address with a subnet mask that is expressed as a number of bits; for example, 10.1.12.10/4
- As an IPv4 address with a network mask; for example, 10.1.16.0/255.255.255.0
- As a netgroup, with the netgroup name preceded by the @ character; for example, @netgroup
- As a network name from files, Network Information System (NIS), or Lightweight Directory Access Protocol (LDAP), preceded by the = character; for example, =networkname
- As a domain name preceded by the .character; for example, .example.com

**NOTE:** Entering an IP address range, such as 10.1.12.10-10.1.12.70, is not permitted. Entries are interpreted as a text string and treated as a hostname.

# Export Policies and Rules

The screenshot shows two windows side-by-side. On the left is the 'Create Export Policy' window, where a policy named 'blue\_exp\_pro1' is being created. It includes fields for 'Client Specification' (192.168.0.0/24), 'Access Protocols' (CIFS, NFS, NFSv3, NFSv4, FlexCache), and 'Access Details' (Read-Only and Read/Write checkboxes for various authentication methods like UNIX, Kerberos 5, etc.). On the right is the 'Create Export Rule' window, which lists rules for the 'blue\_exp\_pro1' policy. One rule is shown with index 1, client specification 192.168.0.0/24, access protocols NFS, NFSv3, and NFSv4, and access details set to 'Read-Only' for all clients.

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In the example scenario, you create an export policy and an export policy rule, and then you apply the rule to the export. You create an export rule with index number 1 in an export policy named vs1\_pro1 on an SVM named vs1. The rule matches all clients in the specified subnet. The rule enables read-only access by any matching client and requires authentication by Kerberos 5 for read-write access.

## Mounts

Use the UNIX `mount` command on the client to mount an exported NFS resource from the storage system.

```
unix1# mkdir /mnt/project1  
  
unix1# mount <systemIP>:/project/pro1 /mnt/project1
```

**NOTE:** The junction path is `/project/pro1`.

To enable an NFS client, mount a remote file system after NFS starts. Usually, only a privileged user can mount file systems with NFS. However, you can enable users to mount and unmount selected file systems by using the `mount` and `umount` commands, if the `user` option is set in `/etc/fstab`. The setting can reduce traffic by having file systems mounted only when they are needed. To enable user mounting, create an entry in `/etc/fstab` for each file system to be mounted.

# Verifying Mounts

To verify exports on a target:

- `Mount`  
When used without options, displays all mounted files

- `showmount -a storagesystemX`  
Displays a list of clients that are mounting from a storage system

- `showmount -e storagesystemX`  
Prints a list of available NFS exports



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To verify exported resources, use the `mount` command in UNIX systems:

- On the client, use `showmount -e`, `nfsstat -m`, or an equivalent command to verify exported resources and mount options.
- With the `showmount` command, you can display:
  - What the storage system is exporting
  - The clients that mount the storage system

In versions earlier than ONTAP 8.3, clients cannot use the `showmount -e` command to view the NFS exports list. Instead, only the root volume (/) is displayed.

## Advanced Learning

For additional learning about NFS, NFSv4, delegations, and pNFS, see the ONTAP NFS Administration instructor-led course.





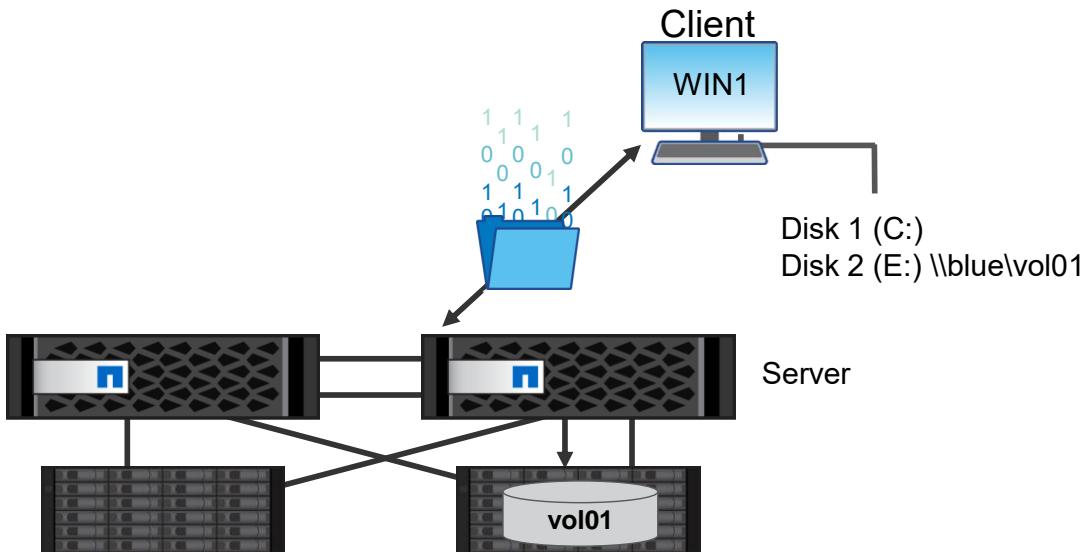
## Lesson 3

# Windows File Services

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# Server Message Block Protocol



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SMB is an application-layer network file-sharing protocol that the Microsoft Windows operating system uses. SMB enables users or applications to access, read, and write to files on remote computers just like on a local computer. For the purposes of this course, the terms SMB and CIFS are used interchangeably (although the definitions of the two terms are not strictly the same).

A user or application can send network requests to read and write to files on remote computers. Messages travel from the network interface card (NIC) of the user's computer, through the Ethernet switch, to the NIC of the remote computer.

SMB provides access to files and directories that are stored on the remote computer, through sharing resources. The network read and write process, which is also called network I/O, is controlled by the rules of network protocols such as IPv4 and IPv6.

## SMB Implementation Steps

1. Verify or add the CIFS protocol license.
2. Enable the SMB functionality on the SVM.
3. Share the available resources.
4. Configure SMB authentication.
5. Authorize the user.
6. Map the shared resources.



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To implement SMB, first enable the SMB functionality on the ONTAP storage system. Then share the available resources. Finally, map the shared resources on the Windows client.

# SMB Implementation

Enable SMB

The screenshot shows the SVM Settings interface. On the left, under Protocols, CIFS and NFS are listed. Under Policies, Export Policies, Efficiency Policies, Protection Policies, and Snapshot Policies are listed. On the right, the Configuration tab is selected in the top navigation bar. Below it, the Server section displays the following information:

Service Status:	Started
System Name:	BLUE
Authentication Style:	Active Directory
Active Directory Domain Name:	LEARN.NETAPP.LOCAL

```
rtp-nau::> vserver cifs create...
```

## Best practice:

Configure NAS protocols through OnCommand System Manager.

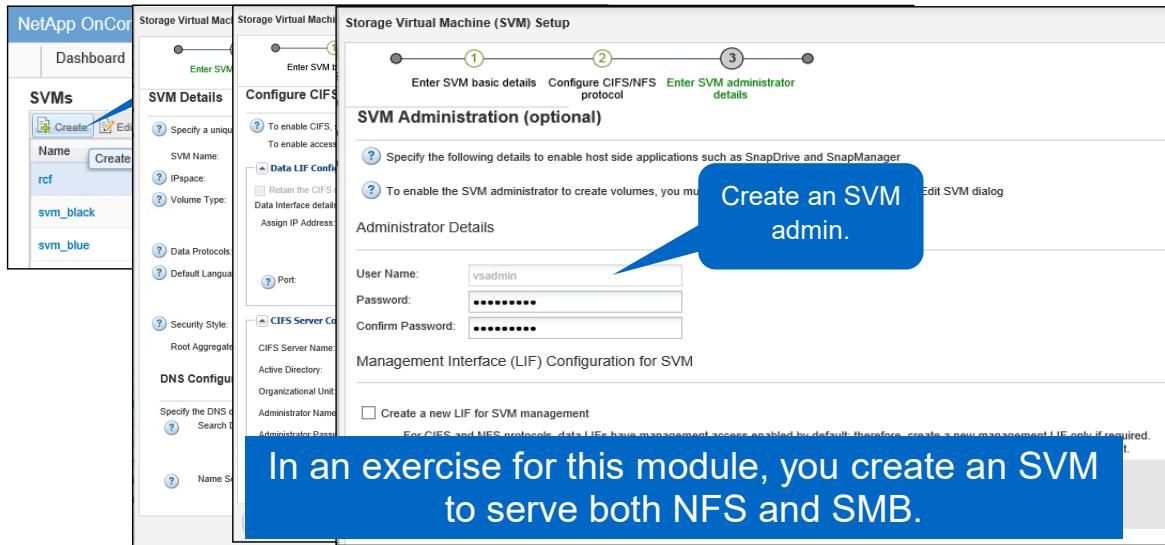
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After you license CIFS, enable the protocol. You can enable SMB through the CLI or OnCommand System Manager. NetApp recommends using the tools and wizards that are available through OnCommand System Manager.

CIFS setup enables you to perform several tasks: create and name a CIFS server that your CIFS clients can access, join the CIFS server to a domain, and create a default set of local CIFS users and groups.

# SVM Create Wizard Walkthrough: CIFS



e a  
and a  
re

In an exercise for this module, you create an SVM  
to serve both NFS and SMB.

## ACTION: Topics for Discussion



You assign exports to volumes and qtrees. Which resources can you share through SMB?

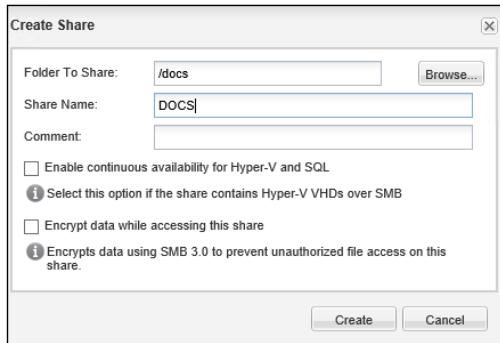


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SMB shares are associated with paths within the namespace. Because the namespace is constructed by junctions, qtrees, and directories, shares can be associated with any of the resources.

# Creating Shares



```
rtp-nau::> vserver cifs share create  
-vserver svm_blue  
-share-name DOCS  
-path /docs  
-share-properties browsable,changetrigger,oplocks
```

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A CIFS share is a named access point in a volume that enables CIFS clients to view, browse, and manipulate files on a file server. When creating CIFS shares, consider certain guidelines.

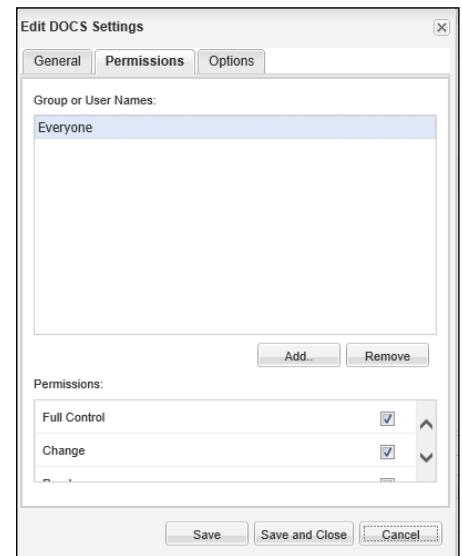
When you create a share, you must provide all the following information:

- The complete path in a volume to the CIFS share
- The name of the share that users enter when they connect to the share

When you create a share, you can optionally specify a description for the share. The share description appears in the Comment field when you browse the shares on the network.

## Share Access Administration

```
rtp-nau::> vserver cifs share  
access-control create  
-vserver svm_blue  
-share-name DOCS  
-user-or-group Everyone  
-permission Full_Control
```



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In the example, on the pro share, you set the share access for the “friends” group to Full Control and delete the “everyone” access control list (ACL) entry.

## Share Permissions

Share Permissions Management Source	Windows Share Permissions
<ul style="list-style-type: none"><li>▪ CLI</li><li>▪ OnCommand System Manager</li><li>▪ Microsoft Management Console (MMC), such as Computer Management</li></ul>	<ul style="list-style-type: none"><li>▪ Full control</li><li>▪ Read-only</li><li>▪ Change</li></ul>

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Share permissions apply only to users who access the resource over the network. The permissions apply to all files and folders in the shared resource.

- **Full Control:** Full control is the default permission that is assigned to the Administrators group on the local computer. Full control permits all Read and Change permissions, plus Changing permissions (NTFS files and folders only).
- **Read:** Read is the default permission that is assigned to the Everyone group. Read permits the following actions:
  - View file names and subfolder names.
  - View data in files.
  - Run program files.
- **Change:** Change is not a default permission for any group. The Change permission enables all Read permissions, plus the following actions:
  - Add files and subfolders.
  - Change data in files.
  - Delete subfolders and files.

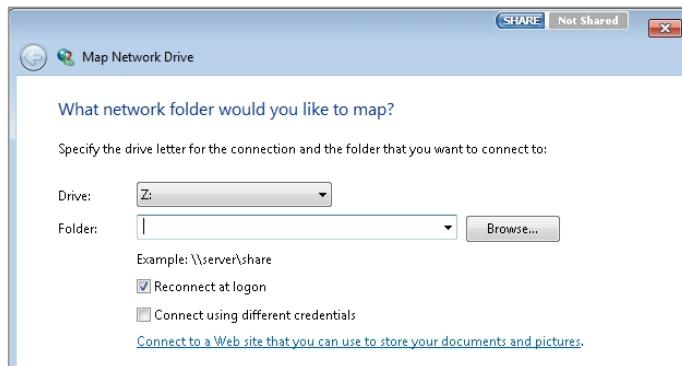
# Mapping a Share to a Client

- CLI

- C:\> **net view \\blue**
- C:\> **net use e: \\blue\DOCS /user:marketing\jdoe**

- UI

- Use the Run dialog box.
- Map a drive.



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The **net view** command displays a list of computers with shared resources that are available on the specified computer.

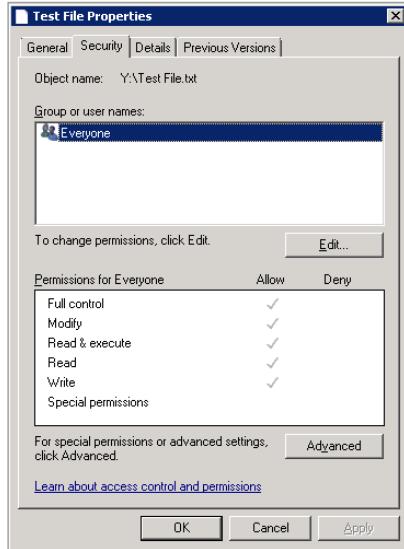
To use the **net view** command, use the following steps:

1. Click the **Start** button, point to **Programs**, and then click the **MS-DOS** prompt.
2. At the command prompt, type **net view \\<computername>**, where **<computername>** is the name of a specific computer whose resources you want to view.

You can connect or disconnect a computer from a shared resource or display information about computer connections. The command also controls persistent net connections. Used without parameters, the **net use** command retrieves a list of network connections.

You can also use Windows to map a share to a client.

# Windows File Permissions



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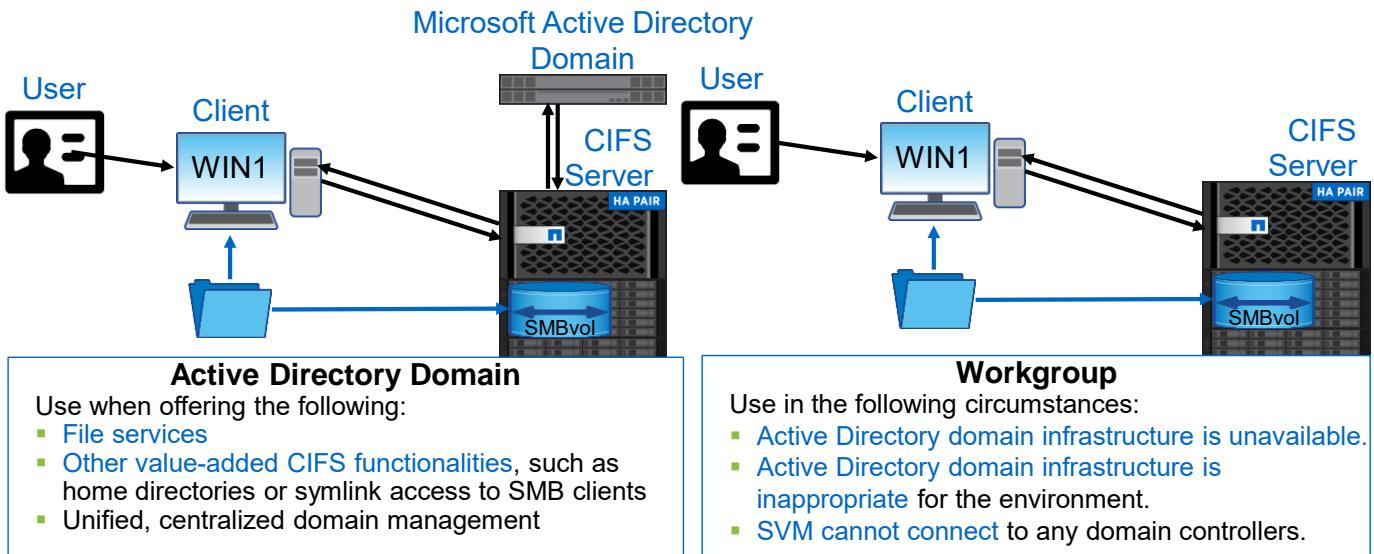
38

Permissions are rules that are associated with objects on a computer or network, such as files and folders. Permissions determine whether a user can access an object and what the user can do with the object. For example, you might have access to a document on a shared folder on a network. Even though you can read the document, you might not have permissions to change the document. Windows file permissions include the following:

- **Full control:** Users can see the contents of a file or folder, change existing files and folders, create new files and folders, and run programs in a folder.
- **Modify:** Users can change existing files and folders but cannot create new ones.
- **Read and execute:** Users can see the contents of existing files and folders and can run programs in a folder.
- **Read:** Users can see the contents of a folder and open files and folders.
- **Write:** Users can create files and folders and make changes to existing files and folders.

# SMB Authentication Methods

ONTAP 9 Software and later supports domain and workgroup authentication



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You can configure an SVM with a CIFS server. You can create the CIFS server either as a member of a Microsoft Active Directory domain or in a workgroup.

# CIFS Servers in Workgroup Mode

## Unsupported features

CIFS servers in workgroup mode do not support the following CIFS features:

- Configuration in OnCommand System Manager
- SMB3 witness protocol
- SMB3 continuously available shares
- SQL over SMB
- Folder redirection
- Roaming profiles
- Group Policy Object (GPO)
- Volume Snapshot Service (VSS)

Before creating a CIFS server, be aware that all the CIFS features that require a Windows domain are unsupported by a CIFS server in workgroup mode.

# MMC Support

## Features

- Create an SMB share.
- Stop an SMB share.
- Set or modify SMB share permissions.
- View details of enumerated open sessions.
- View details of enumerated open files.
- Close a session.
- Close a file.

Share Name	Folder Path	Type	# C
admin\$		Windows	0
blue_root	C:\	Windows	1
blue_vol1	C:\blue_vol1	Windows	1
c\$	C:\	Windows	0
ipc\$		Windows	1

Read-only Support on Clusters Before  
Data ONTAP 8.3

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Microsoft Management Console (MMC) support includes several capabilities.

## Advanced Learning



For additional learning on such topics such as name mapping, Branch Cache, Dynamic Access Control, persistent handles, and copy offload, see the ONTAP CIFS Administration course.

# ACTION: Complete an Exercise

Module 8: Configuring NAS Protocols



Duration: 45 minutes

## Access your lab equipment.

Use the login credentials that your instructor provided to you.

## Complete the specified exercises.

- Go to the exercise for the module.
- Start with Exercise 1.
- Stop at the end of Exercise 1.

## Participate in the review session.

- Share your results.
- Report issues.

## Share Your Experiences

Roundtable questions for the equipment-based exercises



Share your experience using the System Manager SVM Creation Wizard to configure CIFS and NFS. Do you expect your NFS mounts and SMB drive mappings to be successful?





## Lesson 4

### Network File Access

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# Network Load Balancing

- Clients can mount to an SVM in one of two ways:
  - Specify a LIF IP address.
  - Specify a host name (for multiple managed IP addresses).
- Load balancing dynamically evaluates the load on LIFs and does one of the following:
  - Selects an appropriately loaded LIF
  - Moves a LIF to a less loaded port
- Load balancing is implemented by using DNS load balancing (NFS or CIFS):
  - On-box (zoning based)
  - Off-box (round robin)

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DNS load balancing and automatic LIF rebalancing methods can help you select an appropriately loaded data LIF and balance user network traffic across all available ports (physical or interface groups).

## DNS Load Balancing

With DNS load balancing, you can create a DNS load-balancing zone on the SVM that returns the least-loaded LIF, based on the network traffic and the availability of the port resources (such as CPU usage, throughput, and open connections). By configuring a DNS load-balancing zone, you can better balance new client connections across available resources. Balance leads to improved performance for the entire cluster. Also, no manual intervention is required for deciding which LIFs to use when mounting a particular SVM. You can use the DNS load-balancing method to balance loads for only new share connections and new mount requests. DNS load balancing cannot be used with existing connections. DNS load balancing works with NFSv3, NFSv4, NFSv4.1, CIFS, SMB 2.0, SMB 2.1, and SMB 3.0.

## Automatic LIF Rebalaсing

With automatic load balancing, LIFs are dynamically migrated to ports with low utilization, based on the failover rules. Automatic LIF rebalancing works only with NFSv3 connections. Automatic LIF rebalancing provides the following benefits:

- Different client connections use different bandwidth. Therefore, LIFs can be migrated based on the load capacity.
- When new nodes are added to the cluster, LIFs can be migrated to the new ports.

# DNS Load Balancing

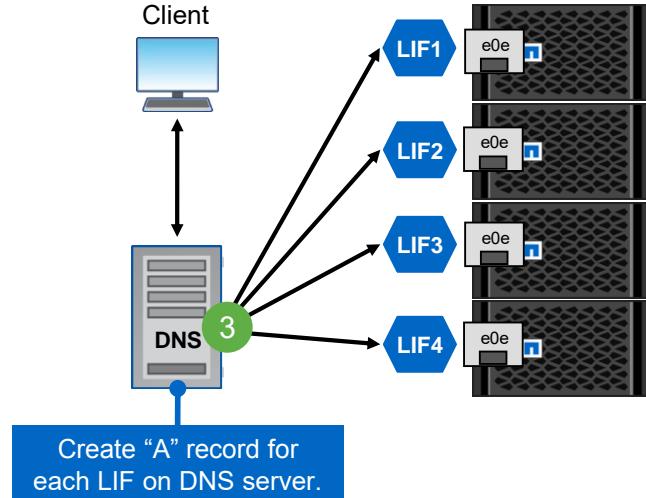
## Off-box

1. Create “A” records for each LIF on site-wide DNS server.
2. Mount client by using host name.
3. Configure DNS Server for round-robin load balancing.

1

```
blue.netapp.com IN A <LIF1 IP Address>
blue.netapp.com IN A <LIF2 IP Address>
blue.netapp.com IN A <LIF3 IP Address>
blue.netapp.com IN A <LIF4 IP Address>
```

2 nfsclient% mountblue.netapp.com://mnt/blue



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With off-box DNS, each data LIF in each SVM that resides in the cluster has a DNS “A” record that is created with the same name.

1. NFS client makes a request for name resolution to the site-wide DNS server.
2. Site-wide DNS server resolves the request to an IP address, by using a round-robin algorithm.
3. Site-wide DNS server responds to the client with the chosen IP address.

As with the on-box method, if an environment has many SVMs, you must account for each data LIFs of each SVM that you add to the site-wide DNS server.

## Namespace References

- *ONTAP File Access Management Guide for NFS*
- TR-4129: *Namespaces in ONTAP*



## NFS References

- *ONTAP File Access Management Guide for NFS*
- *ONTAP NFS Configuration Express Guide*
- TR-4067: *ONTAP NFS Implementation Guide*
- Additional training:  
*ONTAP NFS Administration* instructor-led training



## SMB References

- *ONTAP File Access Management Guide for CIFS*
- *ONTAP CIFS/SMB Configuration Express Guide*
- *TR-4191: Best Practices Guide for ONTAP Windows File Services*
- Additional training:  
*ONTAP SMB (CIFS) Administration* instructor-led training



# ACTION: Complete an Exercise

Module 8: Accessing NAS Data from Client Computers



Duration: 15 minutes

## Access your lab equipment.

Use the login credentials that your instructor provided to you.

## Complete the specified exercises.

- Go to the exercise for the module.
- Start with Exercise 2.
- Stop at the end of Exercise 2.

## Participate in the review session.

- Share your results.
- Report issues.

## Share Your Experiences

Roundtable questions for the equipment-based exercises



Were you able to use both the SMB and NFS protocols to access the same volume in the namespace?



## Module Summary

This module focused on enabling you to do the following:

- Describe NAS support on NetApp ONTAP software
- Create NFS and SMB servers within a storage virtual machine (SVM)



## Module 9

# SAN Protocols

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1

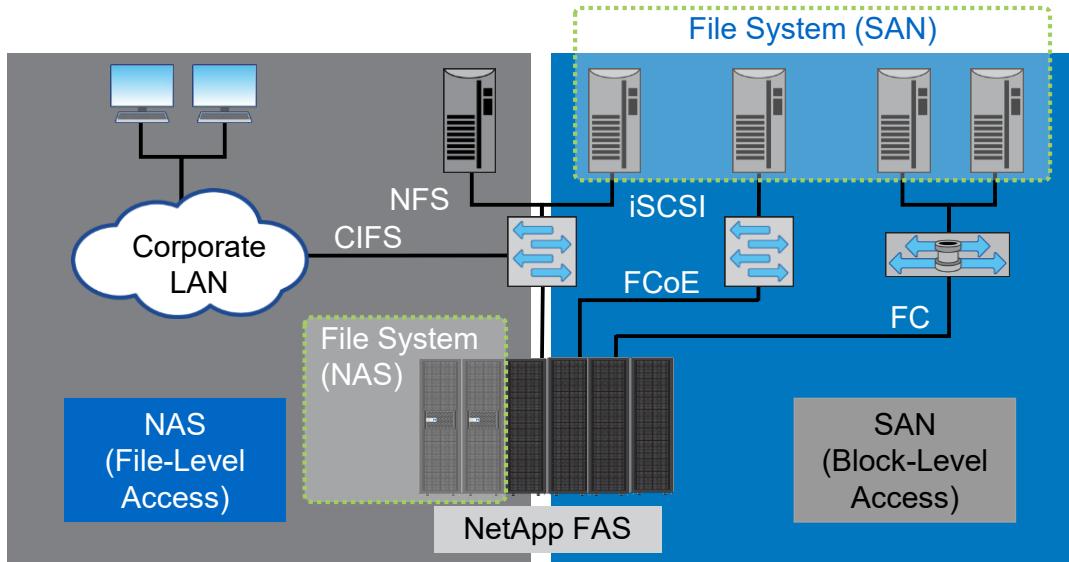
## About This Module

This module focuses on enabling you to do the following:

- Describe SAN support on NetApp ONTAP software
- Configure iSCSI within a storage virtual machine (SVM)

# Unified Storage

Review

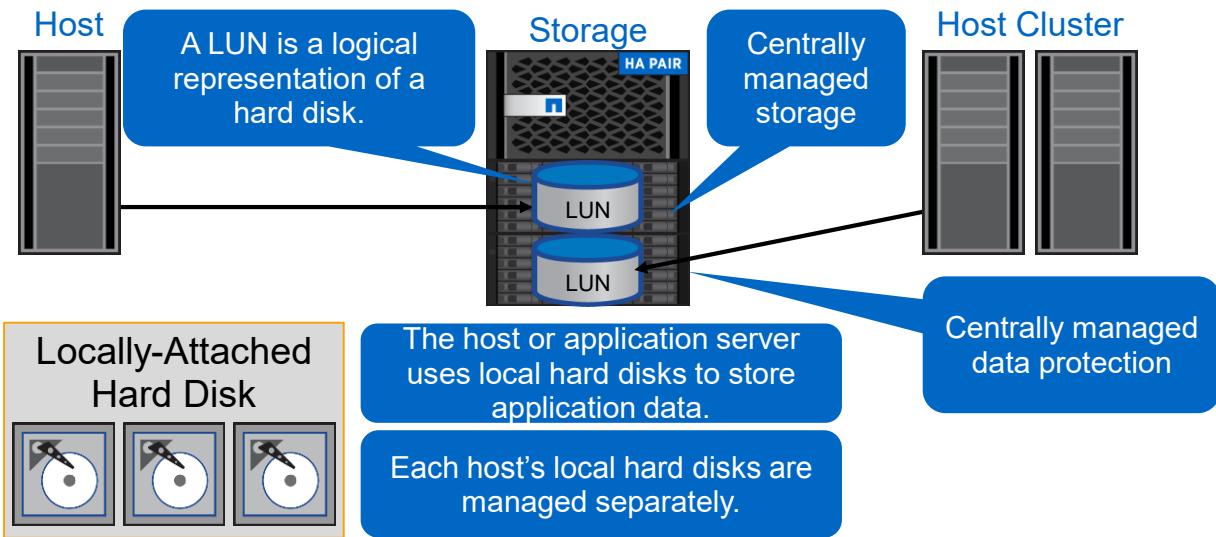


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3

A SAN is a block-based storage system that uses FC, FCoE, and iSCSI protocols to make data available over the network. SAN is currently supported in clusters of up to eight nodes.

# SAN



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In an application server environment, locally attached hard disks, also called direct-attached storage (DAS), are separately managed resources. In an environment with more than one application server, each server's storage resource also needs to be managed separately.

A SAN provides access to a LUN, which represents a SCSI-attached hard disk. The host operating system partitions, formats, writes to, and reads from the LUN as if the LUN were any other locally attached disk. The advantages of using SAN storage include support for clustered hosts, where shared disks are required, and centrally managed resources. In the example, if a SAN was not used, the administrator would need to manage separate resources for each application server and host cluster. In addition to centrally managed resources, SAN also enables centrally managed data protection, using NetApp ONTAP Snapshot copy technology.

## SCSI Concepts

- SCSI provides low-level block access to data.
- Low-level block access is highly efficient and requires less overhead than NAS.
- SCSI offers a high level of resiliency.
- The relationship between an initiator and a target is called a *nexus*.
- iSCSI uses TCP/IP for transport, but retains SCSI architecture.



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SCSI provides low-level block access to data, typically in 512-byte blocks. Low-level block access requires less overhead than file-level access. SCSI has a high level of resiliency that is suitable for an enterprise-level protocol.

A client-server service-delivery model describes the relationships between SCSI devices. A relationship between two SCSI devices is called a *nexus*. The client, or SCSI initiator, sends a command and the server, or SCSI target, returns a response. The initiator uses SCSI commands to request a read from a LUN or write to a LUN.

iSCSI does not use the complete SCSI standard.

## Review Activity: Terminology



Match each term with the appropriate function.

FC	A protocol that communicates over a FC switched fabric network
iSCSI	A protocol that communicates by using TCP/IP to transport data
FCoE	A protocol that requires a universal target adapter (UTA) or converged network adapter (CNA) for communication
Initiator	The host in a SCSI relationship
Target	The SVM in a SCSI relationship



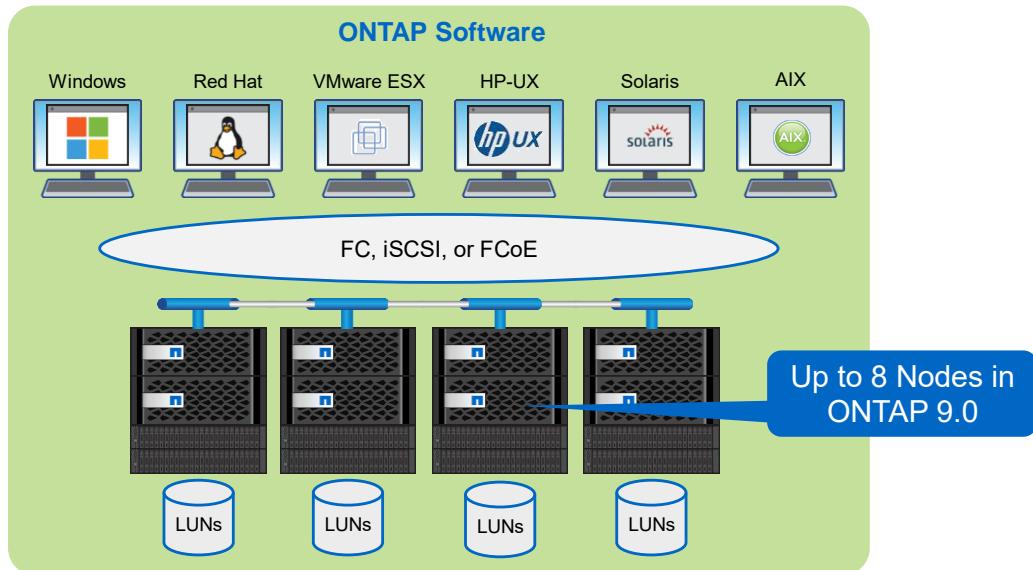
# Lesson 1

## SAN Support in ONTAP

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7

## Scalable SAN Support



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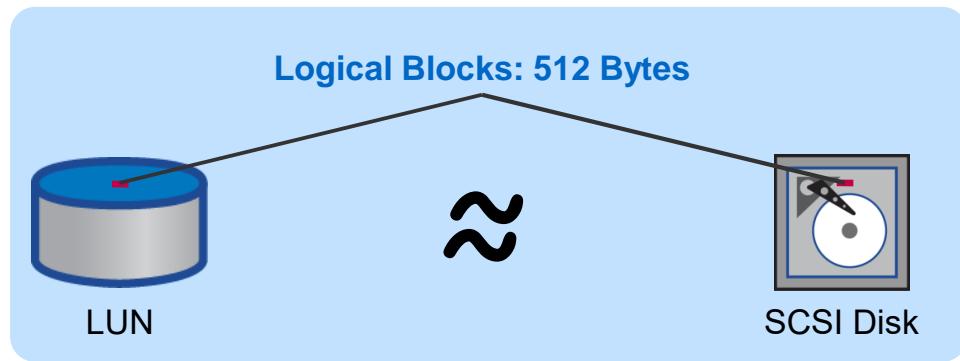
8

ONTAP software continues to support Windows, Red Hat Linux, VMware ESX, HP-UX, and Solaris hosts. ONTAP software now also supports AIX as a SAN host. To function with scalable SAN, all SAN client stacks must support asymmetric logical unit access (ALUA).

As of NetApp Data ONTAP 8.3, the maximum number of LUNs per cluster increased to 98,304. The increase enables 12,288 LUNs per node, times the maximum SAN cluster size of eight nodes.

Consult the NetApp Supportability Matrix for details about supported versions of SAN hosts.

## Logical Representation of an iSCSI Disk

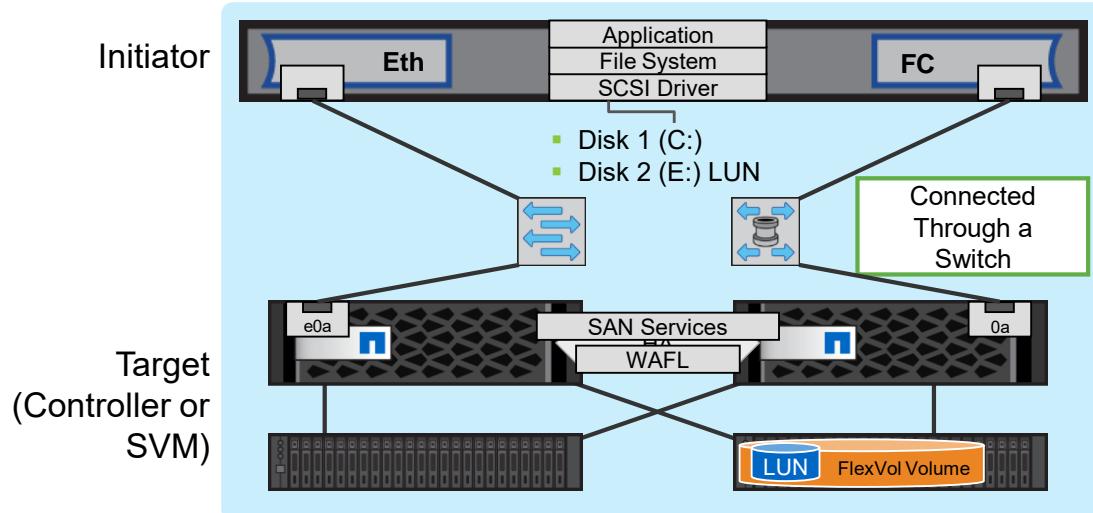


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9

# Connecting Initiator to Target

How can you connect an initiator to a target?



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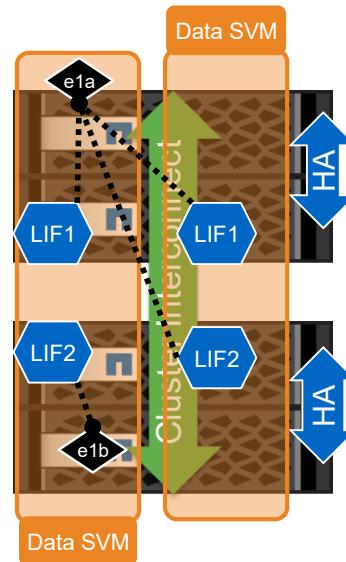
10

# SAN Data Logical Interfaces

SAN data logical interfaces (LIFs):

- Are assigned a home node and port
- Are single-protocol (FC or iSCSI)
- Do not fail over
- Can be moved to different ports or nodes within an SVM (LIF must be offline)
- Can be grouped into port sets

**Recommendation:** Use at least one LIF per node, per SVM, per network.



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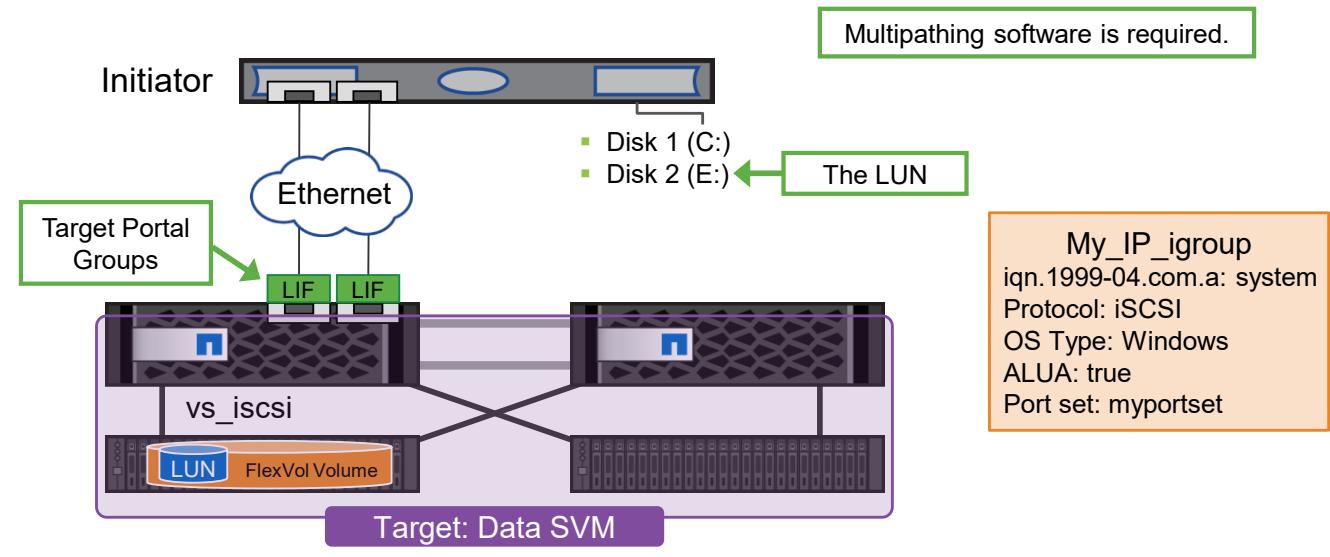
11

SAN data logical interfaces (LIFs) do not migrate or fail over the way that NAS does. However, the logical interfaces (LIFs) can be moved to another node or port in the SVM.

To move a data LIF with SAN protocols, use the `network interface modify` command:

1. To view the current status of a LIF, use the `network interface show` command.
2. Change the admin status of the LIF to down (offline).
3. Change the location of the LIF to a new node or port by using the `network interface modify` command.
4. Change the admin status of the LIF to up (online).
5. Verify the changes by using the `network interface show` command.

# iSCSI Architecture



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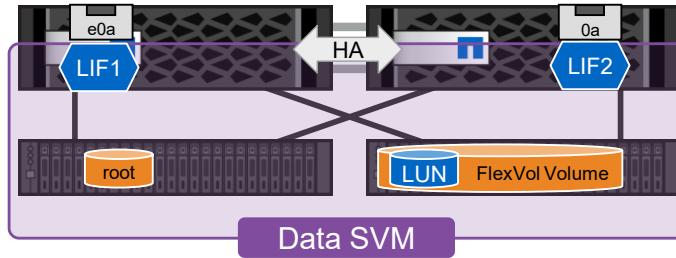
12

Data is communicated over ports. In an Ethernet SAN, the data is communicated by means of Ethernet ports. In an FC SAN, the data is communicated over FC ports. For FCoE, the initiator has a converged network adapter (CNA) and the target has a unified target adapter (UTA).

# Targets and Naming

Each SVM is the following:

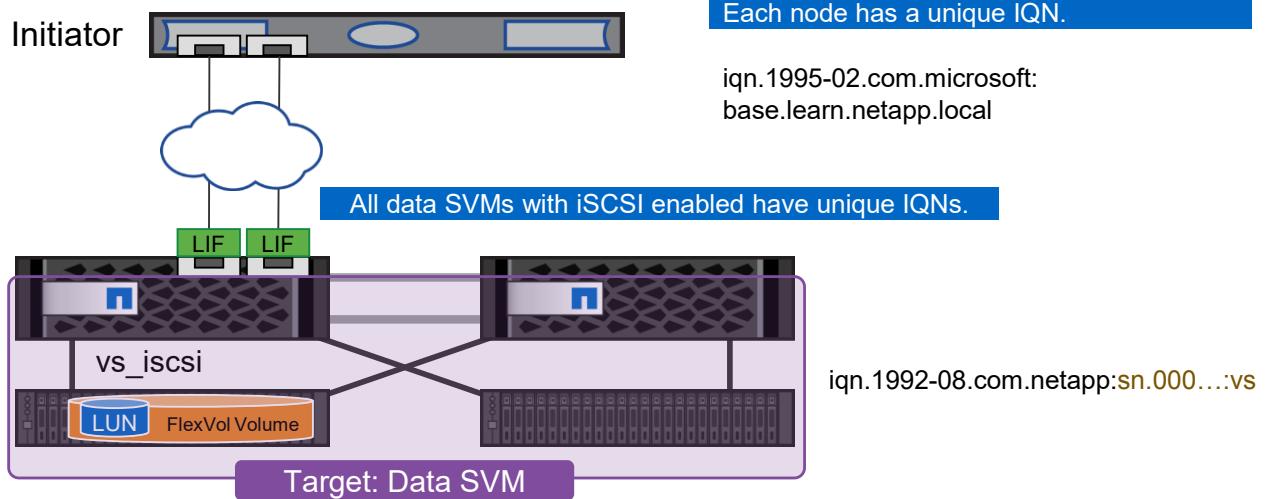
- A separate target
- Assigned a unique node name:
  - iSCSI Qualified Name (IQN)
  - Worldwide node name (WWNN)



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# iSCSI Nodes





## Lesson 2

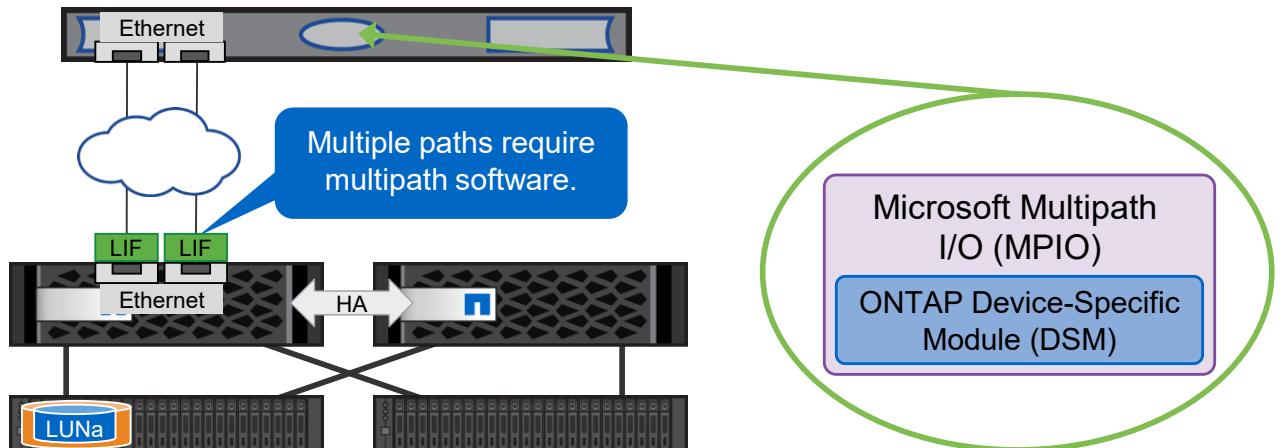
### iSCSI Configuration

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# Windows Multipath Driver

## Overview



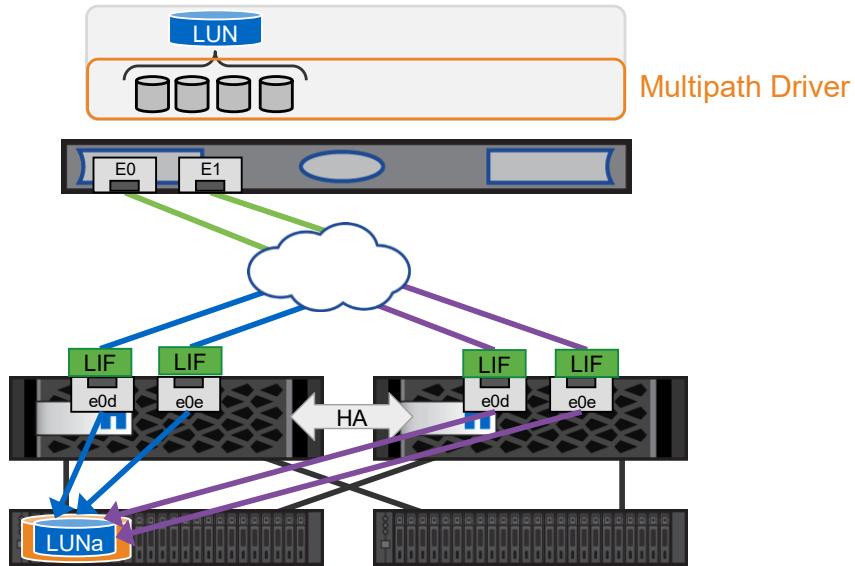
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16

Microsoft Multipath I/O (MPIO) software is required any time that a Windows host has more than one path to the storage system. The MPIO software presents a single disk to the operating system for all paths, and an ONTAP device-specific module (DSM) manages path failover. Without MPIO software, the operating system might see each path as a separate disk, which can lead to data corruption.

On a Windows system, there are two main components to any MPIO configuration: the Windows MPIO components and a DSM. MPIO is supported for Windows Server 2003, Windows Server 2008, and Windows Server 2012 systems.

## Multipath I/O Example



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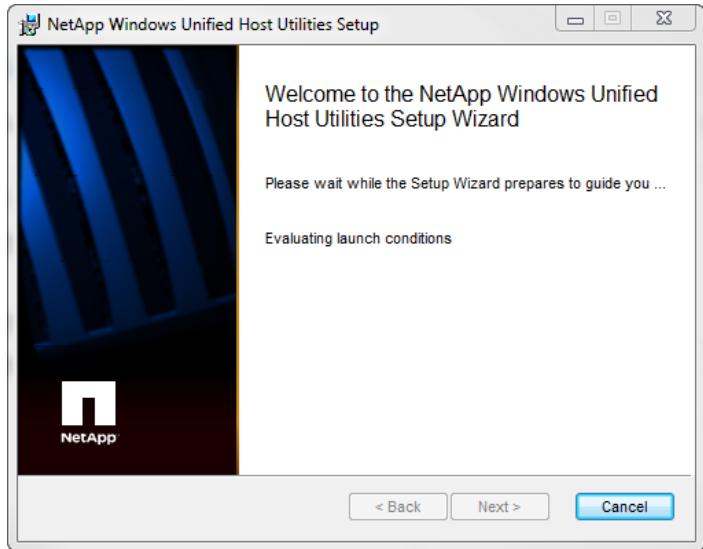
17

As paths are added between the storage controllers and the host, the LUN is seen once through each path. When a multipath driver is added to the host, the multipath driver can present the LUN as a single instance.

The figure illustrates four paths. Two paths are active and optimized. Two paths are active and nonoptimized.

**NOTE:** The paths in the figure are simplified for conceptual purposes. Depending on the platform and version, paths might appear differently, physically or logically, but the concept of ALUA states (active/optimized, active/non-optimized, or unavailable) is the same. ONTAP active/nonoptimized paths are over the cluster interconnect.

# Host Utilities



- Download from NetApp Support
- Depending on operation system, features might include:
  - Proper configuration of host operating system values
  - Proper configuration of host bus adapter (HBA) values
  - Documentation
  - Diagnostic programs for troubleshooting problems
  - Includes device-specific module (DSM)

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Host Utilities is a set of software programs and documentation that enables you to connect host computers to LUNs on NetApp storage systems. Download Host Utilities from the NetApp Support site for the operating system that runs on your host.

Host Utilities features for each operating system might differ slightly. Windows Unified Host Utilities, for example, includes an installation program that sets required parameters on the host computer and on certain host bus adapters (HBAs). Parameters include setting time-out values to enable proper failover.

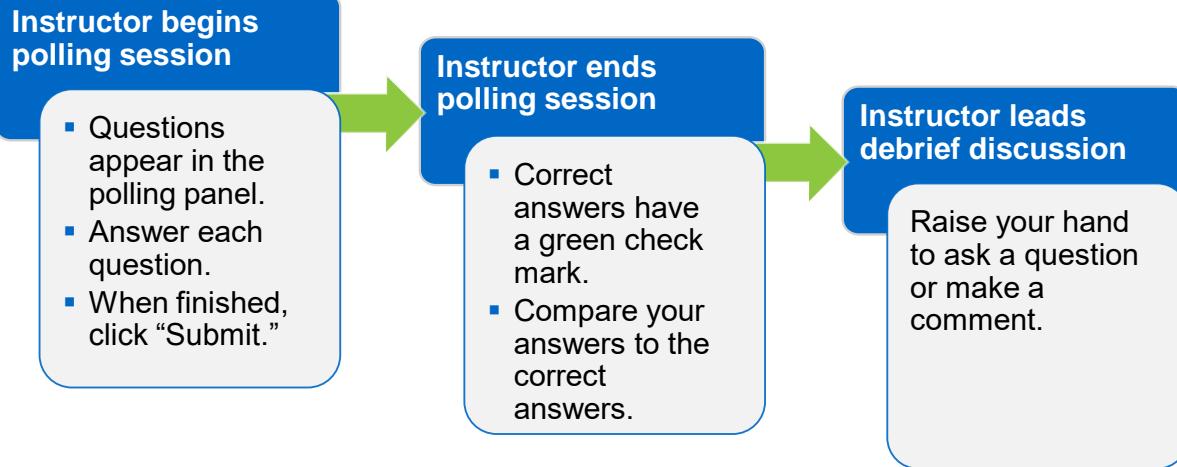
The package also includes documentation to describe how to install Host Utilities and troubleshoot typical problems. The package might also include diagnostic programs to troubleshoot problems with hosts that connect to the storage system.

# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes



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This poll has one quick question about Performance Manager. When the instructor begins the polling session, you see the polling question that you are to answer. After all answers are submitted, the instructor closes the poll.

After the polling session ends, the instructor briefly answers the question for you.



## Poll Question

Check your understanding

With which set of protocols does ONTAP software support asymmetric logical unit access (ALUA)?

- a. FC
- b. FC and FCoE
- c. FC, FCoE, and iSCSI
- d. FC, FCoE, iSCSI, and NFS

## iSCSI Implementation Steps

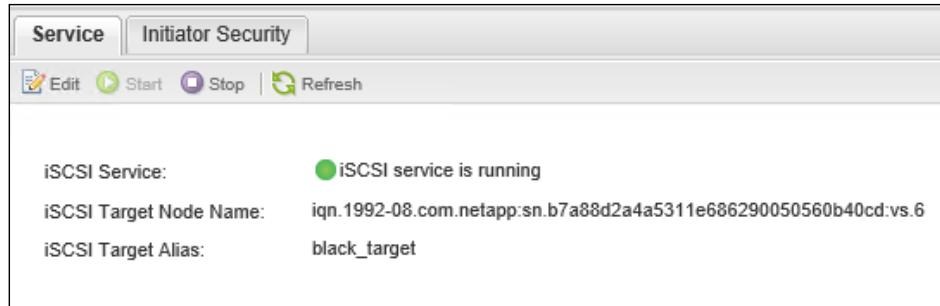
1. License the iSCSI protocol.
2. Create or designate a data aggregate.
3. Create or designate an SVM.
4. Create iSCSI LIFs.
5. Create or designate a data volume.
6. Create a LUN.
7. Create an initiator group (igroup).
8. Map the LUN to the appropriate igrup.
9. Locate the LUN on the host computer and prepare the disk.

Discussed in this lesson

The figure shows the basic steps to implement iSCSI for an SVM on ONTAP software. You can enable iSCSI by using either the CLI or the NetApp OnCommand System Manager UI.

# ONTAP iSCSI Implementation

Enable iSCSI



The screenshot shows the 'Service' tab of the ONTAP iSCSI configuration interface. It displays the following information:

iSCSI Service:	iSCSI service is running
iSCSI Target Node Name:	iqn.1992-08.com.netapp:sn.b7a88d2a4a5311e686290050560b40cd:vs.6
iSCSI Target Alias:	black_target

Below the table are buttons for Edit, Start, Stop, and Refresh.

```
rtp-nau::> vserver iscsi create -vserver svm_black aggr1-target-alias black
```

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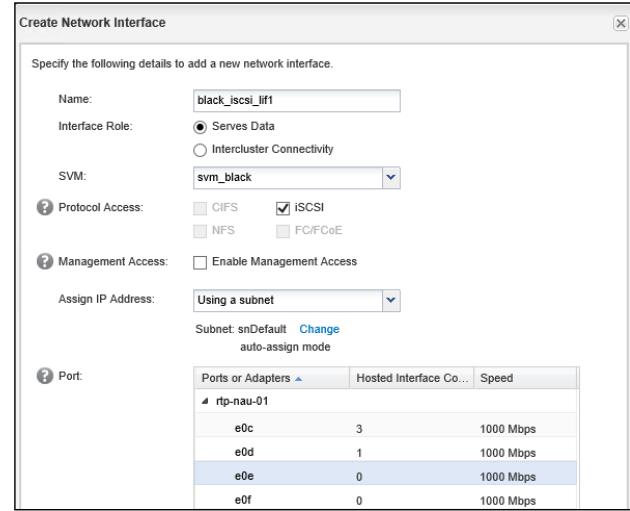
22

When iSCSI is enabled, the operational status of the iSCSI service on the specified SVM is up and ready to serve data.

# ONTAP iSCSI Implementation

## Configure an interface

**!** Create at least one LIF per node, per network, for each SVM serving data with the iSCSI protocol.



```
rtp-nau::> net int create -vserver svm_black -lif black_iscsi_lif1  
-role data -data-protocol iscsi -home-node rtp-nau-01  
-home-port e0e -subnet snDefault
```

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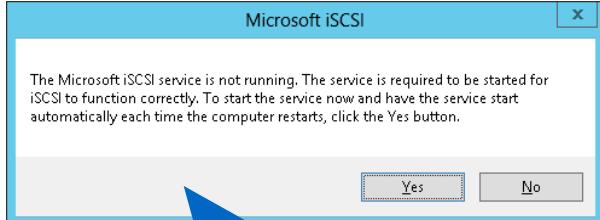
23

For ONTAP software, to create an iSCSI LIF, you must specify the -role parameter as data and the -protocol parameter as iscsi. A built-in firewall exists for extra security. A LIF should be associated with the firewall role of the data. To verify the firewall role for a particular LIF, use the instance switch on the network interface show command.

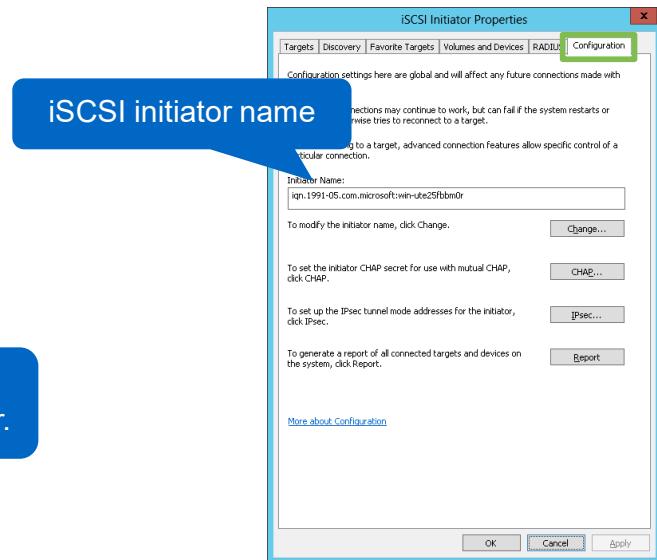
**NOTE:** You should create at least one LIF for each node and each network on all SVMs that are serving data with the iSCSI protocol. NetApp recommends having network redundancy, either through multiple networks or link aggregation.

# Windows iSCSI Implementation

## Identify the iSCSI node name



The prompt might appear the first time that you start the iSCSI initiator.



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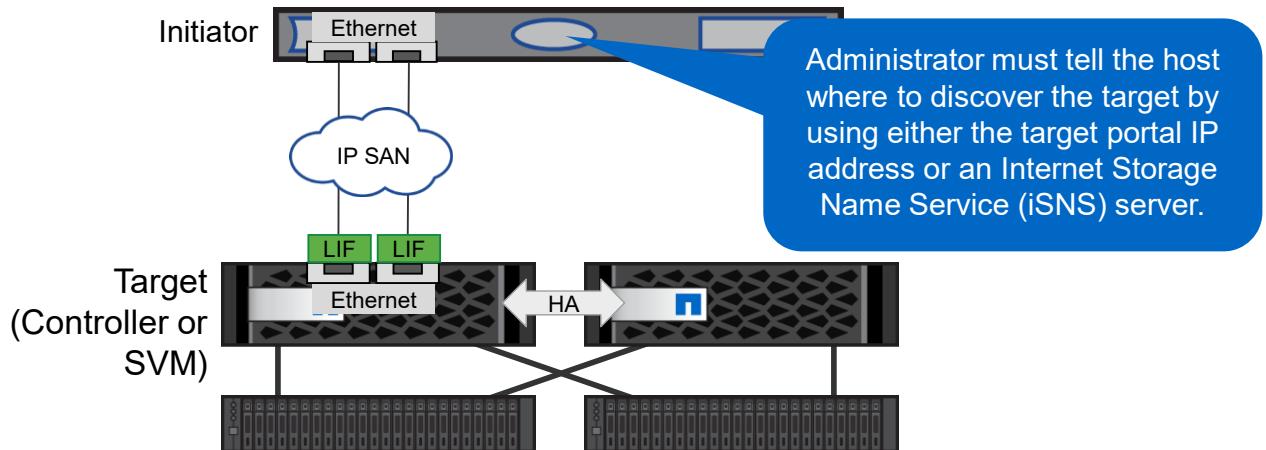
24

The iSCSI software initiator creates the iSCSI connection on the Windows host. For Windows Server 2003, you must download and install the software initiator. The iSCSI software initiator is built in to Windows Server 2008 and Windows Server 2012.

If the system has not used an iSCSI initiator before, a dialog box appears, which requests that you turn on the service. Click **Yes**. The iSCSI Initiator Properties dialog box appears.

# Windows iSCSI Implementation

## Target discovery methods



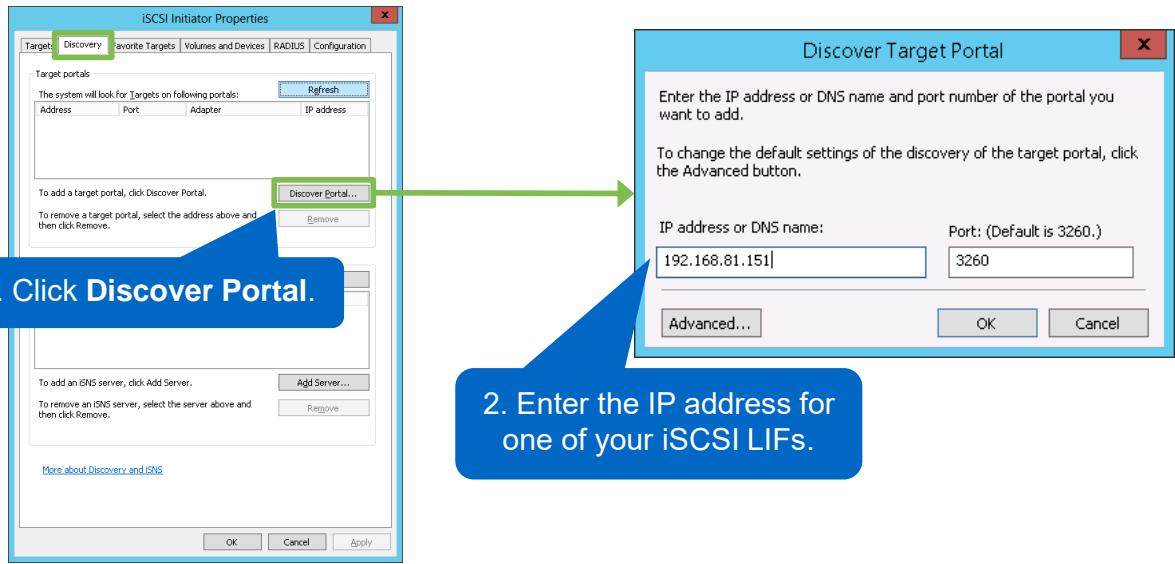
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The administrator must direct the software initiator on the host to discover the target. Discovery can be performed through one of two methods: send targets (entering the target portal IP address) or using an iSNS server. The slides illustrate the send targets method, which is most widely used and require no other servers to implement.

# Windows iSCSI Implementation

## Target discovery



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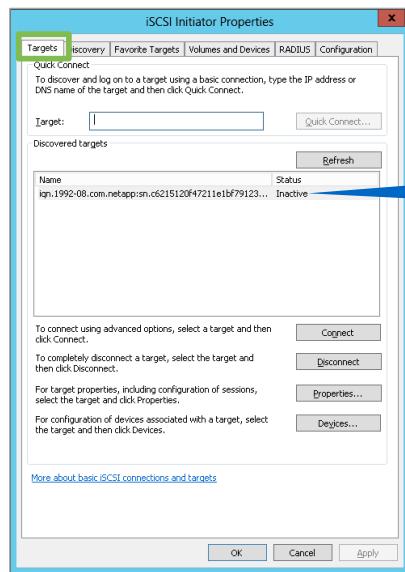
26

To discover an iSCSI target:

1. In Windows Server Manager, from the Tools menu, select **iSCSI Initiator**.
2. If the system has not used an iSCSI initiator before, a dialog box appears, requesting that you turn on the service. Click **Yes**.  
The iSCSI Initiator Properties dialog box appears.
3. Click the **Discovery** tab.
4. Click **Discover Portal**, enter the IP address for one of your LIFs on the target SVM, and then click **OK**.
5. Click the **Targets** tab, then select the discovered target's IQN and click **Connect**.
6. In the Connect To Target dialog box, select **Enable multi-path**, and then click **OK**.
7. Verify that the target has a status of Connected (as shown on the next slide).

# Windows iSCSI Implementation

Target discovered



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When a target is discovered, the target appears in the iSCSI Initiator properties as Inactive.

# Windows iSCSI Implementation

## Connect to a target

1. Select the IQN.

2. Click Connect.

3. In the Connect To Target dialog box, select the **Enable multi-path** checkbox, and then click OK.

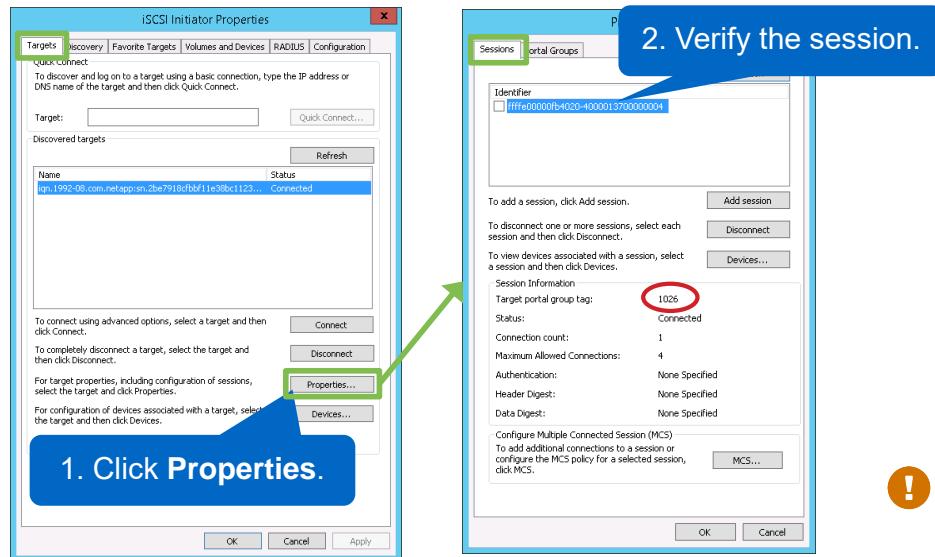
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Select the inactive target and click the **Connect** button. The Connect To Target dialog box opens. In that dialog box, you can enable persistent bindings (Favorite Targets), enable multipath, and modify advanced options.

# Windows iSCSI Implementation

## Verify the session



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! Use `iscsi session show` to verify on storage system.

When a successful connection is made with the storage system, a session is created. If multiple paths are available, a session needs to be created for each path (or LIF).

You can also display information about sessions or connections on the storage.

The `iscsi session show` command displays session information, and the `vserver iscsi connection show` command displays connection information.

The session information is also available through OnCommand System Manager.

# ONTAP Portal Groups

iSCSI Interfaces			
Network Interface	Target Portal Group	IP Address	Current Port
black_iscsi_lif1	1029	192.168.0.122	rtp-nau-01:e0e

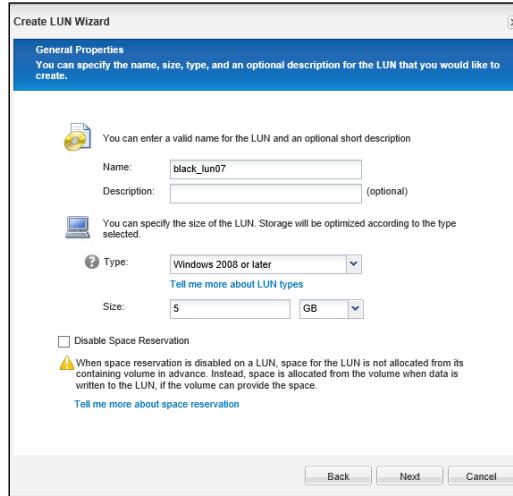
```
rtp-nau::> vserver iscsi interface show -vserver svml
      Logical          IP          Curr      Curr
Vserver  Interface    TPGT ... Address    Node      Port
-----  -----  -----
svm_black black_iscsi_lif1 1029  192.168.0.122 rtp-nau-01  e0e
```

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When a session is created between an initiator and a target, a session ID is generated. Session IDs are typically a long string of digits, which can be difficult to use for identification of a particular session. An easier way to identify a session by LIF is to use the Target Portal Group tag.

# Creating a LUN

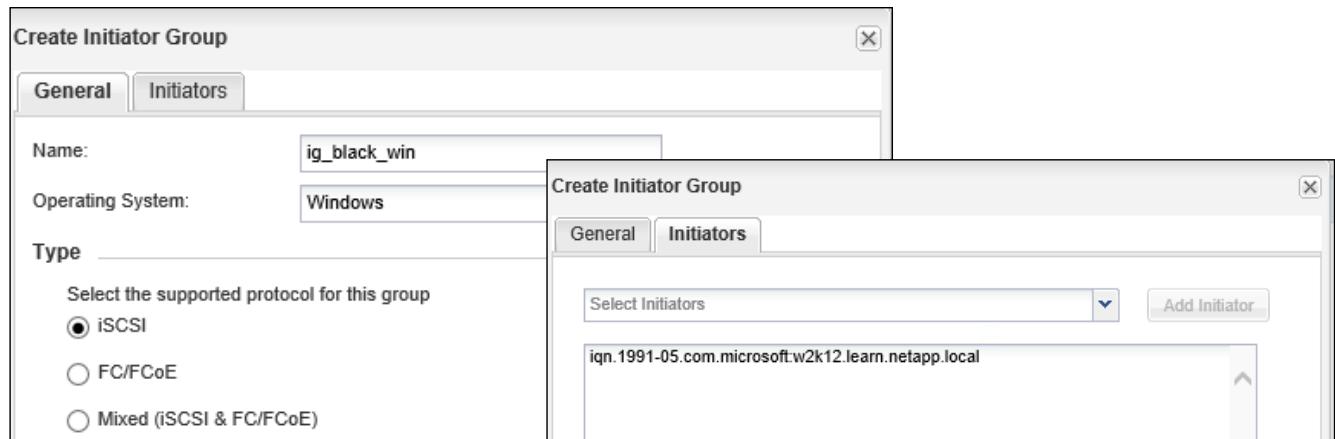


```
rtp-nau::> lun create -vserver svm_black -volume black_lun_vo107  
-lun black_lun07 -size 5GB -ostype windows_2008
```

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## Creating an igroup

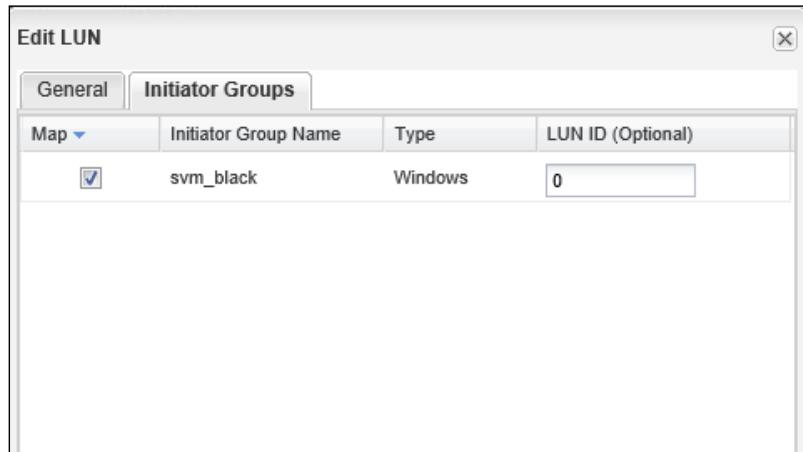


```
rtp-nau::> lun igrup create -vserver svm_black -igroup ig_black_win  
-protocol iSCSI -ostype windows  
-initiator iqn.1991-05.com.microsoft:w2k12.learn.netapp.local
```

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# Mapping a LUN



```
rtp-nau::> lun map -vserver svml -volume black_lun_vol07 -lun black_lun07  
-igroup ig_black_win
```

# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes

## Instructor begins polling session

- Questions appear in the polling panel.
- Answer each question.
- When finished, click "Submit."

## Instructor ends polling session

- Correct answers have a green check mark.
- Compare your answers to the correct answers.

## Instructor leads debrief discussion

Raise your hand to ask a question or make a comment.

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This poll has one quick question about Performance Manager. When the instructor begins the polling session, you see the polling question that you are to answer. After all answers are submitted, the instructor closes the poll.



## Poll Question

Check your understanding

What is required for a LUN to serve data in an ONTAP environment?

- a. a junction path to the global namespace
- b. igroup-to-LUN mapping
- c. a mount point in the volume
- d. an enabled LUN reservation
- e. all of the above

# ACTION: Complete an Exercise

Module 9: Configuring iSCSI



Duration: 45 minutes

## Access your lab equipment.

Use the login credentials that your instructor provided to you.

## Complete the specified exercises.

- Go to the exercise for the module.
- Start with Exercise 1.
- Stop at the end of Exercise 1.

## Participate in the review session.

- Share your results.
- Report issues.

# Share Your Experiences

Roundtable questions for the equipment-based exercises



How is SAN configuration different on a single-node cluster versus a multinode cluster?



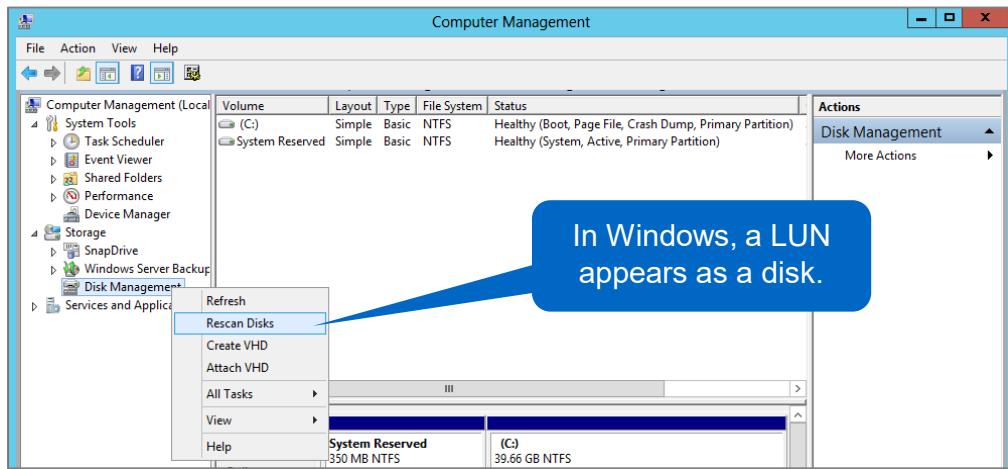
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# Windows LUN Implementation

## Discover LUN

To configure an NTFS volume LUN, first discover the LUN by selecting **Disk Management > Rescan Disks**.



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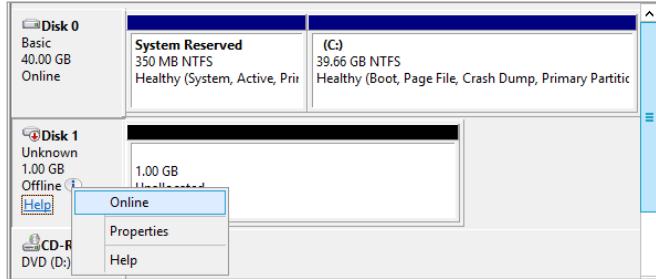
There are many ways to discover and prepare the LUN in Windows. Each version of Windows might have slightly different tools that you can use. This module illustrates the most often used method. In Windows, a LUN appears as a disk and is labeled as a disk.

Open **Computer Management**. Select **Disk Management**. If the LUN that you created is not displayed, rescan disks by right-clicking **Disk Management** or, from the Action menu, select **Rescan Disks**.

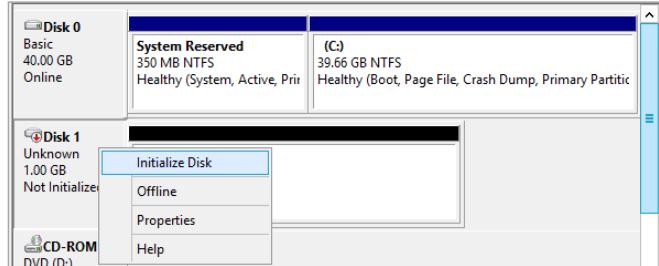
# Windows LUN Implementation

## Initialize disk

1. Right-click the disk, and then select **Initialize Disk**.



2. Right-click the new disk, and then select **Online**.



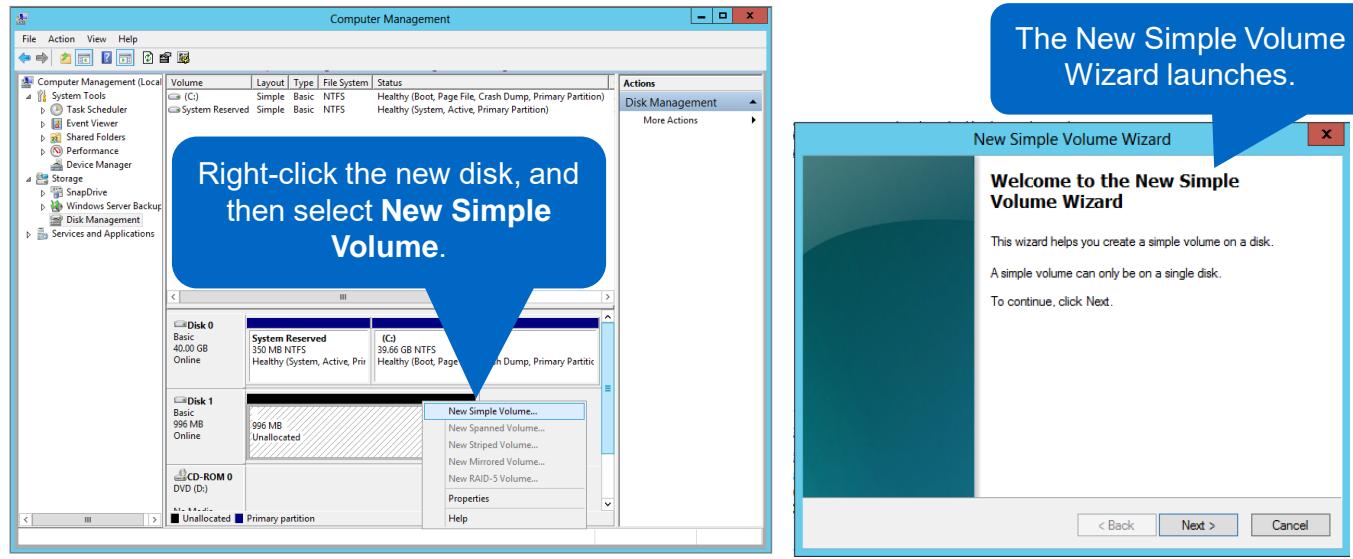
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Depending on how many LUNs you mapped, one or more disks might appear. Identify the disk that you want to prepare.

# Windows LUN Implementation

## Provisioning a volume (1 of 3)



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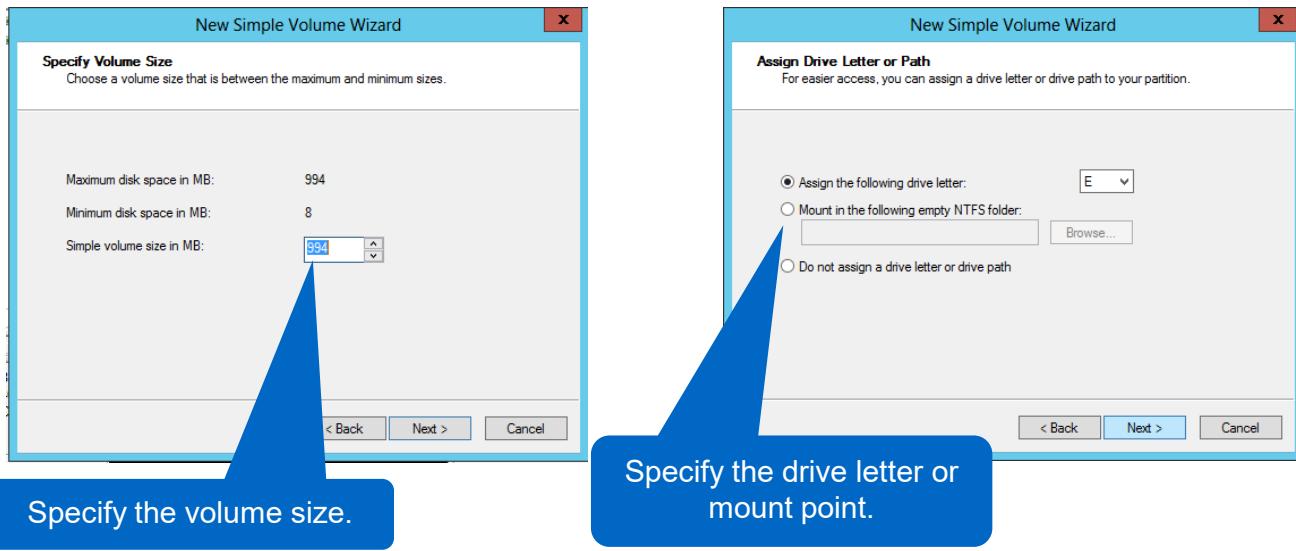
40

Now that the disk—the LUN was presented to Windows—is online and initialized, you need to provision a volume on which to put data. There are many ways to provision a volume in Windows. This module illustrates the most often used method: the New Simple Volume Wizard from the Disk Management utility.

In the Disk Management utility, launch the New Simple Volume Wizard by right-clicking the disk that you want to provision and selecting **New Simple Volume**.

# Windows LUN Implementation

## Provisioning a volume (2 of 3)



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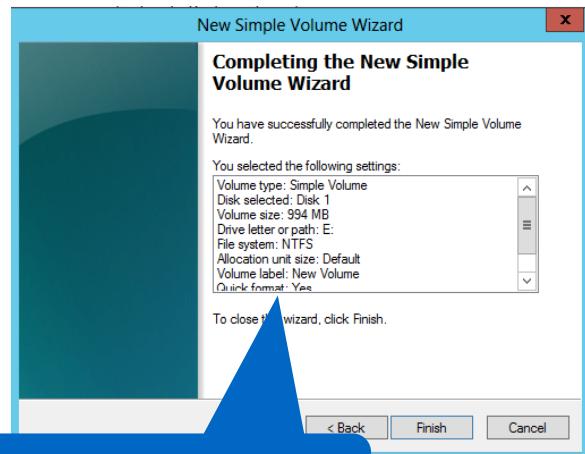
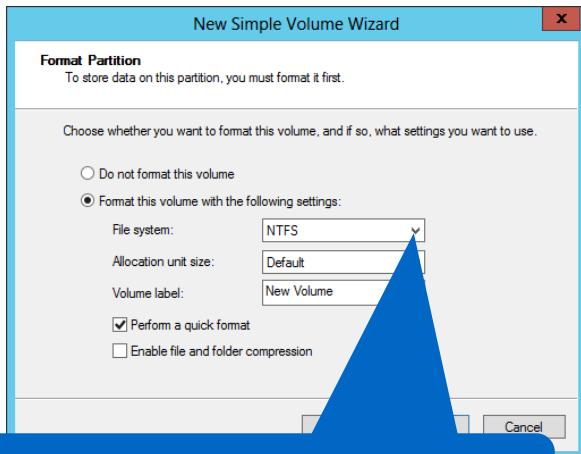
41

You need to specify the size of the volume—typically equal to the LUN size. (The volume spans the LUN.)

You also need to select a way to access the volume, by assigning a drive letter or a mount point. You can also choose not to do anything if you do not want the volume to be accessible yet.

# Windows LUN Implementation

## Provisioning a volume (3 of 3)



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Format the volume with a file system, typically NTFS. Now is a good time to label the volume for easier identification.

Verify the settings, and then click **Finish** to complete the process.

# ACTION: Complete an Exercise

Module 9: Accessing a LUN from a Windows Host



Duration: 20 minutes

## Access your lab equipment.

Use the login credentials that your instructor provided to you.

## Complete the specified exercises.

- Go to the exercise for the module.
- Start with Exercise 2.
- Stop at the end of Exercise 2.

## Participate in the review session.

- Share your results.
- Report issues.

# Share Your Experiences

Roundtable questions for the equipment-based exercises



How does partitioning and formatting a LUN from the Windows host differ from partitioning and formatting a physical hard drive in Windows?



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## Advanced Learning



To learn more about topics such as FC and FCoE SAN, configuring Linux hosts, foreign LUN import, LUN mobility enhancements, and NetApp SnapDrive data management software, see the ONTAP SAN Administration instructor-led course:

- Implementation details about using Windows and Linux as initiators
- Information about SnapDrive for Windows and SnapDrive for UNIX

## SAN References

- *ONTAP SAN Administration Guide*
- *ONTAP SAN Configuration Guide*
- *ONTAP SAN Express Setup Guide*
- *ONTAP iSCSI Configuration for Windows Express Guide*
- *ONTAP FC Configuration for Windows Express Guide*
- TR-4080: *Best Practices for Scalable SAN in ONTAP*

## Module Review

This module focused on enabling you to do the following:

- Describe SAN support on NetApp ONTAP software
- Configure iSCSI within a storage virtual machine (SVM)



## Module 10

### Cluster Maintenance

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1

## About This Module

This module focuses on enabling you to do the following:

- Upgrade NetApp ONTAP software patches and releases
- Follow best practices for peak performance
- Notify administrators about cluster events
- Prepare to engage NetApp technical support



## Lesson 1

### Upgrading Your Cluster

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# Upgrade Advisor

- Submit system identification
- Select target ONTAP version
- Generate an upgrade plan

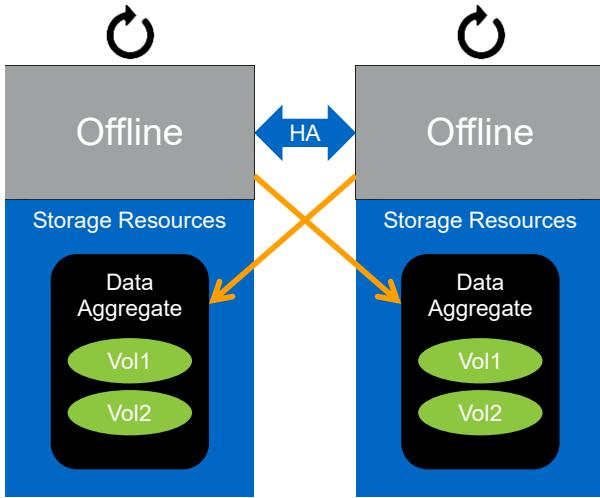


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4

Upgrade Advisor is an online tool, available on the NetApp Support Site, that simplifies the process of planning ONTAP upgrades. When you submit your system identification and target release to Upgrade Advisor, the tool compares AutoSupport data about your cluster to known requirements and limitations of the target release. Upgrade Advisor then generates an upgrade plan (and optionally a back-out plan) with recommended preparation and execution procedures.

# Rolling Upgrade



To perform a software upgrade in a cluster that consists of two or more nodes:

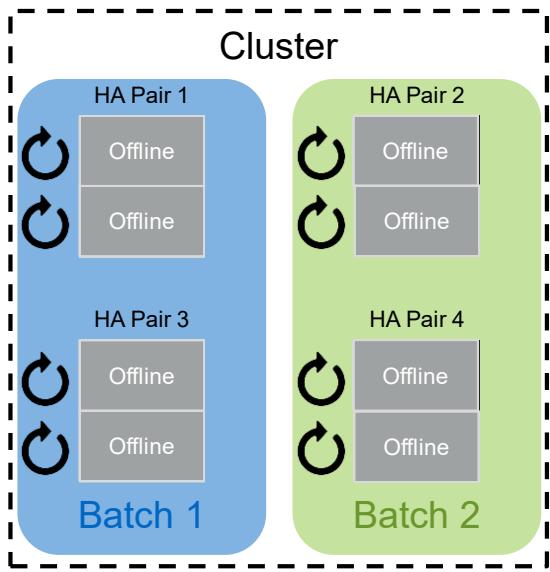
1. The HA partner takes control of the storage resources.
2. Take the node that is being upgraded offline.
3. After a reboot, the node is upgraded.
4. When the upgrade is completed, the upgraded node returns control to the original node.
5. Repeat the process on the other node of the HA pair.
6. Repeat the process on additional HA pairs.

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Rolling upgrades can be performed on clusters of two or more nodes but run on one node of an HA pair at a time.

# Batch Upgrade



To perform a software upgrade in a cluster that consists of eight or more nodes:

1. Separate the cluster into two batches, each of which contains multiple HA pairs.
2. In the first batch, take one node in each HA pair offline and upgrade the nodes while the partner nodes take over the storage.
3. When upgrades are completed on the first nodes, then upgrade the other nodes of the HA pairs.
4. Repeat the process on the second batch.

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You can perform batch upgrades on clusters of eight or more nodes. Unlike rolling upgrades, batch upgrades can be run on more than one HA pair at a time.

# Software Upgrade with NetApp OnCommand System Manager

The screenshot shows the 'Cluster Update' section of the NetApp OnCommand System Manager. The left sidebar lists cluster components: conntel (Storage, Configuration, High Availability, Configuration Updates, Cluster Update, Diagnostics). The 'Cluster Update' tab is selected. The main area displays the 'Cluster Software (Data ONTAP) Update' process. It includes a 'Refresh' button, a note about downloading software from the NetApp Support site, and a link to 'Tell me more about preparing for a Data ONTAP cluster update'. Below this are three tabs: 'Select' (selected), 'Validate', and 'Update'. A 'Cluster Version Details' section shows the current cluster version as 'NetApp Release 8.3.2RC1: Thu Nov 05 13:41:17 UTC 2015'. A table titled '▼ Show version details for nodes or HA pairs' lists a single entry: 'conntel-01/conntel-02' with 'Data ONTAP Version' 'NetApp Release 8.3.2RC1: Thu Nov 05 13:41:17 UTC 2015/NetApp'.

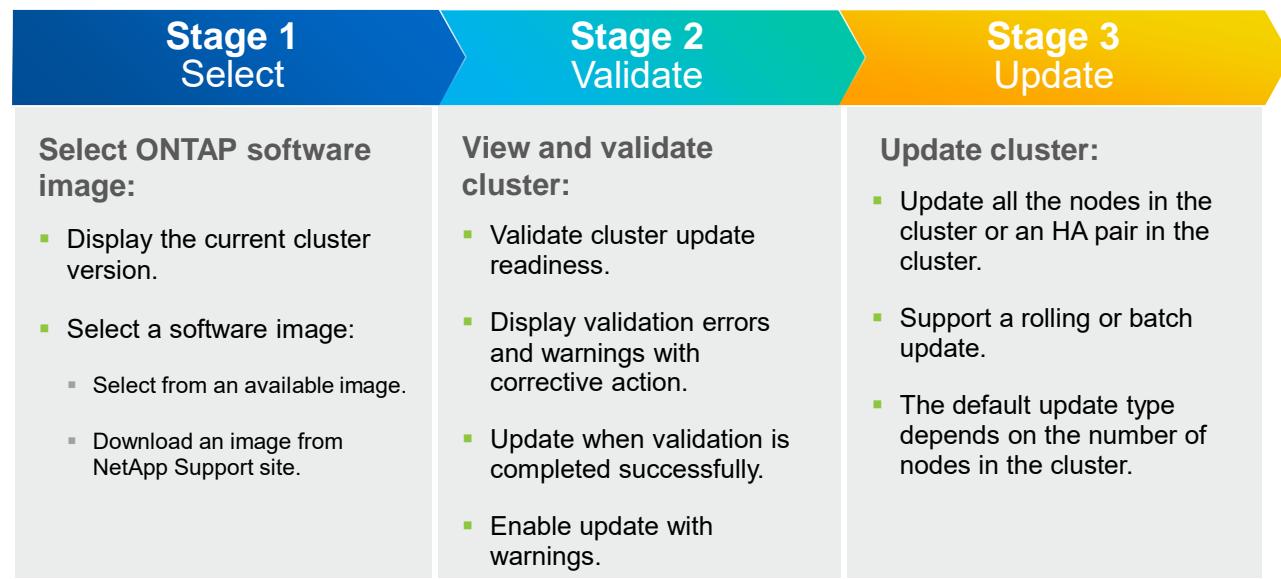
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Use CLI commands to perform rolling upgrades and batch upgrades.

You can use the CLI to perform automated upgrades. If you are upgrading from NetApp Data ONTAP 8.3.1 or later and prefer to use a UI, you can use NetApp OnCommand System Manager to perform an automated NDU instead.

# Automated Upgrade



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The automated upgrades that you can perform by using System Manager consist of three stages: Select, Validate, and Update.

In the first stage, you select the ONTAP software image. The current version details are displayed for each node or HA pair.

In the second stage, you view and validate the cluster against the software image version for the update. A pre-update validation helps you determine whether the cluster is ready for an update. If the validation is completed with errors, a table displays the status of the various components and the required corrective actions. You can perform the update only when the validation is completed successfully.

In the third and final stage, you update all the nodes in the cluster or an HA pair in the cluster to the selected version of the software image. While the update is in progress, you can choose to pause and then either cancel or resume the update. If an error occurs, the update is paused and an error message is displayed with the remedial steps. You can choose to resume the update after performing the remedial steps or cancel the update. You can view the table with the node name, uptime, state, and ONTAP software version when the update is successfully completed.

## ACTION: Try This Task



From the clustershell on svl-nau, type:

```
system node image show -instance
```

1. How many nodes are in your cluster?
2. Which version of ONTAP software is current on each node?
3. Can you tell which image is currently booted?

1. There are four nodes in the cluster.
2. Some revision of ONTAP 9.0 should be installed but this will vary.
3. Verify in the Image Name field.

# Nondisruptive Addition of Nodes to a Cluster

To add nodes to a healthy multinode switched cluster:

1. Verify that the nodes are configured as HA pairs and connected to the cluster interconnect.
2. Power on both nodes of the HA pair.
3. Start the Cluster Setup wizard on one of the nodes.
4. Use the **join** command and follow the wizard.
5. Repeat Steps 3 and 4 on the partner node.

```
rtp-nau::> cluster setup
```

Welcome to the cluster setup wizard.

You can enter the following commands at any time:  
"help" or "?" - if you want to have a question clarified,  
"back" - if you want to change previously answered questions, and  
"exit" or "quit" - if you want to quit the cluster setup wizard.  
Any changes you made before quitting will be saved.

You can return to cluster setup at any time by typing "cluster setup".  
To accept a default or omit a question, do not enter a value.

Do you want to create a new cluster or join an existing cluster?  
{create, join}: join

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You can expand an existing cluster by nondisruptively adding nodes to the cluster.

You must add nodes from HA pairs that are connected to the cluster interconnect. Nodes are joined to the cluster one at a time.

# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes

## Instructor begins polling session

- Questions appear in the polling panel.
- Answer each question.
- When finished, click "Submit."

## Instructor ends polling session

- Correct answers have a green check mark.
- Compare your answers to the correct answers.

## Instructor leads debrief discussion

Raise your hand to ask a question or make a comment.



## Poll Question

Check your understanding

1. Which two upgrade types can group HA pairs that are upgraded together?  
(Choose two.)
  - a. [rolling](#)
  - b. [batch](#)
  - c. [automated](#)
  - d. [hardware](#)



## Poll Question

Check your understanding

2. Which three phases are part of an automated upgrade? (Choose three.)
  - a. [Select](#)
  - b. [Validate](#)
  - c. [Failover](#)
  - d. [Update](#)



## Poll Question

Check your understanding

3. Which three protocols can you use to download the ONTAP software image? (Choose three.)
- a. [NFS](#)
  - b. [FTP](#)
  - c. [TFTP](#)
  - d. [HTTPS](#)
  - e. [HTTP](#)
  - f. [CIFS](#)



## Lesson 2

### Events and Alerts

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## Alerts

Tools to monitor system:

- AutoSupport
- Event Management System (EMS)
- System Manager
- Unified Manager

The screenshot shows a monitoring interface with a header bar containing 'Hardware and Diagnostics' and 'Protection' dropdowns, and tabs for 'Aggregates' and 'Events'. Below this is a section titled 'System Alerts' with a toolbar featuring 'Acknowledge', 'Suppress', 'Delete', and 'Refresh' buttons. A table lists alerts with columns for SubSystem (No. of Alerts), Alert ID, Node, and Severity. One alert is listed: 'environment (1 Alerts)' with Alert ID 'CriticalPSUFruOffAlert', Node 'conntel-01', and Severity 'critical'.

SubSystem (No. of Alerts)	Alert ID	Node	Severity
environment (1 Alerts)	CriticalPSUFruOffAlert	conntel-01	critical

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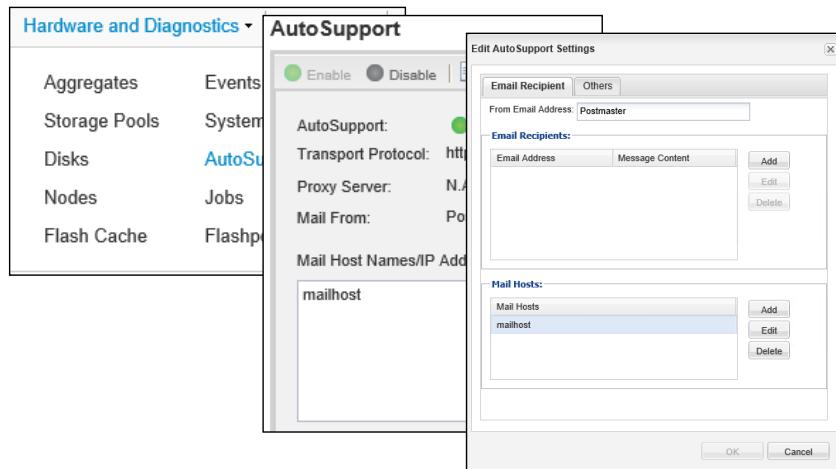
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Monitoring your system regularly is a best practice.

In the example, a notification from System Manager needs to be diagnosed. When there is an alert or event, first try the solution that the monitoring software suggests.

## AutoSupport Tool

- Integrated monitoring and reporting technology
- Health check of AutoSupport-enabled NetApp systems
- Enabled on each node of the cluster



```
svl-nau::> autosupport modify -node * -support enable -transport smtp  
      -mailhost xx.xx.xx.xx -from bob@learn.local  
      -to support@netapp.com -noteto tom@learn.local -state enable  
svl-nau::> system node autosupport invoke-node svl-nau_02 -type test
```

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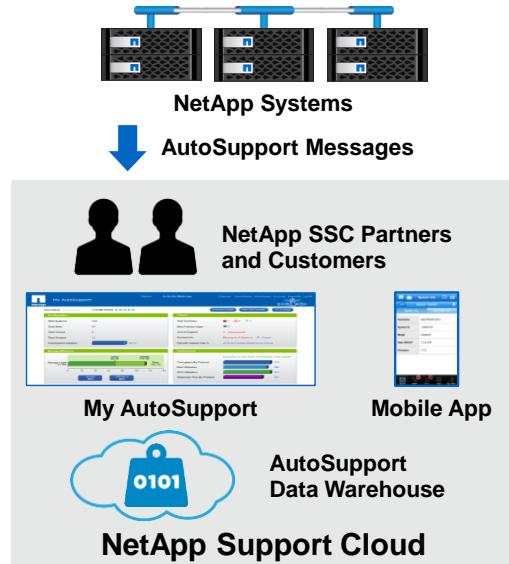
The AutoSupport tool is an integrated and efficient monitoring and reporting technology that checks the health of AutoSupport-enabled NetApp systems on a continual basis. The AutoSupport tool should be enabled on each node of the cluster.

To manage AutoSupport in System Manager, on the node's Configuration tab, click the **AutoSupport** link. The AutoSupport tool can be enabled or disabled. To configure AutoSupport, click **Edit**, and then enter your configuration information.

# My AutoSupport

## Key features:

- Identifies risks and provides best practice tips
- Compares your hardware and software versions and alerts you to potential obsolescence
- Provides performance and storage utilization reports to proactively plan capacity needs
- Provides new system visualization tools, Transition Advisor, and Upgrade Advisor for ONTAP systems



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My AutoSupport is a suite of web-based applications hosted on the NetApp Support site and accessible via your web browser. Using the data from the AutoSupport support tool, My AutoSupport proactively identifies storage infrastructure issues through a continuous health-check feature and automatically provides guidance on remedial actions that help to increase uptime and avoid disruptions to your business.

For example, My AutoSupport might find a configuration issue, a bad disk drive, or version incompatibility on your system. Or My AutoSupport can notify you of end-of-life (EOL) issues or an upcoming support contract expiration date.

If you plan any changes to your controllers, NetApp recommends manually triggering an AutoSupport message before you make the changes. The message provides a “before” snapshot for comparison, in case a problem arises later.

# EMS

- EMS does the following:
  - Writes events to the event log
  - Sends and routes notifications of events
  - Collects events throughout the cluster
  - Can view events of all nodes from any node
- rtp-nau::> event log show
- Each event contains the following:
  - Message name
  - Severity level
  - Description
  - Corrective action, if applicable

Hardware and Diagnostics ▾		Protection ▾			
Aggregates		Events			
Storage Pools		System Alerts			
Disks		AutoSupport			
<b>Events</b>					
Refresh					
Time	Node	Severity	Source		
Aug/18/2016 03:53:03	rtp-nau-01	notice	raido_thread		
Aug/18/2016 03:53:03	rtp-nau-01	notice	raido_thread		
Aug/18/2016 03:53:03	rtp-nau-01	notice	raido_thread		
Aug/18/2016 03:53:03	rtp-nau-01	notice	raido_thread		
Aug/18/2016 03:53:03	rtp-nau-01	notice	raido_thread		
Aug/18/2016 03:53:03	rtp-nau-01	notice	raido_thread		
Aug/18/2016 03:53:03	rtp-nau-01	notice	raido_thread		
Aug/18/2016 03:53:03	rtp-nau-01	notice	raido_thread		

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The event management system (EMS) collects and displays information about events that occur on your cluster. You can manage the event destination, event route, mail history records, and SNMP trap history records. You can also configure event notification and logging.

# Event-Log Filtering

Filter EMS log messages by severity, time, message name, and other criteria.

```
rtp-nau::> event log show -severity {EMERGENCY|ALERT|ERROR|NOTICE|INFORMATIONAL|DEBUG}
rtp-nau::> event log show -time "08/30/2016 10:00:00".."08/30/2016 11:30:00"
rtp-nau::> event log show -severity informational -message-name kern.uptime.filer
```

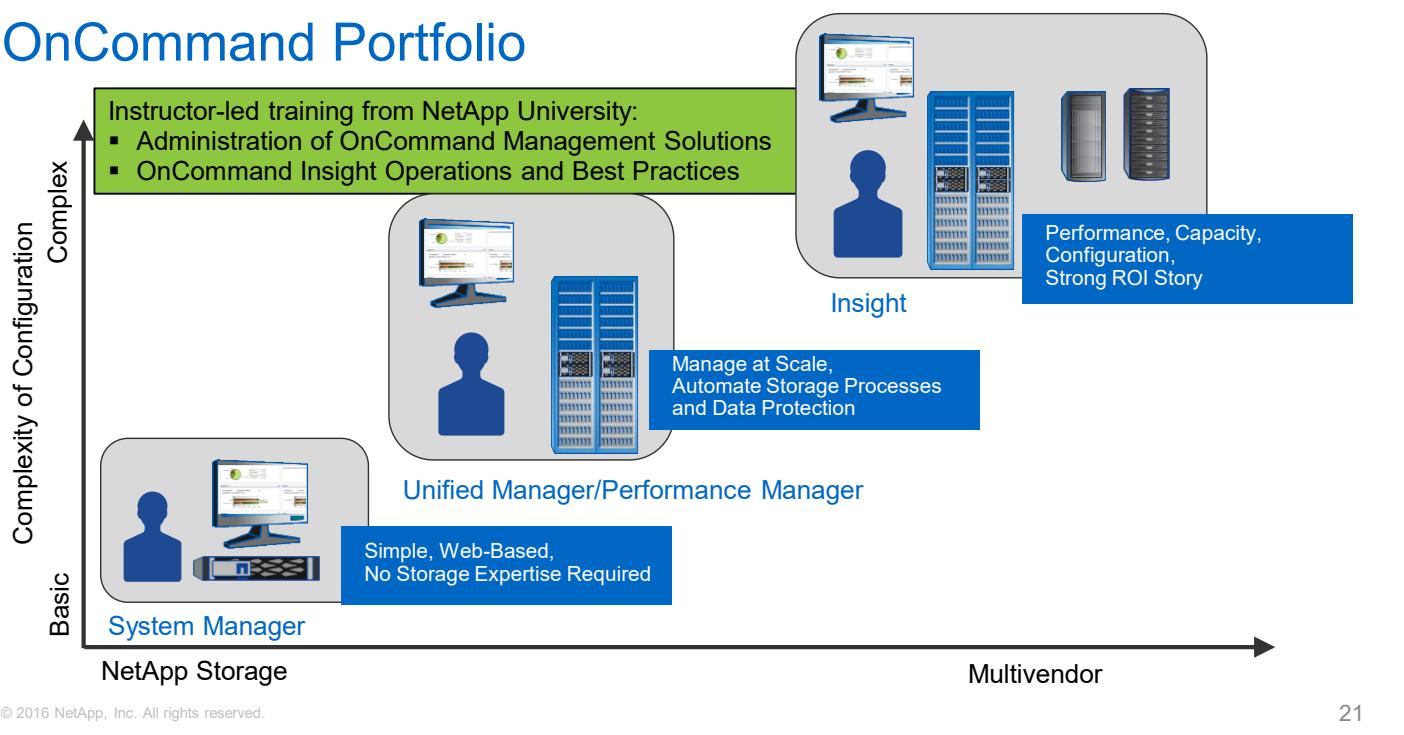
The screenshot shows the NetApp OnCommand System interface. On the left, there's a sidebar with 'Dashboard' and 'LUNs' buttons. Below them, under 'rtp-nau', are 'Cluster Details' and 'Cluster' buttons, followed by an 'Alerts' section which displays '0 Emergency EMS Events'. The main area is titled 'Events' and contains a table with columns: Time, Node, Severity, and Source. The table lists several entries for 'rtp-nau-01' at different times, all marked as 'notice'. To the right of the table is a dropdown menu for filtering events by severity, with checkboxes for All, EMERGENCY, ALERT, ERROR, NOTICE, INFORMATIONAL, and DEBUG. The 'All' checkbox is checked. The bottom right corner of the interface has a copyright notice: '© 2016 NetApp, Inc. All rights reserved.' and the number '20'.

```
rtp-nau::> event log show ?

[ -detail | -detailtime | -instance | -fields <fieldname>, ... ]
[ [-node] <nodename> ]                                     Node
[ [-seqnum] <Sequence Number> ]                            Sequence#
[ -time <"MM/DD/YYYY HH:MM:SS"> ]                         Time
[ -severity {EMERGENCY|ALERT|ERROR|NOTICE|INFORMATIONAL|DEBUG} ] Severity
(default: <=ERROR>)

[ -source <text> ]                                       Source
[ -message-name <Message Name> ]                          Message Name
[ -event <text> ]                                         Event
[ -action <text> ]                                        Corrective
Action
[ -description <text> ]                                     Description
[ -filter-name <text> ]                                    Filter Name
```

# OnCommand Portfolio



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There are many management tools to choose from.

Although System Manager provides simplified device-level management and Unified Manager can be used to monitor cluster resources at scale, both products are used to monitor only ONTAP storage systems. NetApp OnCommand Insight enables storage resource management, including configuration and performance management and capacity planning, along with advanced reporting for heterogeneous environments.

# OnCommand System Manager Dashboard

The screenshot displays the NetApp OnCommand System Manager dashboard for the cluster 'svl-nau'. The interface is organized into several sections:

- Alerts:** Shows 0 Emergency EMS Events and 0 Health Monitor Alerts.
- Capacity:** Displays utilization for five aggregates: svl0...\_004 (45.77%), svl0...\_001 (23.28%), svl0...\_001 (17.29%), svl0...\_002 (7.20%), and svl0...\_002 (0.1%).
- Network Details:** Shows 1 Subnet, 2 Broadcast Domains, and 2 IPspaces. A warning message indicates 3 network interfaces are not configured at the home port.
- Cluster:** Information about the cluster, including NetApp Release 9.0RC2: Tue Jul 26 08:55:23 UTC 2016, 2 Nodes, and License Status (green checkmark).
- Disk Details:** Shows 84 Total Disks, with 208.09 GB assigned to 53 disks. Breakdown: Spares (19.63 GB), Aggregates (133.49 GB), and Root (54.97 GB).
- Selected Activities:** Shows 0 Volume Move Operations with the message "No alerts for Volume Move".

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The OnCommand System Manager dashboard shows at-a-glance system status for a storage system. It displays vital storage information, including efficiency and capacity utilization for various storage objects, such as aggregates and volumes.

# OnCommand Unified Manager

The screenshot shows the 'Events' section of the OnCommand Unified Manager interface. On the left, there are three filter panels: 'Status' (with 'Critical' checked), 'State' (with 'New' and 'Acknowledged' checked), and 'Impact Level' (with 'Risk' checked). The main area displays a table of events with columns: Triggered Time, Status, State, Impact Level, Impact Area, and Name. One event is selected, highlighted in blue: '15 Mins Ago' (Status: Error, State: New, Impact Level: Risk, Impact Area: Protection, Name: SnapMirror Relationship Lag error).

Triggered Time	Status	State	Impact Level	Impact Area	Name
0 Min Ago	⚠️	New	Risk	Protection	SnapMirror Relationship Lag warning
0 Min Ago	⚠️	New	Risk	Protection	SnapMirror Relationship Lag warning
0 Min Ago	⚠️	New	Risk	Protection	SnapMirror Relationship Lag warning
15 Mins Ago	❗	New	Risk	Protection	SnapMirror Relationship Lag error
15 Mins Ago	⚠️	New	Risk	Protection	SnapMirror Relationship Lag warning
15 Mins Ago	⚠️	New	Risk	Protection	SnapMirror Relationship Lag warning
15 Mins Ago	⚠️	New	Risk	Protection	SnapMirror Relationship Lag warning
2 Hours 33 Mins Ago	✖️	New	Incident	Availability	One or More Failed Fans
24 Hours 22 Mins Ago	⚠️	New	Risk	Protection	Automatic Data Health Fail

To learn more about OnCommand Unified Manager and how it integrates with OnCommand Performance Manager and OnCommand Workflow Automation, enroll in the instructor-led course:  
**Administration of OnCommand Management Solutions**

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By using OnCommand Unified Manager, you can configure global threshold values for all your aggregates and volumes, to track any threshold breaches.

Events are notifications that are generated automatically when a predefined condition occurs or when an object crosses a threshold. The events enable you to take action to prevent issues that can lead to poor performance and system unavailability. Events include an impact area, severity, and impact level. Events are categorized by the type of impact area, such as availability, capacity, configuration, or protection.

You can create alerts to notify you when a particular event is generated. You can create alerts for a single resource, group of resources, and events of a particular severity type. You can specify the frequency with which you want to be notified.

You can integrate OnCommand Workflow Automation with Unified Manager to execute workflows for your storage classes. You can also monitor SVMs that have an infinite volume but do not have storage classes. When Unified Manager is integrated with Workflow Automation, the reacquisition of Workflow Automation cached data is triggered.



## Lesson 3

### Performance Best Practices

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# Performance Considerations

- Workloads
- I/O operation types:
  - Random
  - Sequential
- Quality of service (QoS)



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Storage system performance calculations vary widely based on the kind of operations, or workloads, that are being managed.

The storage system sends and receives information in the form of I/O operations. I/O operations can be categorized as either random or sequential. Random operations, such as database operations, are usually small, lack any pattern, and happen quickly. In contrast, sequential operations, such as video files, are large and have multiple parts that must be accessed in a particular order.

Some applications have more than one dataset. For example, a database application's data files and log files might have different requirements. Data requirements might also change over time. For example, data might start with specific requirements that change as the data ages.

If more than one application shares the storage resources, each workload might need to have quality of service (QoS) restrictions imposed. QoS restrictions prevent applications or tenants from being either bullies or victims.

# Analyzing I/O

## IOPS

- I/O is measured in input/output operations per second (IOPS).
- IOPS measures **how many** requests can be managed in one second.
- IOPS data is most useful if I/O has any of the following features:
  - I/O request patterns are random.
  - I/O requests are small.
  - Multiple I/O sources must be managed.



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Input/output operations per second (IOPS) is a measurement of how many requests can be managed in one second. Factors that affect IOPS include the balance of read and write operations in the system and whether traffic is sequential, random, or mixed. Other factors that affect IOPS include the application type, the operating system, background operations, and I/O size.

Applications with a random I/O profile, such as databases and email servers, usually have requirements that are based on an IOPS value.

# Analyzing I/O

## Throughput (utilization)

- Throughput is measured in megabytes per second.
- Throughput is a measurement of [how much](#) data can be managed in one second.
- Throughput data is most useful when I/O has any of the following features:
  - I/O request patterns are sequential.
  - I/O requests are large.
  - Storage is dedicated to one application.



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Throughput is a measurement of the average number of megabytes, that is how much data, can be transferred within a period for a specific file size. Throughput is measured in megabytes per second.

Applications with a sequential I/O profile, such as video or audio streaming, file servers, and disk backup targets, usually have requirements that are based on megabytes per second.

# Analyzing I/O

## Latency

- Latency is measured in milliseconds.
- Latency is a measurement of **how long** data processing takes.
- Latency values are most useful when you are comparing flash performance.



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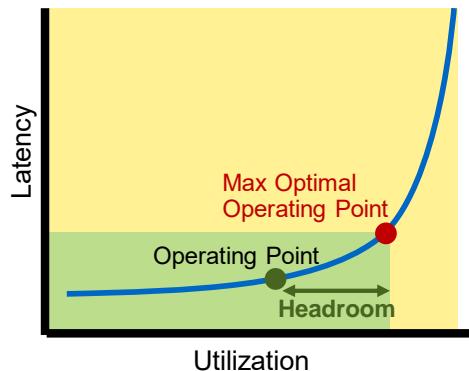
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Latency is the measurement of how long a storage system takes to process an I/O task. Smaller latency values are better.

Latency for hard disks is typically measured in milliseconds. Because solid-state media is much faster than hard disks, the latency of the media is measured in submilliseconds or microseconds.

# Clusterwide and Node-Level Performance Visibility

- Monitoring headroom enables the provisioning of workloads so that a node or aggregate is not loaded beyond the maximum optimal operating point.
- Headroom assessment varies with workload, and the optimal operating point is dynamic.
- The optimal operating point is determined by analyzing system behavior under load and applying a heuristic “knee of the latency curve” algorithm.
- Headroom is the difference between the maximum optimal and current operating points.



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Knowing the available performance capacity in the cluster helps you to provision and balance workflows. Performance capacity is how much work you can place on a node or an aggregate before latency begins to affect the performance of all workloads. You can use Performance Manager or the CLI to measure performance capacity.

To use CLI to obtain the remaining performance capacity, use the following steps:

1. Change to advanced privilege level:

```
set -privilege advanced
```

2. Start the statistics command line prompt:

```
statistics start -object resource_headroom_cpu
```

3. Display real-time headroom information:

```
statistics show -object resource_headroom
```

4. Return to administrative privilege:

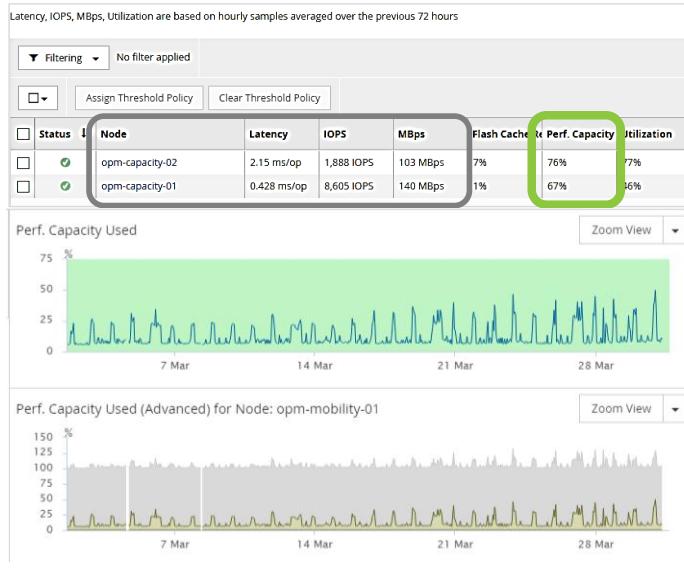
```
set -privilege admin
```

Compute the available performance capacity by subtracting the `optimal_point_counter` from the `current_counter`. For example, if the utilization capacity for a particular CPU is -14% (72%-86%) over an hourly basis, the node's CPU might be overutilized on average for the past one hour. In addition, you can specify daily, weekly, or monthly to get the same information, but averaged over a longer period.

**NOTE:** The `resource_headroom_cpu` CM object in the example represents the entire node (all CPUs collectively). You can get the available performance capacity on aggregates by using the same `stat` command syntax but with the `resource_headroom_aggr` CM object.

# ONTAP 9 NetApp OnCommand Performance Manager

## Capacity reporting



- Performance Manager reports the current percentage of **performance capacity** used; 100% is the maximum optimal operating point.
- Visibility of performance capacity enables provisioning of new workloads while staying within the desired zone of operation.
- Timeline views are also available.

## Remaining Performance Capacity

- Available performance capacity or “headroom” for additional workload.
- Steps to collect a CPU sample

```
rtp-nau::> set -privilege advanced  
rtp-nau::*> statistics start -object resource_headroom_cpu  
rtp-nau::*> statistics show -object resource_headroom
```

Counter	Value
ewma_hourly	-
ops	4376
latency	37719
utilization	60
optimal_point_ops	2573
optimal_point_latency	3589
optimal_point_utilization	72
optimal_point_confidence_factor	1

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$$72\% - 60\% = 12\%$$

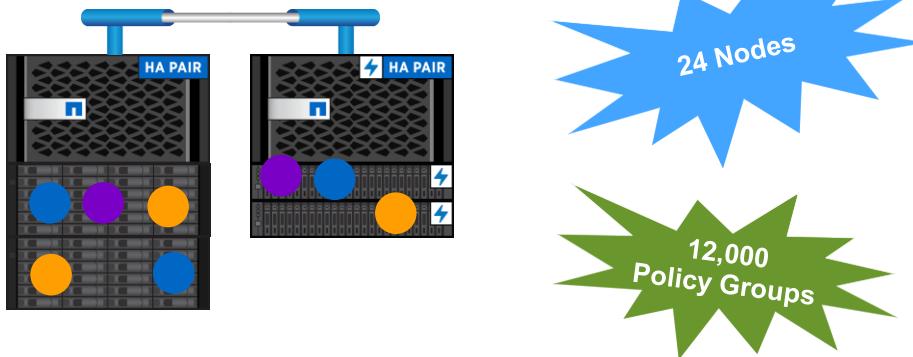
Knowing the available performance capacity in the cluster helps you provision workflows and balance them. Performance capacity is how much work you can place on a node or an aggregate before performance of all workloads begins to be affected by latency.

You compute the available performance capacity by subtracting the optimal\_point\_utilization counter from the utilization counter. In this example, the utilization capacity for this CPU is 12% (72%-60%). This suggests that the node's CPU has been underutilized on average for the past one hour.

Additional headroom capability is available in OnCommand Performance Manager 7.0.

## QoS Scaling

- Policy group count per cluster is 12,000
- Support for up to 24 nodes.
- Policy groups can have both IOPS and megabytes per second throughput limits.



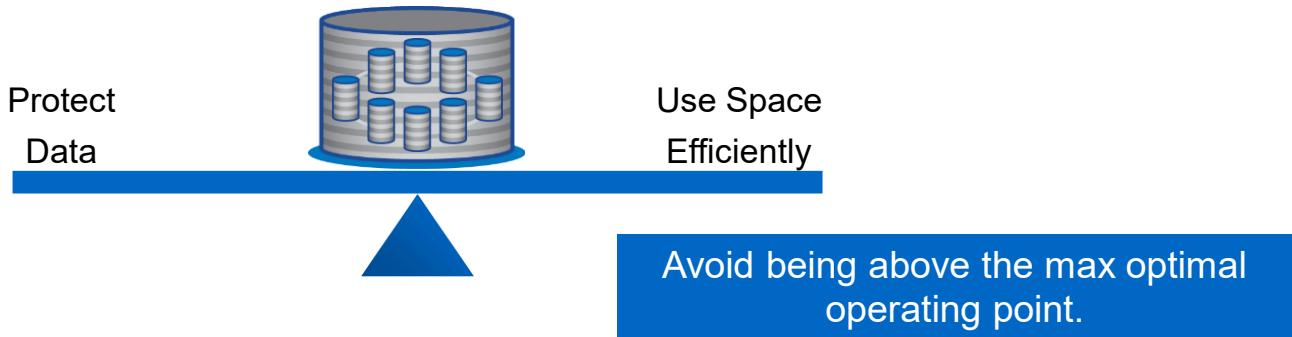
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With ONTAP 9, workloads can apply both IOPS and megabytes per second controls to storage QoS limits.

# ONTAP Performance

- You must balance the need for performance and the need for resilience:
  - More disks per RAID group increase performance.
  - Fewer disks per RAID group increase resilience.



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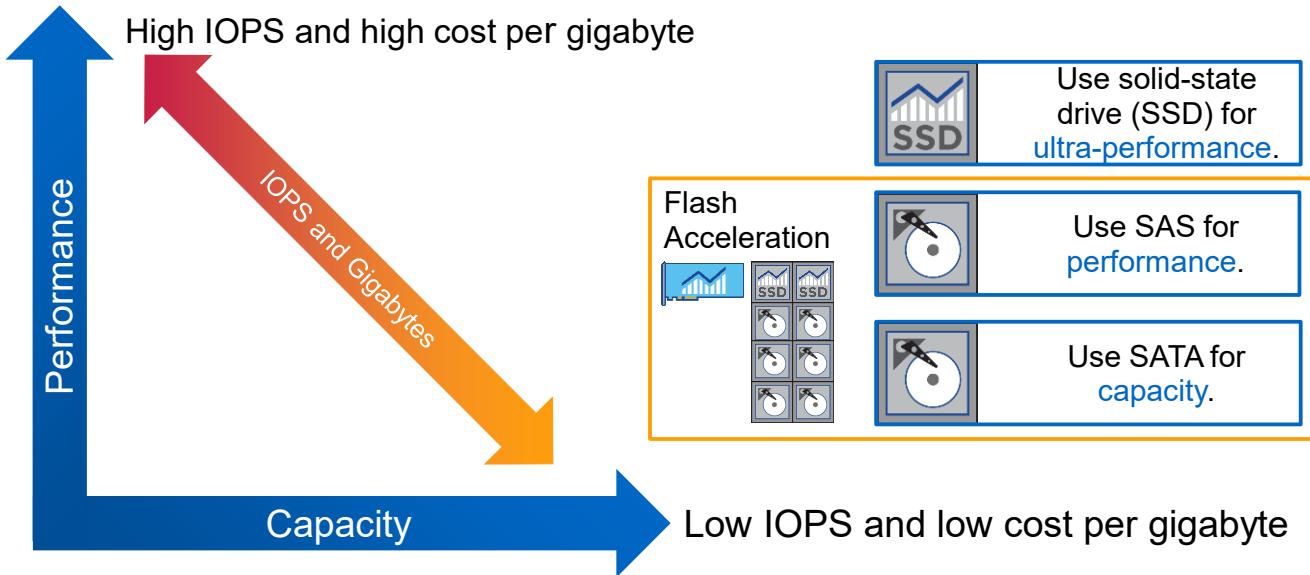
33

ONTAP software performance is measured at the aggregate level. To support the differing security, backup, performance, and data sharing needs of your users, you can group the physical data storage resources on your storage system into one or more aggregates. You can then design and configure the aggregates to provide the appropriate level of performance and redundancy.

When creating aggregates and the underlying RAID group, you must balance the need for performance and the need for resilience. By adding more disks per RAID group, you increase performance by spreading the workload across more disks, but at the cost of resiliency. In contrast, adding fewer disks per RAID group increases the resiliency because the parity has less data to protect, but at the cost of performance.

By following best practices when you add storage to an aggregate, you optimize aggregate performance. You should also choose the right disk type for the workload requirements.

# Performance of Disk Types



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The proper disk type depends on the performance or capacity requirements of the workload.

When a workload requires the largest capacity at the lowest cost with lower performance, use SATA disks.

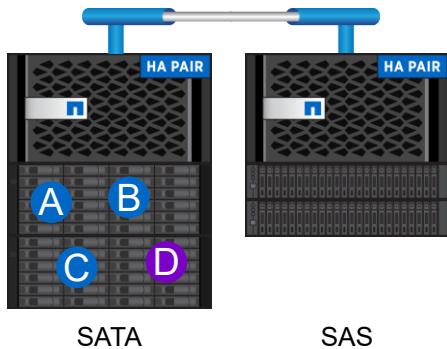
When a workload requires the highest performance at the lowest cost with lower capacity, use solid-state drives (SSDs).

When a workload requires a balance of capacity and performance, use SAS disks.

Sometimes, a workload might require large amounts of capacity at the lowest cost but at a higher performance than SATA or SAS provides. To improve the performance of high-capacity hard disks, you can use Flash Cache or a Flash Pool technologies.

# Maintain Optimal Operating Point

Adding and relocating resources



Relocating resources nondisruptively:

- Moving volumes and LUNs
- Moving an aggregate between the nodes of an HA pair
- Creating a FlexClone of a volume or LUN

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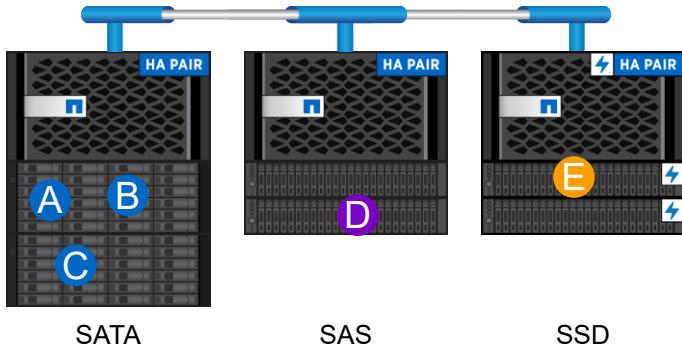
As well as discussing performance at the node level, discussing performance at the cluster level is important.

In the example, an administrator creates volumes on a two-node cluster that is used for file services. The system is configured with SATA disks to meet the workload requirements.

After some time, the administrator needs to add a volume for a database application. The SATA disks do not meet the requirements for the new workload. The administrator decides, for future growth, to nondisruptively add another HA pair with SAS disks. With new nodes with SAS disks active in the cluster, the administrator can nondisruptively move the volume to the faster disks.

# Maintain Optimal Operating Point

All Flash FAS



## NetApp ONTAP FlashEssentials features:

- Coalesced writes to free blocks
- Random read I/O processing path
- Highly parallelized processing architecture
- Built-in QoS
- Inline data reduction and compression

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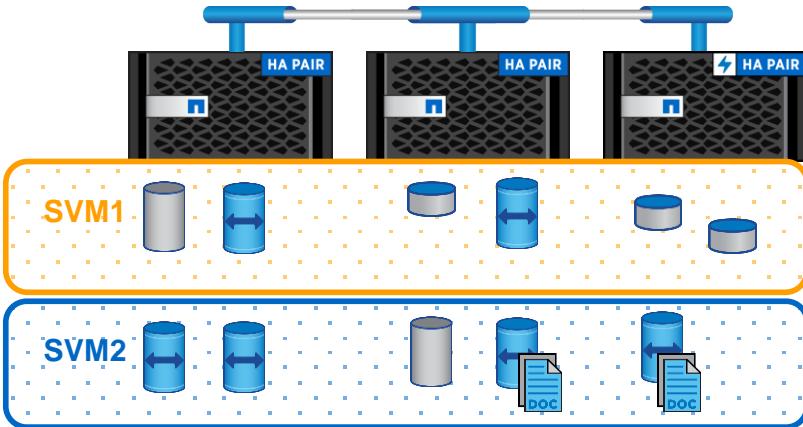
36

The administrator has a new requirement for a workload that requires high-performance requirements. For easier management of the various workload types, the administrator decides to create in the cluster a new high-performance tier that uses All Flash FAS controllers.

NetApp ONTAP FlashEssentials is the power behind the performance and efficiency of All Flash FAS. All Flash FAS uses high-end or enterprise-level controllers with an All Flash personality, which supports SSDs only. For more information about All Flash FAS and FlashEssentials, see *Using All Flash FAS with ONTAP* on the NetApp Support site.

# Maintain Optimal Operating Point

## Storage QoS



- Consistent performance for mixed workloads and mixed tenants
- Policies to monitor, isolate, and limit workloads of storage objects:
  - Volume
  - LUN
  - File
  - SVM



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You can use storage QoS to deliver consistent performance by monitoring and managing application workloads.

You can configure the storage QoS feature to prevent user workloads or tenants from affecting one another. The feature can be configured to isolate and throttle resource-intensive workloads. The feature can also enable critical applications to achieve consistent performance expectations.

Policies are throughput limits that can be defined in terms of IOPS or megabytes per second.

# Maximizing Performance

## Ways to minimize performance issues:

- Correctly size and follow best practices for the specific workload.
- Verify the supported minimums and maximums.
- Adhere to the ONTAP storage platform mixing rules.
- Check compatibility of components, host operating system, applications, and ONTAP software.

## Potential performance issues:

- **Controller:** Resource overutilization, ONTAP version, offline or rebooting
- **Storage:** Disk types, aggregate configuration, volume movement, free space
- **Networking:** Configuration, LIF location, port saturation, port speeds, indirect access
- **Host or clients:** Application, drivers, network adapter, user knowledge



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Start with a properly sized system and follow best practices for ONTAP software, the host operating system, and the application. Verify and adhere to the supported minimums, maximums, and mixing rules. Use the NetApp Interoperability Matrix Tool (IMT) to check compatibility.

Situations can change and issues arise over time. Performance issues can occur for many reasons. Performance analysis can be complex and is beyond the scope of a fundamentals course.



## Lesson 4

### Manage Logs and Core Files

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## System Logs

- Log messages can be sent to the following:
  - The console
  - The message log
- You can access the message log by using the following:
  - The `debug log` command
  - System Manager
  - A web browser

<http://cluster-mgmt-ip/spi/svl-nau-01/etc/log/>



Use the `debug log` command  
to browse the `messages.log` file.

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The system log contains information and error messages that the storage system displays on the console and logs in message files.

# NetApp Technical Support

The screenshot shows the NetApp Support website. At the top, there's a blue header bar with the NetApp logo, a search bar containing 'I need support on...', and a 'Login' button. Below the header, a navigation menu includes 'Products', 'Downloads', 'Tools', and 'Documentation'. A main banner features a man in a server room and the text 'Access Support Guides' with a 'LEARN MORE' button. To the right is a sidebar with 'Sign In' and 'Forgot Password?' links, and sections for 'New to NetApp?', 'Register Now!', and 'Learn about registration benefits'. Below the banner are three cards: 'Getting Started' (with an image of a server room), 'Preventive Care Program' (with an image of three people), and 'NetApp Contact Center' (with an image of a person on a phone). At the bottom left is a copyright notice: '© 2016 NetApp, Inc. All rights reserved.'

■ **NetApp Support:**  
[mysupport.netapp.com](http://mysupport.netapp.com)

■ **My AutoSupport:**  
[mysupport.netapp.com/myautosupport](http://mysupport.netapp.com/myautosupport)

■ **Hardware Universe:**  
[hwu.netapp.com](http://hwu.netapp.com)

■ **NetApp IMT:**  
[mysupport.netapp.com/matrix](http://mysupport.netapp.com/matrix)

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For support information, documentation, software downloads, and access to My AutoSupport, see NetApp Support at [mysupport.netapp.com](http://mysupport.netapp.com).

To access AutoSupport for your storage systems, see My AutoSupport at [mysupport.netapp.com/myautosupport](http://mysupport.netapp.com/myautosupport).

For system configuration information, see the NetApp Hardware Universe at [hwu.netapp.com](http://hwu.netapp.com).

To determine the compatibility between various NetApp and officially supported third-party products, see the NetApp IMT at [mysupport.netapp.com/matrix](http://mysupport.netapp.com/matrix).

## References

- *ONTAP Upgrade and Revert/Downgrade Guide*
- *Nondisruptive Upgrade Technical FAQ*
- TR-4150-0313: *Operational Best Practice – AutoSupport*
- NetApp Knowledge Base: <https://kb.netapp.com>



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You can find the technical triage templates at  
[https://kb.netapp.com/support/index?page=content&cat=TRIAGE&channel=HOW\\_TO](https://kb.netapp.com/support/index?page=content&cat=TRIAGE&channel=HOW_TO).

# ACTION: Complete an Exercise

Module 10: Exploring the Event Log



Duration: 30 minutes

## Access your lab equipment.

Use the login credentials that your instructor provided to you.

## Complete the specified exercises.

- Go to the exercise for the module.
- Start with Exercise 1.
- Stop at the end of Exercise 1.

## Participate in the review session.

- Share your results.
- Report issues.

## Share Your Experiences

Roundtable questions for the equipment-based exercises



When you observed the behavior in Iometer, were the benefits of storage QoS apparent?



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## Module Review

This module focused on enabling you to do the following:

- Upgrade NetApp ONTAP software patches and releases
- Follow best practices for peak performance
- Notify administrators about cluster events
- Prepare to engage NetApp technical support



## Module 11

### Data Protection Features

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## About This Module

This module focuses on enabling you to do the following:

- Describe the integrated data protection features in NetApp ONTAP software
- Describe NetApp data protection solutions
- Identify the tools and software that are used to manage and monitor NetApp data protection features

## ACTION: Topics for Discussion



- Which types of data protection challenges might you encounter in a typical customer environment?
- How might NetApp data protection technologies fit into such an environment?



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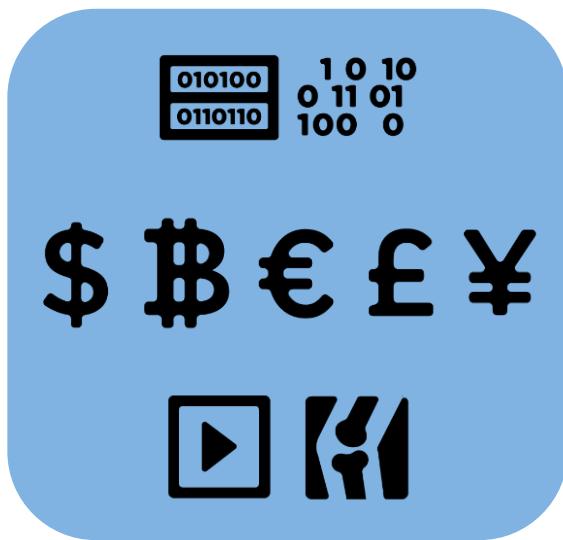
## Lesson 1

### Data Protection

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# Data Currency



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## Data protection SLA terms:

- Recovery point objective (**RPO**) is the maximum amount of acceptable data loss during a failure.
- Recovery time objective (**RTO**) is the maximum acceptable time that is required to make the data available after a failure.

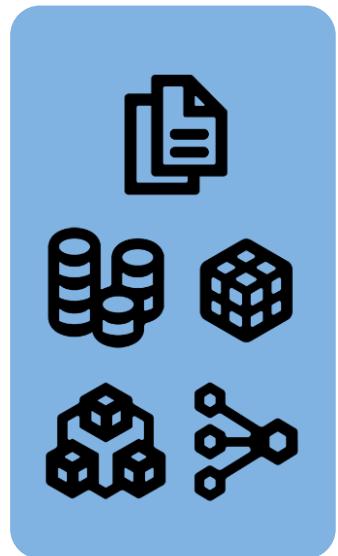
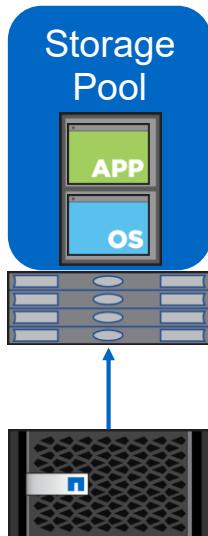
When you discuss data and data protection, you must first consider the currency of data. Assign a monetary value to the data, based on the significance to the organization that owns the data. For example, the video of child's first steps is important to the child's family but might be of little value outside the family. However, the medical records of the same child are of great importance to the health of the child, the family, and possibly many other people. The health records can be used to identify, heal, or prevent health issues for the child, the family, and possibly other people around the globe. Protecting a video or picture on a cellphone and protecting health records in a health network with many doctors and hospitals present very different challenges.

Data currency is important when defining the terms of an SLA between the service provider and the customer. The two terms most commonly used are recovery point objective (RPO), which is the maximum amount of acceptable data loss during a failure, and recovery time objective (RTO), which is the maximum acceptable time that is required to make the data available after a failure. Determining the RTO and RPO help to define the data protection solution or solutions that meet particular SLA requirements.

# Data Consistency

Consistency types:

- Point-in-time
- Transactional
- Crash
- Application



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Data consistency requirements vary widely depending on the workload requirements. Start by examining a single text file on a share or volume. When you back up a file—for example, by using a NetApp ONTAP Snapshot copy—the file is consistent in that point in time. The backup protects the file at a particular point in time, and if needed, you can restore the file to that exact point. When ONTAP software creates a Snapshot copy, the copy is at the volume level, and so all the files in a volume are backed up at the same time. As previously stated, for most file shares, this level of consistency is adequate.

For block-level data from a host using SAN protocols, where the host controls the file system, consistency is required between the host and the storage system. If the host writes data while the storage system is performing a backup, the data consistency between the host and storage system might be compromised. The same is true with applications that write structured data; for example, a database application data. For such workloads, transactional consistency is required. Transactions must be paused or quiesced while the data is backed up. With ONTAP software, Snapshot copies are nearly instantaneous and so the pause is brief, but the backup must be orchestrated between the host, application, and storage system.

Server and desktop virtualization poses a unique challenge as multiple layers of data need to be protected. The host administrator uses the virtualization software to create storage pools or containers on the storage system. The host administrator uses the storage pools or containers to create virtual machines and virtual disks to present to the VMs. Lastly, the administrator installs applications on the virtual machines, which in turn write data to the virtual disks. In a virtualized environment, you need to consider the host and its data, the virtual machines and their data, and the applications and their data. For virtual machines in particular, there are two consistency types: crash and application. The difference between the types is whether only the virtual machine is backup-aware or whether both the virtual machine and application are backup-aware, respectively.

# Data Protection Challenges

## Challenges

High Availability	Backup and Archive	Disaster Recovery	Compliance	Cloud Integration
<p>Data needs to be available during a hardware failure.</p> 	<p>Quick and efficient point-in-time copying and restoring of data needs to occur both locally and remotely.</p> 	<p>Data needs to be available during a site failure.</p> 	<p>Data needs to comply with at-rest encryption and retention policies for regulatory or business requirements.</p> 	<p>Data needs to be replicated to or near the cloud for backup, archive, or disaster recovery.</p> 

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Consider the different types or categories of data protection and the challenges that each poses.

High availability includes features that provide availability or takeover of resources if a component or controller fails. High availability typically occurs within a data center.

Backup and archive includes features that back up or archive data locally or remotely.

Disaster recovery includes features that mirror data either locally or remotely. If a failure occurs at the mirror source (or primary site), the data at the mirror destination (or disaster-recovery site) is made available. Disaster recovery is typically considered a site-level protection and usually occurs between two data centers.

Compliance includes features that encrypt data or prevent data from being deleted or changed for a specified period. Compliance features are typically used to comply with a regulation or policy requirement; for example the Sarbanes-Oxley Act or the Health Insurance Portability and Accountability Act (HIPAA).

Cloud integration includes features that back up, restore, archive, or mirror data to a destination that is either in or near the cloud.



## Lesson 2

### NetApp Data-Protection Solutions

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# High-Availability Solutions

High Availability	Backup and Archive	Disaster Recovery	Compliance	Cloud
Feature	Protection			
NVRAM	Write acknowledgement before committing to disk			
High-availability (HA) pairs	Data availability if a controller fails			
RAID-DP or RAID-TEC	Provides double-parity or triple-parity protection that prevents data loss if two or three drives fail			

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The listed features are part of ONTAP software and require no additional licensing.

The fundamentals of high availability is covered in the ONTAP Cluster Fundamentals course and is not discussed in this course.

You can learn more about high availability administration in the ONTAP Cluster Administration course.

# Backup and Archive Solutions

High Availability	Backup and Archive	Disaster Recovery	Compliance	Cloud
Feature	Protection			
Snapshot technology	Point-in-time volume-level copy			
SnapRestore data recovery software	Snapshot copy recovery			
SnapVault backup solution	Replication-based disk-to-disk backup			
Tape or SMTape	Tape backup or restore using an NDMP-compliant backup application			

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The listed features listed are used to back up and archive data locally, remotely, or to tape. Snapshot copies, NDMP, and SMTape are part of ONTAP software and require no additional licensing. Enabling SnapRestore and SnapVault software requires licensing.

The fundamentals of Snapshot technology was covered in the ONTAP Cluster Fundamentals course and only a review is provided in this course. This course focuses on when to use Snapshot copies or restore from a Snapshot copy by using SnapRestore software. The course also discusses how SnapVault software can be used as a disk-to-disk backup solution.

You can learn more about Snapshot and SnapRestore administration in the ONTAP Cluster Administration course. In addition, SnapVault administration and tape backups are covered in the ONTAP Data Protection Administration course.

# Disaster Recovery Solutions

High Availability	Backup and Archive	Disaster Recovery	Compliance	Cloud
Feature	Protection			
SnapMirror software	Asynchronous volume-level data replication for data movement and disaster recovery			
FlexClone technology	Instantaneous, space-efficient copies of replicated data			
Load-sharing mirrors	Namespace (SVM root volume) protection			
SyncMirror software	Synchronous aggregate-level mirror			
MetroCluster software	Zero RTO/RPO disaster recovery			

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Note: SVM=storage virtual machine

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The listed features are used for disaster recovery. Load-sharing mirrors and SyncMirror software are part of ONTAP software and require no additional licensing. Enabling the SnapMirror and FlexClone software requires licensing.

Flexible clones and load-sharing mirrors are discussed in the ONTAP Cluster Fundamentals and ONTAP NAS Fundamentals courses, respectively, and are not discussed in this course.

This course focuses on SnapMirror, SnapVault, storage virtual machine (SVM) disaster recovery, NDMP, and tape backup. We also discuss how SyncMirror and MetroCluster software work and where the technology is used.

You can learn more about FlexClone and load-sharing mirror administration in the ONTAP Cluster Administration course.

# Compliance Solutions

High Availability	Backup and Archive	Disaster Recovery	Compliance	Cloud
Feature	Protection			
NetApp Storage Encryption (NSE)	Full disk encryption (FDE) using a self-encrypting disk (SED)			
SnapLock compliance software	WORM solution to meet external and internal requirements for retaining, protecting, and accessing regulated and reference data			

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The listed features are used for comprehensive encryption and retention of data at rest.

Compliance solutions are not covered in this course. You can learn more about compliance in the ONTAP Compliance Solutions course.

# Cloud Solutions

High Availability	Backup and Archive	Disaster Recovery	Compliance	Cloud
Feature	Protection			
NetApp Private Storage for Cloud (NPS for Cloud solution)	Dedicated, private NetApp storage (near-cloud)			
NetApp Snap-to-Cloud disaster recovery solution	Cloud-integrated data storage for disaster recovery			
NetApp AltaVault cloud-integrated storage technology	Cloud-integrated backup and recovery			

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The listed features are used for backup, archive, or disaster recovery in the cloud.

Although NetApp Snap-to-Cloud disaster recovery solution and NetApp Private Storage for Cloud (NPS for Cloud solution) are not directly covered in this course, the knowledge you gain in the course can easily be transferred to those solutions. In addition, this course focuses on ONTAP 9 Data Management Software, so NetApp AltaVault cloud-integrated storage technology is not discussed. You can find more about AltaVault training by searching the NetApp Learning Center.

# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes

## Instructor begins polling session

- Questions appear in the polling panel.
- Answer each question.
- When finished, click “Submit.”

## Instructor ends polling session

- Correct answers have a green check mark.
- Compare your answers to the correct answers.

## Instructor leads debrief discussion

Raise your hand to ask a question or make a comment.



## Poll Question

Check your understanding

Which data protection challenge does SnapLock software address?

- a. high availability
- b. backup and archive
- c. disaster recovery
- d. compliance
- e. cloud integration



## Lesson 3

### NetApp Tools to Monitor and Manage Data Protection

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# Managing and Monitoring



Feature	Description
NetApp OnCommand System Manager	Provides fast, simple configuration and management for an ONTAP cluster
NetApp OnCommand Unified Manager	Monitors the health and simplifies management of multiple ONTAP clusters
NetApp OnCommand Workflow Automation (NetApp WFA)	Automates storage tasks and data protection processes
NetApp OnCommand APIs	Integrates with third-party management solutions

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The listed products are used to manage and monitor data protection solutions.

This course uses NetApp OnCommand System Manager only. You can find training for the other products by searching the NetApp Learning Center.

# Host- and Application-Level Software



Feature	Description
SnapDrive data management software	Automates storage and data management for physical and virtual environments
SnapManager software	Streamlines storage management and simplifies configuration, backup, and restore for enterprise operating environments
NetApp SnapCenter software	Centralizes data protection and clone management with a single interface across all application environments

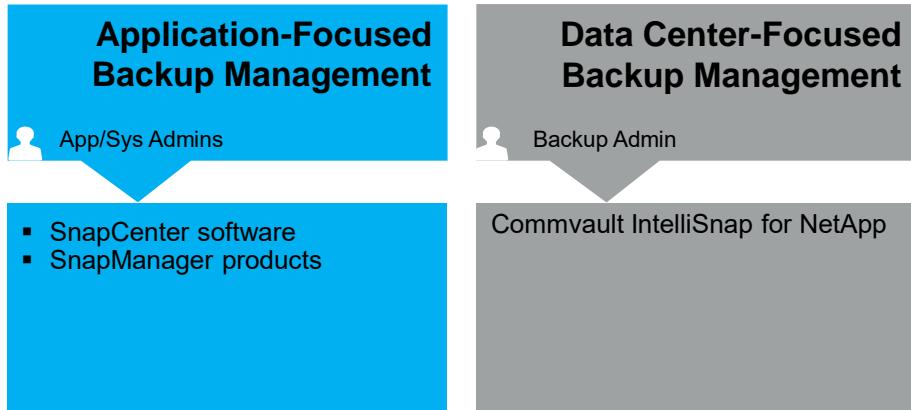
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The listed products are used to simplify data protection management.

The products are not covered in this course. You can find training for the listed products by searching the NetApp Learning Center.

# Partner Management Software



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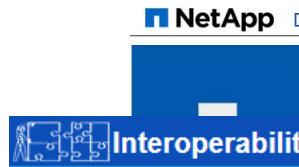
19

In addition to the NetApp data protection management software, which is written primarily for application or system administrators, NetApp partners offer software that is written primarily for backup administrators.

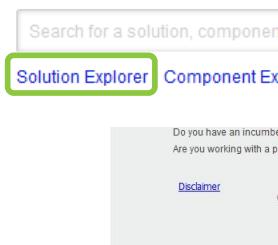
For details on the listed partner products, visit the specific partner websites.

# Data Protection Tools

- Data Protection Assessment Tool:  
[www.netapp.com/us/products/  
data-protection](http://www.netapp.com/us/products/data-protection)
- NetApp Interoperability Matrix Tool (IMT):  
[mysupport.netapp.com/matrix](http://mysupport.netapp.com/matrix)
- Documentation:  
[mysupport.netapp.com](http://mysupport.netapp.com)



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## Documentation

[By Product Library](#) [By Product Category](#)

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[7-Mode Transition Tool](#)

A

[AFF8000 Series](#)

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[AltaVault OST Plug-in](#)

[ApplianceWatch](#)

[ApplianceWatch PRO](#)

C

[Caching Modules](#)

[CIFS Protocol](#)

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NetApp provides a variety of tools to help decide on a solution and to search for supported configurations.

The data protection assessment tool can help discover the NetApp data protection solution or solutions that best fit your requirements. A link to the tool can be found on the data protection products page on the NetApp website.

The NetApp Interoperability Matrix Tool (IMT) is a web-based application that enables you to search for configurations of NetApp products and components that meet the standards and requirements that NetApp specifies. To find data protection solutions, click the Solutions Explorer link.

Documentation for the data protection solutions can be found on NetApp Support under the documentation tab.

# ACTION: Take a Poll

Check your understanding



Duration: 5 minutes

## Instructor begins polling session

- Questions appear in the polling panel.
- Answer each question.
- When finished, click “Submit.”

## Instructor ends polling session

- Correct answers have a green check mark.
- Compare your answers to the correct answers.

## Instructor leads debrief discussion

Raise your hand to ask a question or make a comment.



## Poll Question

Check your understanding

Which two NetApp data protection products create application-consistent backups? (Choose two.)

- a. SnapDrive software
- b. SnapManager software
- c. SnapMirror software
- d. SnapCenter software
- e. SnapVault software

## Additional Data-Protection Learning

Where can I learn about advanced topics like configuring intercluster replication, fan-in and fan-out strategies, and NetApp data protection interfaces?

- ONTAP Data Protection Fundamentals web-based course
- ONTAP Data Protection Administration two-day instructor-led course
- ONTAP MetroCluster Installation two-day instructor-led course



## References



- *ONTAP 9 Data Protection Guide*
- *MetroCluster Installation and Configuration Guide*
- *MetroCluster Management and Disaster Recovery Guide*
- *ONTAP 9 SVM Root Volume Protection Express Guide*
- *ONTAP 9 Cluster Peering Express Guide*
- *TR-4183i: SnapVault Best Practices Guide for ONTAP*
- *TR-4015: SnapMirror Configuration and Best Practices Guide for ONTAP*

## Module Review

This module focused on enabling you to do the following:

- Describe the integrated data protection features in NetApp ONTAP software
- Describe NetApp data protection solutions
- Identify the tools and software that are used to manage and monitor NetApp data protection features

## ACTION: Provide Feedback



Please take a few minutes to complete the survey for this course.



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Your feedback is important for ensuring the quality of NetApp courses. Your instructor will give you instructions about how to find the survey for this class and about how to use the survey web site.

# ACTION: Take the Post-Class Assessment

A short quiz



Duration: 15 minutes

The instructor provides the exam link.

- Open the assessment in a browser.
- Read and answer each question.

Submit your answers.

- Click “Submit” after each question.
- After the final question, your score is displayed.

Recall your baseline score.

- Compare your post-class assessment score to your baseline score.
- See how much you learned from the class.

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To measure your new knowledge of course topics, take the post-class assessment. You access the assessment via the link that is provided.

[https://www.brainshark.com/netapp/CDOTA\\_posttest](https://www.brainshark.com/netapp/CDOTA_posttest)

You can compare your pre-assessment score with your post-assessment score to measure how much you have learned. All scores are private and are not retained or communicated.



# Thank You



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